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A history of Australian Capital Territory arboreta 1928 ~ 2003

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A history of Australian Capital Territory arboreta

1928 ~ 2003

(Managed by Forestry and Timber Bureau and CSIRO)

Prepared for

Forest & Wood Products Australia

by

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on behalf of the
Friends of the ACT Arboreta and
Southern Tablelands Farm Forestry Network

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Executive summary

Arboreta are known to have existed in Europe since the 15th century. Foresters have been aware of the significance of provenance for the growth of new species introductions since the 17th century, and the planting of introduced trees with potential for afforestation in test plots and arboreta, to observe their growth in local environments, was a typical initial phase in colonial forestry development.

Radiata pine was reported growing in Melbourne's Botanic Garden in 1858 by the then director, Ferdinand von Mueller. Richard Schomburgk, a subsequent director of the Adelaide Botanic Garden, and an inaugural member of South Australia's Forest Board in the 1870s, planted an arboretum containing *Pinus halepensis*, *P. roxburghii*, *P. torreyana* and *P. canariensis* in the garden, and arboreta were planted by South Australia's Woods and Forests Department at Bundaleer and Roseworthy in the 1880s.

Australia's desire for self-sufficiency in softwoods saw radiata pine being widely planted for wood production in New South Wales, Victoria and South Australia by the beginning of the 20th century. Selection of the species appears to have been based on observations of growth in gardens and farm windbreaks in a variety of locations in southern Australia.

The Australian Capital Territory's (ACT) first arboretum was begun at Yarralumla in 1913 to test the suitability of introduced species for the Canberra landscape, and included a number of species with afforestation potential.

Establishment of the Australian Forestry School in 1927, and the Commonwealth Forestry Bureau in 1930 in Canberra, with Charles Lane Poole as Principal of the former and the Commonwealth's Inspector-General of Forests in charge of the latter, provided the catalyst for the commencement of a program of arboretum establishment in the ACT, capitalising on the diverse range of sites available.

Over the ensuing 39 years a total of 36 arboreta were established by the Commonwealth Forestry Bureau and its successors on sites ranging from near-sea level at Jervis Bay to the summits of the Brindabella ranges west of Canberra city, and westwards as far as a semi-arid site near Jerilderie in New South Wales.

The arboreta occupied a wide range of sites and climatic zones, with corresponding temperature and rainfall extremes. Average annual temperature ranged from a low of about 5ºC in the Mt Ginini arboretum at 1600 m above sea level (asl) in the Brindabella summits, to a high of about 25ºC at Jerilderie at about 100 m asl. Average annual total rainfall varied similarly, with the arboreta at Jerilderie and Mt Ginini receiving about 400 mm/yr and 1550 mm/yr respectively.

The first plantings in the arboreta were mainly of *Pinus* species, including radiata pine and ponderosa pine, utilising seed collected in the western United States and Europe by Jacobs, Lindsay and Byles in the late 1930s. As the program expanded so too did the number of countries from which seed was supplied. The provenance of the seed was often indeterminate, especially when supplied by seed vendors such as Rafn & Son in Denmark, Vilmorin *et Cie* in France and Herbst Brothers in New York but, as awareness of the importance of provenance grew, records improved.

By the time of the last plantings in 1969, the seed of 39 genera had been planted, and 242 species and varieties from 37 countries were represented. Both softwood and hardwoods were planted. *Pinus* species made up about two-thirds of all species

planted, the bulk of which came from the western United States and Mexico and consisted predominantly of ponderosa, radiata, attenuata, nigra, sylvestris, patula and muricata pines.

In most cases the arboretum sites were prepared by removing the native vegetation, often by hand-felling. Little site cultivation or weed control was undertaken. An arboretum typically consisted of a number of square plots of about 400 m^2 spaced about 20 m apart, containing 81 trees at 2.4 m square spacing. However, plot size, plot shape and the number of trees planted were sometimes varied to suit the characteristics of the site and the number of seedlings available. Some 'plots' contained only a single tree. Refilling was often required to replace trees lost due to drought, insects and animal predation.

By 1954 a total of 19 arboreta containing 571 plots of 159 species and varieties had been established and the primary objectives of the program were to:

- Determine the species and strains of exotic trees which would grow best in the southern highlands of eastern Australia;
- Provide breeding material for the production of improved races of trees; and
- Identify species which could replace radiata pine in the event of biological catastrophe.

By then it was becoming clear that radiata pine was growing faster than any other species on almost all sites, confirming its place as the preferred species for southern Australian afforestation. However it was thought that hybrids of both radiata pine and other species might be more suited to the colder and dryer sites, and provenance tests and crosses of radiata pine with *Pinus attenuata* and of *P. patula* with *P. greggii* were established in and close to the arboreta. The advent of *Dothistroma pini* curtailed this work.

Between 1959 and 1968 a further 17 arboreta were established, including two at Jervis Bay to test species' suitability for south-eastern coastal sites, at Mt Ginini testing growth at a very high altitude site, which some considered had potential for wholesale conversion to exotics, at Jerilderie where species with potential for dry-land afforestation were tested, and an arboretum of poplars west of Canberra.

Several species of *Pinus* from Mexico, which had not been much explored elsewhere for their afforestation potential, were introduced to the arboreta in the 1950s–1960s.

Measurement of the arboreta occurred somewhat sporadically, typically on a three-yearly cycle as the number of plots and arboreta increased. A sample of tree diameters at breast height and of tallest-tree heights were measured, avoiding edge effects resulting from the small plot size. Volume per hectare was not measured.

A comprehensive measurement of 630 plots in 24 arboreta, the rest having been either abandoned for various reasons, or burnt, was undertaken in 1972/73 by the Forestry and Timber Bureau, and reported upon in 1974. The main conclusions from that report were that:

… it is obvious that P. radiata *will remain the preferred species for commercial plantations…*; and

P. radiata *has shown tolerance to some very poor sites and generally its performance has been far superior to that of its rivals. Except in the highest arboretum, No. 26 (Mt Ginini) at 1690 m,* P. radiata*, contrary to earlier expectations, has survived heavy snow damage and on sites up to 1460 m it has produced large volumes of wood of reasonable quality…*, and

The arboreta have largely fulfilled their role as species trials and there are no plans for continuing the introduction of … new species.

That conclusion was reiterated by Pryor in 1995:

… the most significant thing is that they've [i.e. the arboreta] *given a negative answer absolutely clearly in deciding that many species of conifer are not as good as* Pinus radiata … *There was nothing tried that was a … challenger to* Pinus radiata.

A review in 2007, of height growth since 1973, provided further confirmation.

Attempts to produce hybrids better suited to the more extreme sites in southern Australia essentially failed, and the Mexican and white pines did not perform well. At the same time, knowledge of the genetics, propagation, management and utilisation of radiata pine had advanced to the stage where only the direst of circumstances would see it replaced by any other species.

Subsequent work in the arboreta was confined mainly to thinning (to improve their appearance, health and stability); removal of species, and one whole arboretum, with potential to spread into adjoining native forest; track maintenance and preparation of interpretive material for the general public, who came to value the arboreta, especially those in the Brindabellas , for their aesthetic and recreational values. The evolving sentiment was aptly expressed by Eldridge in 1985:

Sit down in one of the arboreta for half an hour, lean your back on a tree, look around, and see if you agree that it is a place for human enjoyment and spiritual reward.

Proposals to preserve five of the Brindabella arboreta considered to have significant heritage value were curtailed in 2003 when all but Bendora arboretum were burnt in wildfires. The Friends of the ACT Arboreta (FACTA) re-measured 49 plots in Stockyard Creek in 2002 prior to its felling, and 280 plots in eleven of the Brindabella arboreta after the fires.

In 2004, in acknowledgement of the historic significance of Bendora arboretum, a proposal to include it on the ACT's Interim Heritage Places Register was prepared by the ACT Heritage Council, and a conservation plan for its management was prepared by FACTA. As of April 2008 the proposal is awaiting acceptance.

As the last remaining arboretum in the Brindabellas and containing magnificent examples of trees which were typical of the arboretum program as a whole, Bendora is worthy of preservation as an enduring, living monument to those who devoted so much effort and dedication to furthering the very significant role of plantation forestry in the economy and landscape of south-eastern Australia.

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1. Introduction

Between 1928 and 1968 36 arboreta were established by the Commonwealth Forestry Bureau (CFB) and its successors in the Australian Capital Territory (ACT), predominantly west of Canberra in the Brindabella Ranges but including two at Jervis Bay on the south-eastern coast, and one at Jerilderie in New South Wales (NSW).

The original purpose of these arboreta was to assess the suitability of a wide range of species for plantation development in southern Australia and, incidentally, to assist with species selection for amenity planting in the ACT.

The CFB, formally established in 1930 and led initially by Lane Poole, directed the establishment and management of the arboreta, many of which were located on land in turn managed by the CFB's Afforestation Branch and subsequently by ACT Forests.

However, planting of the ACT's very first arboretum — Westbourne Woods at Yarralumla — by Charles Weston, Canberra's newly appointed Officer-In-Charge of the Afforestation Branch in the Department of Home Affairs, commenced in 1914. Its purpose was to test the suitability of species for landscaping Canberra City. Weston also established the first of the ACT's pine plantation forests on Mt Stromlo in 1915.

In 1928 Cyril Cole, a forester with the Territory's Afforestation Branch, established two un-named arboreta, and a third called Laurel Camp, at Pierces Creek in the Brindabella foothills west of the Murrumbidgee River.

Lane Poole, Inspector-General of the CFB and Principal of the relocated Australian Forestry School (AFS) at Yarralumla, established an arboretum at Blundells Farm in 1929 and, subsequently, a series of arboreta in the ACT.

By 2002, 23 of the FTB's 35 arboreta were still extant, the remainder having been either abandoned or burnt. Their role had been extended to provide sites for experimental plantings, not only of a wide range of species and provenances from around the world, but also of new material created by selections and crosses from the earlier plantings. By that time they had come to be valued more for their aesthetic and recreational values, and less for their scientific values.

On the 18 January 2003, all the remaining arboreta in the ACT to the west of Canberra, except Bendora arboretum near the Brindabella summits, were burnt in a wildfire.

The arboreta played a significant role in forestry development in southern Australia and in the development of Canberra City. Much of the material describing their establishment, measurement, management and significance lay scattered in various archives, files and publications.

With the demise of the arboreta it is appropriate to assemble this material in a comprehensive form more readily accessible to those with an interest in the arboreta and in early forestry development in the ACT. That is the purpose of this report.

2. The Arboreta

Two of the arboreta established by Cole at Pierces Creek were wholly or partly destroyed by fire in 1939, as were the arboreta established at Blundells in 1929 and at Reids Pinch South in 1932. The latter two were re-established in 1939.

By 1954, 17 arboreta had been established, increasing to 36 by 1968. The last planting in an arboretum occurred in 1970 at Jerilderie.

The arboreta established in the ACT, which are the subject of this report, and their fate are listed in Table 2.1.

Table 2.1: Arboreta in the ACT

Arboretum name	Fate	Arboretum name	Fate
1 Blundells	Burnt 2003	19 Halls Block	Burnt 2003
2 Reids Pinch North	Burnt 2003	20 Kowen, Cpt* 60	Abandoned
3 Reids Pinch South	Burnt 2003	21 Green Hills	Burnt 2003
4 Picadilly Circus	Burnt 2003	22 Kowen Cpt 71	Abandoned
5 Bendora	Extant	23 Blue Range Cpt 206	Burnt 2003
6 Snow Gum	Burnt 2003	24 Kowen Cpt 73	Abandoned
7 Stockyard Creek	Felled 2002	25 Vanitys Crossing Cpt 195	Abandoned
8 Blue Range	Burnt 2003	26 Mt Ginini	Burnt 2003
9 Blue Range	Burnt 2003	26a Mt Ginini Underplanting	Abandoned
10 Blue Range	Burnt 2003	27 Wombat Creek	Burnt 2003
11 Bendora South	Abandoned	28 Neds Block	Burnt 2003
12 Mountain View	Burnt 2003	29 Cotter Homestead	Abandoned
13 Blue Range	Burnt 2003	30 Uriarra, Pabral Block	Burnt 2003
14 Pierces Creek Cpt 108	Burnt 1991	31 Jervis Bay Hole in the Wall	Burnt 1972
15 Uriarra Cpt 84a	Abandoned	32 Jervis Bay Hole in The Wall	Burnt 1972
16 Halls Block	Burnt 2003	33 Boboyan	Abandoned
17 Laurel Camp	Burnt 2003	34 Jerilderie	Abandoned
18 Westbourne Woods	Abandoned	Poplar, adjacent to Blundells	Burnt 2003

* 'Cpt': Compartment. An administrative unit of a forest.

The locations of the arboreta (except for Jerilderie) are illustrated in Figure 2.1 and, for those arboretum sites west of the Murrumbidgee, stylistically in Figure 2.2 (Anon. 1957b). They were located predominantly in the Brindabella Ranges west of the Murrumbidgee River, but three sites occurred in Kowen Forest east of Canberra City, two at Jervis Bay on the eastern coast about 150 km south of Sydney, and one at Jerilderie in NSW.

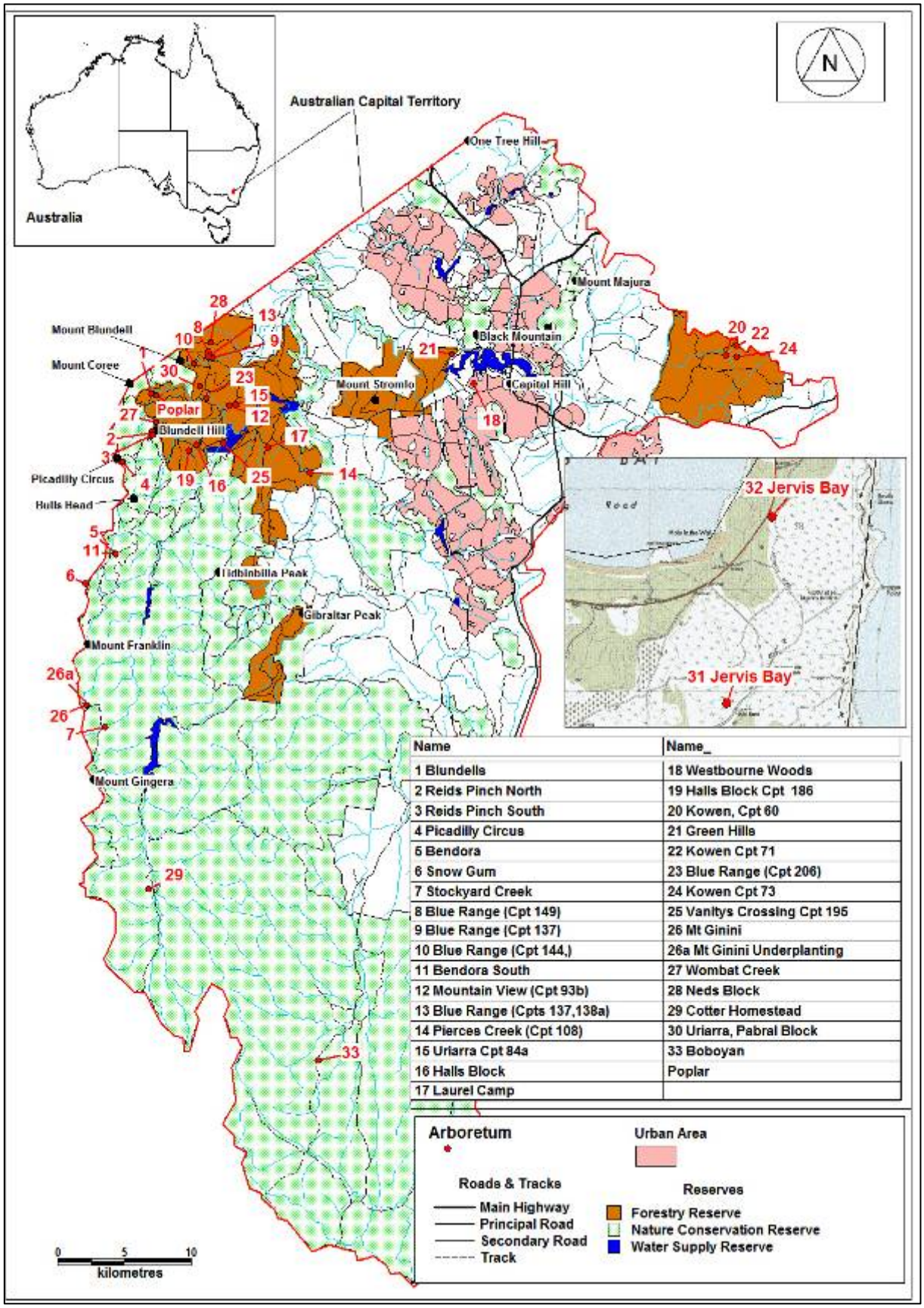


Figure 2.1: Arboretum locations

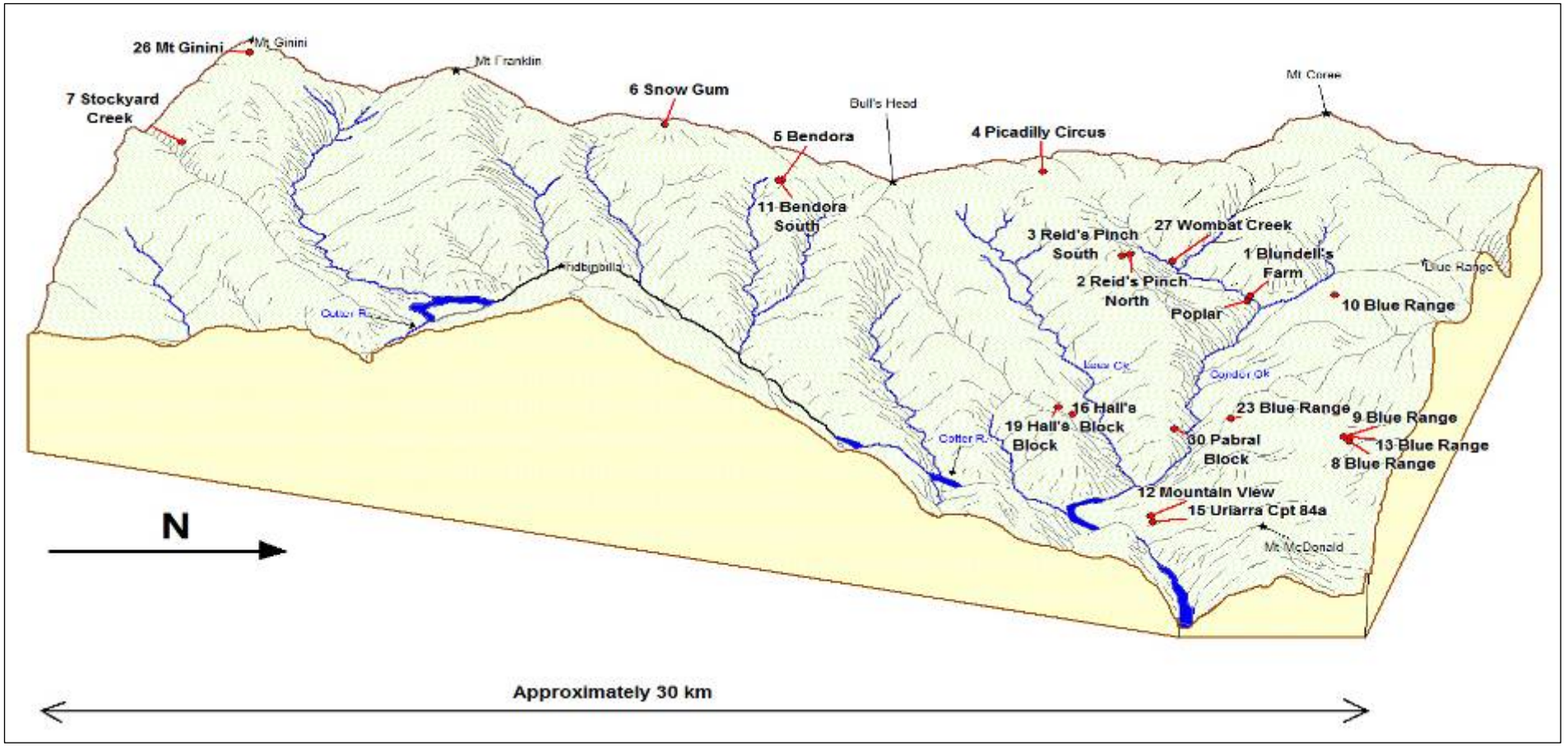


Figure 2.2: Arboretum sites in the Brindabella Ranges – stylistic view

3. Historical Context

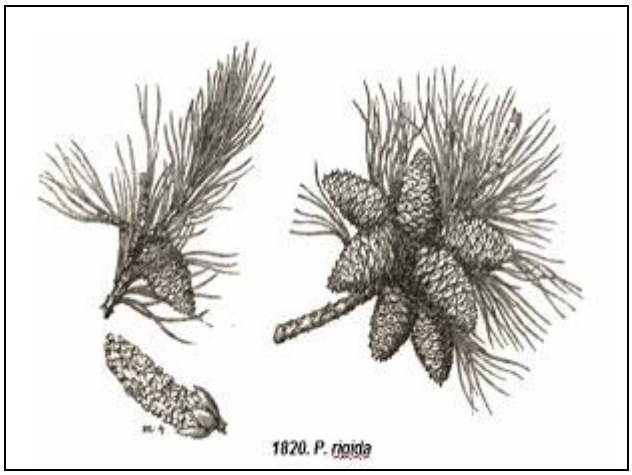
Arboreta are known to have existed since medieval times. The Trsteno arboretum near Dubrovnik in Croatia, for example, dates from the late 15th century, and wealthy European landowners often established arboreta on their estates. Notable arboreta in the UK include Ardkinglas conifer arboretum in Scotland dating from the 1700s, Kew Gardens arboretum established in 1759, the Harcourt arboretum established in 1835 (forming part of Oxford University's Botanic Garden), and Scone Palace pinetum in Scotland planted in 1848.

The first commercial arboretum in the UK appears to have been established as part of a plant nursery business by Joachim Loddiges at Hackney (now part of Greater London) in about 1816, which supplied material to the Adelaide Botanic Garden in South Australia and also imported live Australian plants in the 1830s.

The term ‘arboretum’ was first used in an English publication by J. C. Loudon in 1833, in *The Gardener's Magazine*, when commenting on George Loddige's (Joachim's son) Hackney Botanic Garden arboretum.

The Bedgebury National Pinetum in Sussex in the UK was established in 1925 on about 130 ha of land formerly part of the forest of Bedgebury Manor estate. It contains about 2100 specimens of about 300 conifer species, representing about 60% of conifer species worldwide.

The trees of North America were noted for their remarkable sizes by the early explorers (e.g. Muir, Douglas) who carried seed back to Europe, Asia, South America, New Zealand, Australia and South Africa where they often grew much faster than the native species, and faster than in their native habitats (Silen and Olsen 1992).



Pinus rigida, page 97, *Arboretum et Fruticetum Britannicum* (abridged), Loudon 1869

Planting of a wide range of species and provenances in ‘test plots’ (even if not in formal arboreta) was a common practice in the development of plantations in the 19th century and early part of the 20th century. The unsophisticated experimental designs were a reflection of the lack of appropriate statistical theory and analytical techniques, and this is apparent in the ACT’s arboreta.

In the US, the Wind River arboretum, in the Wind River Valley near Carson, Washington, which was established in 1912 by the USDA Forest Service, was the first systematic attempt to test the performance of species from around the world in the Pacific Northwest (Silen and Olson 1992).

In Europe the importance of seed provenance for forest production has been recognised by foresters since the 17th – 18th centuries. Experimental proof was provided by Vilmorin in France in 1820 who planted seeds from 30 European provenances of Scots pine (*P. sylvestris*) in the vicinity of Paris in what was probably the first documented provenance trial of a forest tree species. Provenance trials of *P. sylvestris* were also extensively planted in northern Europe, notably Russia, between about 1877 and 1916 (Pravdin 1964).

Early importations of radiata pine seeds to Australia were used for ornamental plantings, but the Sydney Botanic Garden did obtain one seedling off the ship Duncan Dunbar in 1857 (Fielding 1957). Radiata pine was also growing in Melbourne's botanic gardens in 1858, under the stewardship of Ferdinand von Mueller (Grant 1989). Von Mueller also distributed radiata pine seedlings in Victoria and South Australia in the 1860s for ornamental plantings and farm windbreaks (Wu *et al.* 2007).

Pinus lambertiana, Lower margin of the main pine belt. John Muir, http://www.yosemite.ca.us/john_muir_writings/the_mountains_of_california/chapter_8.html .

In South Australia Schomburgk planted *P. halepensis, P. pinea, P. roxburghii, P. torreyana* and *P. pinaster* in the Adelaide Botanic Garden arboretum in the 1870s. The Woods and Forests Department established arboreta at Roseworthy Agricultural College just north of Adelaide, and at Bundaleer, in the 1880s, as well as many other trial plantings throughout the State. Radiata pine was also reported growing in Adelaide's Botanic Garden in 1878 (Lewis 1975).

Trial plantings of *Pinus pinaster* were made in Western Australia in 1896 and in plantations on the northern Swan Coastal Plain in 1923, using seed from France (Butcher, 2007). The Pilot Hill arboretum near Tumut in NSW was planted in 1924 with *Pinus contorta, P. ponderosa, P. lambertiana* and *Pseudotsuga menziesii*.

In New Zealand at least one arboretum was established by the former New Zealand Forest Service, but tests of species tended to occur in large scale (c. 100 ha) commercial plantings, many of which were not very successful. Many of the same *Pinus* species planted in the ACT's arboreta were also tested in New Zealand. Elsewhere in New Zealand there are at least eight significant conifer collections, most on privately owned land (Salmon 2000).

In 1875 the South Australian Government established a 'Forest Board' which, charged with the responsibility of demonstrating the 'practicability' of forestry, first established pine and eucalypt plantations in 1876 from seedlings, including '*Pinus insignis'*, grown in nurseries at Wirrabara, Mount Gambier and Bundaleer.

In Victoria *Pinus insignis* was being planted by 1895, but it wasn't until 1907 that the Forests Act created a State Forests Department with responsibility for development of State-owned coniferous plantations. The legislation was strengthened by a new Forests Act in 1918.

In NSW, trials of coniferous species for plantation development had begun under Ednie Brown in the late 1890s, and by 1926 the annual planting program had risen to about 1000 ha per year, with mixed success. Brown dispatched A.D. Helms to procure suitable seed in North America and Europe in 1920 (Carron 1985).

In Western Australia (WA) Lane Poole, as Conservator of Forests, advocated the development of pine plantations in his Forests Bill of 1918, and in 1921 a Royal Commission on Forestry recommended that funds be made available for development of *Pinus pinaster* plantations.

Early plantation development in Tasmania commenced on a small scale in 1922 on 'wasteland' nutritionally unsuited to coniferous species, and it was largely unsuccessful.

After Federation in 1901 the Australian states retained sovereign control of their lands and forests. However, the heads of the various state forestry agencies held a number of conferences, the first in Sydney in 1911, in which common issues of national significance were discussed, among them the management and conservation of natural forests as well as the need for coniferous plantations.

In 1914–1915 D.E. (later Sir David) Hutchins, an eminent British Empire forester, reviewed Australia's forests and their management and was highly critical of the latter, expressing his opinions in no uncertain terms. Lane Poole too was also very critical of the lack of professional forest management in the state forestry agencies, and by 1919 was strongly advocating a role for the Federal Government in the development and implementation of a national forest policy, and a Federal research, management and training function.

At the sixth interstate forestry conference in Brisbane, in 1922, the heads of the state forestry services discussed extension of the area of plantations with the objective of national self-sufficiency in timber. The interstate conference in 1925 discussed a mechanism to involve the Federal government in plantation development whereby the states would provide land and management, with the Commonwealth providing finance, both parties to split the net proceeds and the states' share being used to repay Commonwealth debt.

In 1925 the Federal Capital Commission began an afforestation program in the Federal Capital Territory, headed by G.J. Rodger. By 1936 a total of 4000 ha of conifer plantations, primarily of radiata and ponderosa pines, had been established in the ACT.

Over the whole of this period there was considerable, and at times acrimonious, debate over state versus Federal control and management of Australia's forest resources, which were seen by Lane Poole and other forestry professionals to have been grossly mismanaged.

Lane Poole was appointed Commonwealth Forestry Advisor in 1924 and began development of an Australian forestry policy which included the formation of a Federal Forestry Bureau consisting of five branches: one to deal with forestry matters in the Commonwealth's territories; one to manage State-Federal financial affairs; an educational establishment for professional foresters; a research centre; and a forest products laboratory.

In 1925 the Federal Government announced its intention to establish an Australian Forestry School to train professional foresters, and a Commonwealth Forestry Bureau to advise on development and utilisation of Australia's timber resources, both to be located in Canberra. The AFS was established in Canberra by 1927, but legislation empowering the Forestry Bureau, in the Department of Home Affairs, was not passed until 1930.

The significance of the legislation to the arboretum program was the mandate it gave to the Bureau to establish experimental stations to study silviculture, forest management and

forest protection. However, in its early years the research effort of the Bureau was severely constrained by a lack of funds. Much of its research was carried out by staff and students of the AFS, and restricted mainly to the ACT.

Prior to this time, although exotic conifer species had been introduced in an attempt to assess their suitability across a range of environments, the approach was piecemeal. The environment of the Federal Capital Territory, with sites ranging from dry grassland to high-altitude wet-sclerophyll forest sites, provided an ideal experimental ground to systematically explore the performance of newly introduced species, as well as exotic species that were already known in Australia, for possible use in southern Australian plantations.

It was against this backdrop that the arboretum program was begun.

4. Movers and Shakers

Charles Lane Poole (1885–1970)

Lane Poole, an English forester, graduated from L'École Nationale des Eaux et Forêts, the prestigious French National Forestry School at Nancy, in 1906. He was appointed Conservator of Forests in WA in 1918 after spending time in Sierra Leone and South Africa.

As Conservator in WA, Lane Poole was responsible for establishment of several arboreta, but resigned as Conservator after strong disagreements with the state's Premier over forest policy.

AFS work party, 1927 (NAA A3087)

He became Acting Principal AFS at Yarralumla, moving from Adelaide to Canberra in 1927. In 1928–1929 he dispatched M.R. (Max) Jacobs to Oxford to study forestry in Western Europe, A.D. (Doug) Lindsay to the US and B.U. (Baldur) Byles to Oxford to study forestry in the Mediterranean forest region.

Lindsay reported extensively on the pines of south-eastern USA (longleaf, loblolly, shortleaf and slash pines, amongst others) and the pines of the Pacific slope (Monterey, bishop, lodgepole and western yellow [ponderosa] pines, Port Orford cedar, redwood, and Douglas-fir). It's probable that seedlings planted in the early arboreta were raised from seeds collected by Lindsay, Byles and Jacobs and sown in the nursery established by Lane Poole in the AFS grounds or in the nearby Yarralumla nursery established by Weston in 1913.

In 1930, Lane Poole became Inspector-General of Forests in charge of the Commonwealth Forestry Bureau, retaining his role as principal of the AFS, which formed part of the Bureau.

By the time Lane Poole retired from the Bureau in February 1945, a total of eight arboreta had been established under his guidance. Several of the seedlots planted in Bendora, Stockyard Creek and 13 Blue Range between 1940 and 1947 are attributed to Lane Poole and also to his daughter, Miss Charlotte Lane Poole.

Charles Carter (1885–1976)

Born in Melbourne, Carter's early employment was as a school teacher, but he obtained a degree in agriculture from Melbourne University in 1920 whilst employed as Senior Master at Victoria's Creswick Forestry School, which post he held from 1916 to 1926. In 1920 he went to Yale University and graduated in 1922 with a Master of Forestry degree. Upon his return to Creswick he was appointed Senior Master.

In 1926 he was appointed senior lecturer at the AFS where he variously taught classes in silviculture, forest dendrology\botany, plant pathology and soil science, using the arboreta as a teaching resource for the students. His skill and interest in wood science, especially of Australian timbers, saw him seconded during vacations to Special Investigations in the Australian Army's Department of Munitions in 1942 and to the Forests Products Division of CSIRO in 1943.

Several of the early seedlots planted in the arboreta are recorded as 'C.E.C.': Charles Ernest Carter.

Andy Wood (1900–1988)

Wood migrated from Scotland to Australia in the 1920s and found employment planting trees for the ACT's Forestry Branch, which was lead at that time by G.J. Rodger. M.R. Jacobs, who succeeded Rodger in 1927, appointed Wood to a temporary research position, which became permanent in 1929. This was the beginning of a close association which was to last until Jacob's death in 1979. In 1937 Wood took charge of FTB's Outdoor Gang, which established several arboreta under his leadership, and he also became keeper of the arboretum records.

He was appointed 'Assistant to the Principal' when Jacobs was appointed AFS principal in 1944, being described by Carron (1985) as the school's 'major -domo', for the next twenty years. As Jacobs' assistant he assisted with Jacobs' research, but his main role was administration of the non-academic affairs of the AFS. He also assisted with the organisation and management of the Commonwealth Forestry Conference in 1957.

Brown said (in Higgins 1995) of Andy Wood:

> *The supervisor of the [student] camp was a man called Andy Wood, who was Max Jacob's assistant and who had quite a significant role in the management of the arboreta in the 30s and 40s . . . and you could describe him as the sergeant-major at the Forestry School who looked after students in vacation time and organised them for field trips and so on during the academic year.*

On transfer of the AFS to the Australian National University (ANU) in 1965 Wood became Administration Officer of the Forestry Department's overseas aid program, finally retiring in 1975. As a mark of esteem, the Institute of Foresters of Australia elected Wood an Honorary Member in 1985.

Max Jacobs (1905–1979)

Jacobs graduated from the University of Adelaide with a Bachelor's degree in forestry in 1925. In 1926 he worked under G.J. Rodger, who had been recently appointed to establish a forestry service in the Federal Capital Territory.

In 1929 he went to Oxford, obtaining a Diploma of Forestry from Oxford and a Doctorate of Forest Science from Tharandt in Germany before returning to Australia to undertake a survey of timber resources in the Northern Territory in 1933.

From 1934 to 1939 he was employed as Research Officer with the newly formed CFB and also lectured at the AFS. At the same time he pioneered the use of radiata pine cuttings as a means of propagation and established some small clonal trials and progeny tests of radiata pine which demonstrated very clearly the significant effect of genetic variation on the growth and form of the species.

Callitris intratropica, N.T.
(FTB photo)

In 1939 Jacobs attended Yale University, on a Harkness Fellowship, and obtained his PhD. In 1940 he undertook a collection of seed from the Californian radiata pine provenances which were subsequently planted out in the arboreta, notably 9 Blue Range. In contrast to prior seed collections, the precise geographic location of the seed sources was carefully recorded by Jacobs.

After war service with the Royal Australian Engineers, serving in New Guinea, he returned to Canberra in 1944 to become Principal of the AFS, succeeding Lane Poole and becoming Director General of the FTB in 1959 after G.J. Rodger. He was instrumental in the formation of the Australian Forestry Council in 1964 and in the negotiation of the softwood plantation agreement between the states and the Federal Government in 1966, before retirement from public service in 1970.

As Director-General of FTB, Jacobs had control of the arboreta and the FTB's annual reports written by him contain accounts, albeit brief, of the progress of their development. It is interesting to note how tree-breeding assumes an increasing importance in the Bureau's activities under Jacob's stewardship.

Jack Fielding (1910–1995)

Fielding attended the AFS at Yarralumla from 1932 to 1933, then worked as a forester with the Queensland Forestry Department until 1938 and as Assistant Research Officer in charge of the Commonwealth's Forest Research Station at Mt Burr Forest Reserve in South Australia until entry to the RAAF in 1942. After war service he became Research Officer at FTB in Canberra and held the position until 1968. During this period he was in charge of the arboreta.

In 1949 he attended the University of California at Berkeley, on a Harkness Fellowship, to study forest genetics, and collected seed of various North American species, including *Pinus radiata* and *Pinus muricata* from California which were introduced mainly to Reids Pinch South arboretum on his return to Australia, after visiting tree breeding facilities in England, France, Denmark and Sweden.

Tallaganda seed orchard 1962
(FTB photo)

Fielding appreciated the significance of genetic variation to tree improvement and was keen to see as wide a provenance range as possible for a genus or species represented in the arboreta, in order to fully assess its performance and to identify superior strains. *Pseudotsuga* was one such genus, for example, and under Fielding's influence the provenance range in the arboreta was extended to cover material from Mexico, California, British Colombia, Alaska, China, Japan and Taiwan. Other examples included the white pines (e.g. *P. strobus*) and pines from Mexico (such as *P. montezumae, P. durangensis, P. michoacana, P. greggii, P. patula* and *P. hartwegii*), which he considered had potential in Australia's dry climate. Mexico is noted for the significant genetic diversity of its pine species.

Seed was difficult to obtain, however, and in the 1950s the potential of these pines had not been much explored anywhere in the world.

He significantly expanded the arboreta in the Brindabellas (Blundells, Reids Pinch, Bendora, Mt Ginini) and established new arboreta at Boboyan, Jervis Bay and Jerilderie, to provide a wider range of test conditions and to accommodate a wider genetic base for a tree improvement program.

He further explored the role and technique of vegetative propagation using cuttings of radiata pine, building on the pioneering work of Jacobs, and he was also responsible for development of the first seed orchard of radiata pine in Australia at Tallaganda (NSW), in association with the former NSW Forestry Commission.

Fielding was very enthusiastic about the potential of pines from Mexico. He experimented with crosses of *P. patula* and *P. greggii* in an attempt to produce a hybrid suited to the cold, dry climate of Canberra and the Southern Tablelands, but found that the cross lacked vigour and straightness. He also produced hybrids of *P. attenuata* and *P. radiata* in an attempt to combine the growth rate of the latter with the drought and cold tolerance of the former, but the advent of *Dothistroma pini*, to which both species are susceptible, curtailed this work.

In 1954 Fielding and Nicholson presented 'The growth of conifers in forest arboreta in the Australian Capital Territory', the first article describing the performance of various species in the arboreta, at the inaugural Institute of Foresters of Australia's conference in Canberra.

Large-scale open-pollinated progeny tests of *P. radiata*, some in association with the arboreta (for example near arboretum 23 Blue Range and arboretum 19 Halls Block), were established from 1951 under Fielding's supervision.

As the tree breeding and progeny testing program developed the arboreta became less important and management was reduced to irregular maintenance and measurement on a three-yearly cycle by an 'Outdoor Field Gang' variously led by Pat Fisher, Gib Hogg, Tony Franklin and Tony Rout.

Fielding also seemed to have a maverick streak in him, and was enthusiastic about conversion of the higher-altitude eucalypt forest in the Brindabellas to plantations. To this end he planted *Pinus contorta* in the eucalypt forest near Mt Ginini to assess the potential of this aggressive species to colonise what some saw as unproductive forestland. Fielding took leave from FTB in 1969 to manage a UN forestry project in Malaysia and retired in 1972.

Lindsay Pryor (1915–1998)

Pryor studied forestry at Adelaide University and then at the AFS where he graduated Bachelor of Science and Schlich Medallist in 1935. In 1936 he earned a Diploma of Forestry from AFS, became Assistant Forester ACT under Lane Poole and undertook a study of the ACT's vegetation which contributed towards his Master of Science degree from Adelaide University in 1939. In that year he was promoted to Assistant Research Officer and then to Acting Forester ACT in 1940, managing ACT's forests until appointed Director of Canberra's Parks and Gardens in 1944. In 1959 he became inaugural Professor of Botany at ANU.

As a student, Pryor visited the arboreta with Carter and undertook exercises in species recognition, plot establishment, and selection of sample trees for measurement of height and diameter.

Later, while working for Lane Poole, Pryor supervised the axe felling and burning of the native vegetation at Stockyard Creek, which had been selected as an arboretum site by Lane Poole. Seedlings, up to 3 years old, which had been raised in the Yarralumla nursery, were planted in pits dug between the stumps with a mattock.

The arboreta at Blue Range (8, 9 and 10) were established by Andy Wood at Pryor's direction as ACT Forest's manager. Italian 'internees' at the Blue Range camp may have been employed for short periods on this work.

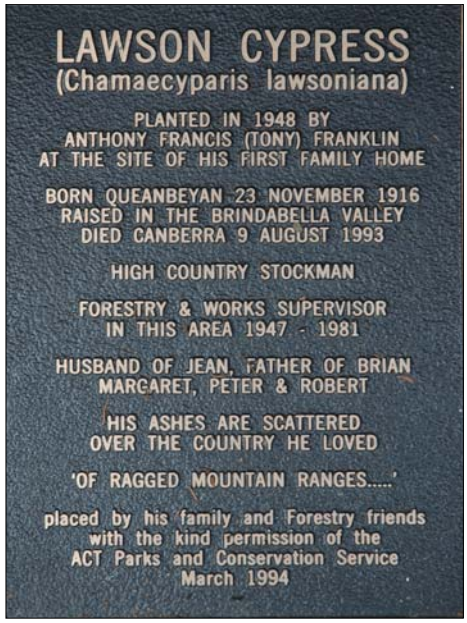
Pryor had a keen sense of the purpose of the arboreta as proving grounds for species which might have had potential for southern Australia's plantations such as the North American white pines (e.g. *Pinus strobus, P. lambertiana* and *P. monticola*), *P. muricata* and Douglas-fir (*Pseudotsuga menziesii*), particularly in the event of catastrophic failure of radiata pine.

He saw the failure of most species in the arboreta to compete with radiata as the species of choice in most plantation situations as one of the most significant outcomes of the arboretum program.

Tony Franklin (1916–1993)

After war service, Franklin returned to live at Bulls Head in 1947 and was employed in bush work both in the Brindabella Ranges and at Uriarra Forest. He moved to Canberra's Department of Works in 1957, and subsequently to FTB at Yarralumla, where he led the outdoor field crew until 1981, directed by Eldridge and others. He also managed FTB's Yarralumla nursery during the final stages of his career.

During this period the outdoor field crew undertook significant maintenance activities in the arboreta, such as thinning, pruning, burning to remove debris, development of recreational facilities and weed control as well as labelling the trees in several arboreta.

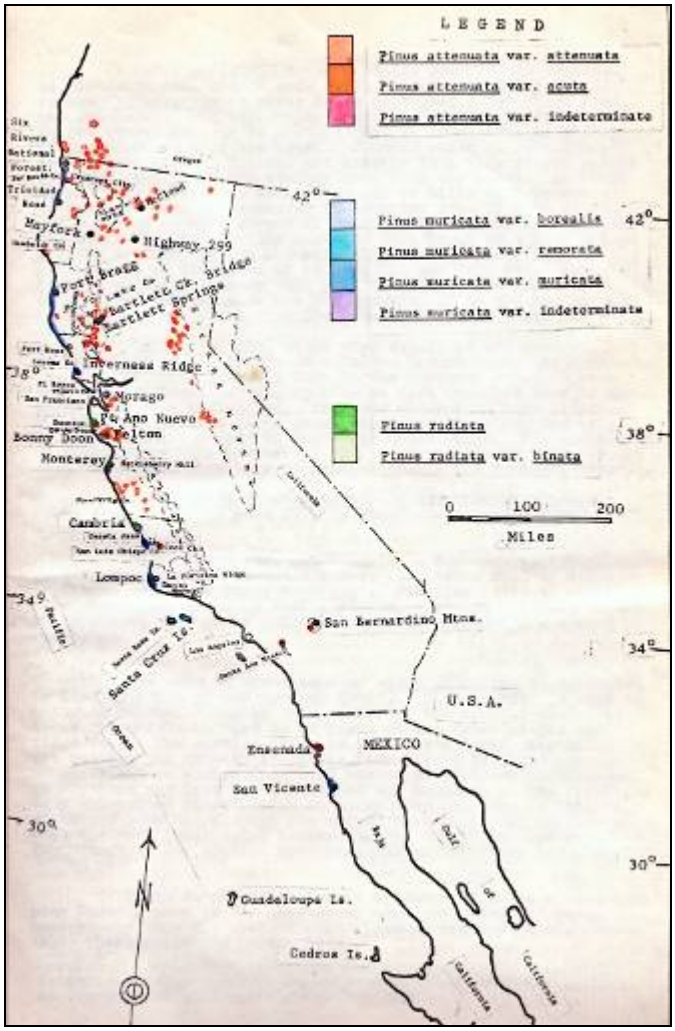


Memorial to Tony Franklin at Bulls Head (Photo: J. Shirley).

Alan Brown (1931–)

As a Commonwealth Forestry Scholarship student at Sydney University in 1948–1949, Brown participated in the maintenance and measurement of the arboreta at Blundells and Reids Pinch from a summer camp supervised by Andy Wood. Brown also attended the AFS at Yarralumla in 1950 and 1951 and visited the arboreta on student field trips.

In 1955 he joined Fielding's silvicultural research group at FTB, participating in the management and measurement of the arboreta. He considerably improved the arboretum records by producing reasonably accurate maps (see appendix 1 for example) of the layout of each arboretum accompanied by comprehensive notes of the species and their provenances in each 'plot', which made information about the arboreta much more widely available.



Closed cone pine provenances, California, USA.
(Permission Alan Brown)

Brown also became heavily involved in the Bureau's tree breeding activities, participating in the progeny development and testing program until the late 1960s.

In 1966 Brown completed his Master of Science with a dissertation entitled 'Isolating barriers between the closed-cone pines' which drew on the genetic material established in Blundells, Reids Pinch South and Halls Block arboreta.

This work established that:

- Differences in flowering times of *P. radiata* and *P. muricata* create a natural barrier to hybridisation;
- The viability of seeds obtained from crossing the northern and southern provenances of *P. muricata* is very low due to reproductive failure at or near the time of fertilisation;
- The southern provenance of *P. muricata* crossed with difficulty with *P. radiata* and *P. attenuata* but the northern provenance was so isolated that hybridisation with either species would be difficult;
- Hybridisation of *P. radiata* and *P. attenuata* should not be precluded by reproductive barriers;
- Growth rates of inter-specific hybrids appeared to be intermediate to that exhibited by their parents.

Subsequently FTB invested some effort in developing *P. attenuata* and *P. radiata* hybrids to combine the cold and drought tolerance of the former with latter's superior growth rate.

Brown also contributed to the tree breeding program which commenced at FTB in the late 1940s and was involved in many of the progeny tests and clonal trials, often established adjacent to the arboreta, and in development of the Tallaganda seed orchard.

In 1961 Brown became a lecturer at AFS at Yarralumla and used the arboreta as a teaching resource, before returning to the FTB's Forest Research Institute and subsequently becoming Chief of CSIRO's Division of Forestry in 1991.

Ken Eldridge (1934–)

Eldridge's introduction to the arboreta was at Westbourne Woods as an AFS student in 1957. In 1969 he completed his PhD in the Forestry School at ANU and was head of FTB's Genetics Subsection from 1969 to 1987 with responsibility for the care and maintenance of the arboreta. However by 1974 it was becoming clear that the arboreta had fulfilled their initial purpose of determining which species were most suitable for plantations in the ACT region. Measurement ceased but their recreational, aesthetic and historical values began to appreciate. Activity in the arboreta was reduced to some thinning, labelling and development of walking tracks for public access, especially at Blundells.

Tree label (Photo: J. Shirley)

Five arboreta (Blundells, Reids Pinch South, Bendora, Picadilly Circus and 8 Blue Range) were identified as worthy of thinning to ensure continued health and stability. An extensive labelling program was completed for these arboreta, giving common and botanical names and provenance of the species in each plot. A series of leaflets about each of these arboreta was also prepared for public information.

In 1978 Eldridge led a group of forestry scientists from Australia, New Zealand and the US which made a comprehensive collection of radiata pine seed from the Californian and Mexican populations, and some of this material was established in the ACT's arboreta.

He had a seminal role in instituting, in 1981, monthly public walks in Westbourne Woods in Yarralumla. Eldridge retired from CSIRO in 1992 but maintains an active role in tree breeding as an Honorary Research Fellow in CSIRO's forest division.

Tony Fearnside (1934–)

Fearnside has been interested in arboreta since his undergraduate days which included visits to the Bedgebury National Pinetum at Bedgebury in Kent, the source of some of the seedlots planted in the ACT's arboreta.

In 1991 Fearnside and Lea assessed the upland arboreta for the then ACT Forests, producing a report 'Management Proposals for Arboreta in the ACT'.

This re-kindled his interest in arboreta and he received two grants from the ACT Heritage Council to prepare nominations for five of the upland arboreta to be included in the ACT's Interim Heritage Places Register. He was assisted in this by Ken Eldridge and Kim Wells.

After the fires of 2003 the ACT's Parks and Conservation Service suggested the formation of a 'Friends' group to help provide technical expertise for the management of Bendora Arboretum.

This led to the formation of the Friends of ACT Arboreta with Kim Wells and Fearnside as co-convenors. With the help of many volunteers and two grants from the ACT Government, FACTA re-measured all of the burnt arboreta and prepared reports to assist with the management and interpretation of Bendora arboretum, and for future planning of the Blundells arboretum site.

In July 2005 FACTA became a formally constituted body with an elected management committee and constitution, and Fearnside became the founding president.

Pinus wallichiana (Photo: J. Shirley)

John Turnbull (1940–)

Turnbull was born in the United Kingdom and gained his forestry qualification at University College of North Wales at Bangor. Employment in Holland on a Dowager Eleanore Peel Trust scholarship, work on the genetics and breeding of poplars, and as a field forester in South Australia preceded recruitment to the Forest Research Institute in 1965 by Fielding.

Turnbull's primary role at FRI, from 1965 to 1969, was management of the arboreta, supervised by Fielding. The search for species suitable for dry-land afforestation saw Fielding and Turnbull establish an arboretum at Jerilderie in 1968. Many species from the Mediterranean and drier parts of North Africa were planted here under Turnbull's supervision, and have subsequently been incorporated in the program of the Australian Low Rainfall Tree Improvement Group (ALRTIG) (www.rirdc.gov.au/reports).

He was also instrumental in extending the representation of species of *Pseudotsuga* in the arboreta, under Fielding's guidance. An attempt, lasting two years, to obtain seeds of *P. sinensis* from China was unsuccessful.

Turnbull was also involved in the extension of Blundells, Bendora and Mt Ginini arboreta, and the establishment of the 'Hole in the Wall' arboreta at Jervis Bay, the Boboyan arboretum and white pine (*P. strobus*) provenance trials in Bendora and Boboyan arboreta.

Turnbull left arboreta work in 1969 to manage the Australian Tree Seed Centre and then the Tree Resources Program at the same time as taking up a role in the Australian Centre for International Agricultural Research. In 1994 he departed CSIRO to work on tree breeding at the Center for International Forestry Research at Bogor, Indonesia.

Cedrus deodara (Photo: J. Shirley)

5. Prior Reports

A number of reports have been written dealing with various aspects of the arboreta.

FTB Annual Reports

Chamaecyparis lawsoniana
(Photo: J. Shirlev)

Lane Poole first mentions the arboreta in his 1940 Commonwealth Forestry Bureau annual report, noting that three new arboreta (Bendora, Stockyard Creek and Pierces Creek) were established.

In 1943 the Annual Report notes that:

> *The work of establishing arboreta was continued. Plantings were made at Stockyard Creek, Bendora and Snow Gum, Condor Farm and a new arboretum was established at Blue Range with entirely satisfactory results. Outstanding results from the establishment of* Pseudotsuga taxifolia *and* P. contorta *var.* murryana *were observed. These arboreta in the mountains are now beginning to afford comparisons for growth of the various possible exotics at different altitudes;*

and in 1945

> *The work of planting up the eight arboreta which are situated from the foothills up to 5000 feet on the Brindabella Range was continued. Comparison between some species at very different altitudes can already be seen, and in the case of western yellow pine the variations between races are distinguishable.*

The arboreta continued to feature in the Bureau's annual reports during G.J. Rodger's stewardship, who succeeded Lane Poole, and in 1953 it was noted that:

> *The outstanding tree is* Pinus radiata*, which is growing faster that any other species in all the arboreta in which it has been planted. In the higher arboreta it is damaged by snow and it is difficult to establish in localities where snow lies for a considerable period during the winter;*

and

> *Of the other species planted,* P. patula *is the fastest growing species, but it also suffers severe damage from snow.*

The 1955 report mentions the potential for afforestation on NSW coastal sites which presumably provided the impetus for establishment of the two 'Hole in the Wall' arboreta at Jervis Bay some years later in 1963. The 1958, 1959, 1960, 1961 and 1962 reports note the establishment of the arboreta at Pierces Creek, Mt Ginini, Wombat Creek and Neds Block respectively.

Subsequent annual reports continue to record activities in the arboreta such as new introductions, planting, pruning and measurement, and the 1969 report included a note on the spread of *Pinus contorta* into cleared areas adjacent to arboreta in which it had

been planted. It was considered unlikely that significant spread into sub-alpine eucalypt forest would occur without forest clearing or fire.

The final entry on the arboreta in the FTB's 1970 Annual Report noted that:

> *Work on the arboreta and provenance trials of introduced conifers was limited to maintenance and re-labelling of the existing experiments.*

Fielding and Nicholson (1954)

Fielding and Nicholson, in a paper to the Australian Institute of Foresters Conference in Canberra in 1954, discussed the development of the 17 arboreta which had been established by that date and the growth of 23 species which had been established in them.

The authors stated that the objectives of the arboretum program were:

- *To determine the species and strains of exotic trees which will thrive best on the various sites in the southern highlands of eastern Australia,*
  and
- *To provide invaluable breeding material for the production of improved races of trees.*

It was considered that the information gained from the program would also:

- *Help provide a sound basis on which foresters may decide which species and strains are the most profitable to employ on such sites – both species for general-purpose softwoods and species useful for special purposes…..*

It was also considered important to:

- *...know the relative growth rates of a number of general-purpose softwoods and the quality of timber they produce,*
  because
- *…in the event of a catastrophe (such as serious disease) overtaking Monterey pine other species may have to be planted on a large scale.*

By 1954 the arboreta contained 55 species and varieties of the genus *Pinus*, ten spruces, nine firs, and species of nine other coniferous genera. A small number of hardwoods were also represented.

The thrust of the arboretum development program at that time was:

- Establishment of hybrids of radiata pine with *Pinus muricata* and *P. attenuata*;
- Introduction of additional pine species (especially from Mexico and Central America), as well as provenances of pine species and other coniferous genera (e.g. *Pseudotsuga*) with potential utility in southern Australia, and species suited to hot dry conditions.

It was noted that:

- Local site variation occurred to some extent in all arboreta, despite the attempt to find uniform conditions;
- Each species was represented by no more than one or two plots, except for ponderosa pine;

- Only a few species were represented by different varieties or geographic races;
- Growth of some species was probably influenced by the establishment methods employed;
- Given the relatively young age of the trees in 1954, it was probable that the relative success of some species would change as the plots aged;
- Some species which might perform well in the south-eastern highlands were not represented in the arboreta.

Of the 23 species discussed in this report, radiata pine was growing faster than any other in all the arboreta in which it had been planted, although at higher elevations it had been damaged by snow.

Of the other species, *Pinus patula* was the fastest growing but was very prone to severe snow damage. Table 5.1, taken from Fielding and Nicholson, compares the height growth of radiata pine with that of other species.

The Forestry and Timber Bureau forest research field crew about 1980. Rear row– Unknown, Julie Harragan, Bill Madden; Front row– Tony Franklin, Tony Rout, Bruno Monteleone, Sid Wolf, Unknown, Mike Reid, ???? Franklin, Dominec Pelle (CSIRO photo)

Table 5.1: Growth of *Pinus* spp. in 1954

Arboretum	Elev'n (m.asl)	Plot age (y)	Species									
			Pinus radiata	***Pinus ponderosa***	***Pinus patula***	***Pinus nigra* v. *calbrica***	***Pinus muricata***	***Pinus taeda***	***Pinus contorta***	***Pinus pinaster***	***Pinus torreyana***	***Pinus coulteri***
			Height (m)									
Blundells	762	24	21	17		15						
Reids Pinch Nth	991	21	21	12								
Reids Pinch Sth	991	14	13		11			9	8			
Picadilly Circus	1235	21	20		14		16		13	12		
Bendora	1250	13	12				10		7			
Snow Gum	1418	12	7	5		5						
Stockyard Creek	1372	13	9	7		7			9			
Mountain View	640	19	23		17						18	
Laurel Camp	655	25	20	12		13						12

P. canariensis, immature female cones
(Photo: J. Shirley)

P. canariensis, male cones
(Photo: J. Shirley)

P. canariensis, mature female cones
(Photo: J. Shirley)

Forestry and Timber Bureau (1957)

At the 6th Commonwealth Forestry Conference a Standing Committee was formed to facilitate the assembly of information about exotic trees from throughout the Commonwealth so that it could be made more readily available to assist member countries in managing and developing their own plantations.

Fielding and Brown, under FTB's auspices, prepared a paper entitled *Exotic Forest Trees in the Australian Capital Territory* (Forestry and Timber Bureau 1957) which was presented at the 7th Commonwealth Forestry Conference held in Australia and New Zealand in 1957.

It contains a general account of Canberra's environs and of forestry activity in the ACT from 1913 to 1957, including development of the arboreta. It also contains notes on the growth of various species in the arboreta, including summaries of growth data and selected photographs.

Much of this information was subsequently used in the revision of Troup's *Exotic Trees in the British Empire* published in 1932, which was renamed *Exotic Trees in the British Commonwealth* (Streets 1962) compiled by Streets and edited by Professor Sir Harry Champion of Oxford University.

Rout and Doran (1974)

In a seminal report Rout and Doran (1974) reported that, by 1972, 25 of the 36 arboreta were being maintained, covering an area of about 39 ha, containing over 770 plots.

In addition, 5.3 ha of replicated provenances of species showing promise for south-eastern Australia (*Pinus attenuata, P. strobus, P. monticola, P. pinaster, P. halepensis, P. brutia* and *Pseudotsuga menziesii*) had been established.

About 630 plots were re-measured in 1972–1973.The measurements consisted of diameter (at breast height over bark (dbhob)) of all the 'internal' trees in a plot, but only the three largest-diameter trees were measured for height. Plot area and stand basal area per hectare were calculated for as many plots as possible for the more important species. Where there were only a few surviving trees in a plot, all were measured for both height and diameter. Comments describing the general condition of the arboreta and notes on individual plots were also recorded.

The report notes a deficiency of information describing seed origin and the lack of standard cultural treatments applied uniformly on all sites which confounds the comparison of species and provenance performance across arboreta. They noted that the better performance of ponderosa pine at Blundells relative to radiata pine (see Figure 5.1) may have been due to an inferior radiata pine seed source. Similarly, in the case of muricata pine the inferior 'green' strain was planted, except in Reids Pinch South, where the 'blue' strain was planted and performed as well as the best radiata provenances.

At 8 Blue Range arboretum they particularly noted the variation in the growth and form of several provenances of *P. ponderosa*, which is discussed further in section 9.

Figure 5.1 is reproduced from data in Table 5.1 in Rout and Doran's report, comparing the height growth of radiata pine with other *Pinus* species in individual arboreta.

On the basis of these data the authors concluded that

> … *it is obvious that* P. radiata *will remain the preferred species for commercial plantations,*

and

P. radiata *has shown tolerance to some very poor sites and generally its performance has been far superior to that of its rivals. Except in the highest arboretum, No. 26 (Mt Ginini) at 1690 m,* P. radiata*, contrary to earlier expectations, has survived heavy snow damage and on sites up to 1460 m it has produced large volumes of wood of reasonable quality,*

and

The arboreta have largely fulfilled their role as species trials and there are no plans for continuing the introduction of … new species.

Douglas–fir (Photo: J. Shirley)

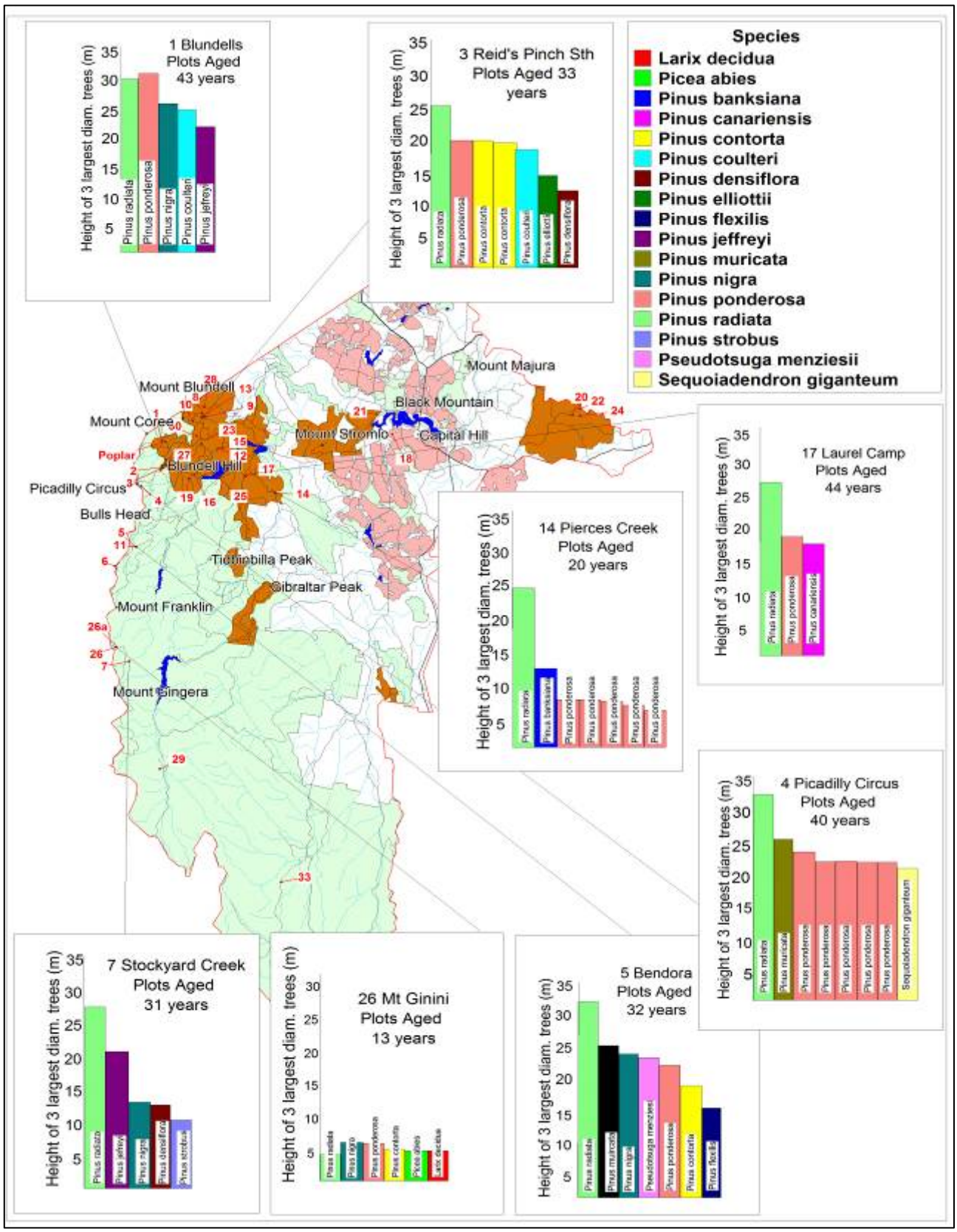


Figure 5.1: Height growth comparisons in 1972 ex Rout and Doran (1974)

Chapman and Vercoe (1984)

Chapman and Vercoe prepared a booklet whose purpose was to provide a layman's guide to a number of arboreta in the ACT. Many of the arboreta which are the subject of this report are described in the booklet. General interpretive information on the Coniferae is provided, along with a brief description of each arboretum, including a number of other urban arboreta within, and in the vicinity of, Canberra City.

Barton, Goodwin and Stephenson (1985)

This report was commissioned by the Department of Territories Forest's Branch (ACT Forests) and the Institute of Foresters of Australia (ACT Branch), as a result of an interest by Dr Wilf Crane (former FTB scientist and forester), to review the status of the arboreta in order to identify one or more worthy of promoting scientific, educational, recreational, historic and aesthetic values to the public at large.

After an initial assessment, Blundells arboretum was selected as the arboretum on which promotional efforts should be concentrated initially, with provision of interpretive signage, literature and walking tracks followed by picnic, toilet and parking facilities at a later date. This was seen as a first step in raising the profile of all the arboreta in the minds of both Canberrans and Australians at large.

Other key recommendations were:

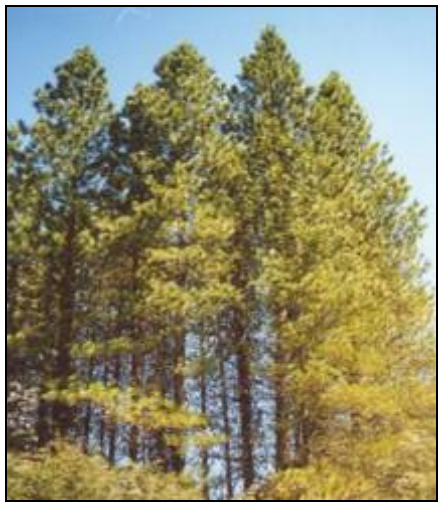
- Inclusion of 'selected arboreta' including Blundells on the 'National Heritage List' and in programs related to the Australian Bicentenary and National Museum;
- Appointment of a coordinator to provide liaison between various government bodies and to oversee development;
- Protection of all arboreta from fire and other destructive human and natural activities.

Blundells arboretum site looking north-west, 2007 (Photo: J. Shirley)

Fearnside and Lea (1991)

In 1991 Fearnside and Lea undertook a review of the condition and values of the arboreta west of Canberra City and made a number of observations and recommendations about their management. They found that, in general, the arboreta were overstocked and in moderate-to-poor condition, except for Blundells, 8 Blue Range and Mountain View.

Sirex noctilio had killed several different species in several arboreta and problematic wattle and eucalyptus regrowth and blackberry was present in many plots. Tracks were overgrown in many cases.



Pinus nigra, Stockyard Creek
(Photo: A. Fearnside)

The arboreta at Blundells and at Blue Range were considered to be of 'world standard', requiring 'comprehensive and holistic' management plans of a 'very high standard', covering interpretative, recreational, landscape, heritage and scientific values.

Reids Pinch South, Bendora, Mountain View, Laurel Camp and Pabral (partly damaged by fire in 1991) were considered to be worthy of special attention for their recreational, landscape and interpretive values.

Stockyard Creek, in Namadji Park, the under-planted conifers and eucalypts at Bendora and arboretum 14 Pierces Creek, which was burnt in 1991, were recommended for abandonment and felling. Stockyard Creek was acting as a source of infestation by lodgepole pine (*Pinus contorta*), other pines and juniper into the park.

The future of Snow Gum arboretum, just outside the ACT border in NSW in the Bimberi Nature Reserve, was regarded as a matter to be resolved with the National Parks and Wildlife Service of NSW.

Further observations and recommendations for the arboreta were:

- The primary scientific purposes espoused by Fielding and Nicholson (1954) were being superseded and the remaining arboreta should be retained primarily for recreation, interpretive and landscape values, although some scientific and teaching values were recognised as well;
- Nearly all the plots should be thinned to maintain their health and appearance, with removal or chipping of felled material;
- The spread of unwanted conifer regeneration into surrounding natural forest should be controlled, with burning to destroy viable seeds where necessary, as a matter of urgency;
- Access to the arboreta, and the plots and species within them, should be documented in situ with signage, and supplemented with pamphlets and guidebooks, together with the development of recreational facilities;
- Continued, adequately funded, care and attention was necessary to maintain the health and appearance of the trees and to provide protection from wind and fire;

- Development plans were required for eight arboreta.

Table 5.2 summarises the main findings for each arboretum surveyed.

Table 5.2: Summary of recommendations (Fearnside and Lea 1991)

Arboretum		Condition	Values[1]				Future management priority
No	Name		I	R	S	L	
1	Blundells*	Generally good	VH	VH	VH	VH	Develop interpretation and recreation plan.
	Poplar		M	M	VH	H	
2	Reids Pinch (N)	Poor	L	L	M	L	Low priority
3	Reids Pinch (S)	Moderate	VH	M	H	M	Develop as 2nd priority
4	Picadilly Circus	Poor	G	M	M	L	Retain, improve recreation
5	Bendora	Moderate	H	H	M	L	Improve recreation and interpretation
11	Bendora	Poor	L	L	L	-	Abandon
6	Snow Gum	Moderate	M	L	M	L	Low priority
7	Stockyard Creek	Poor	M	M	M	L	Demolish
8	Blue Range*	Good	H	H	H	H	High priority in accordance with overall plan
9	Blue Range	Moderate	M	H	H	VH	
10	Blue Range	Moderate	L	L	L	M	
13	Blue Range	Good	VH	H	L	VH	
12	Mountain View*	Good	M	H	M	H	Develop interpretation
14	Pierces Ck	Burnt 1991	L	L	L	L	Abandon
16	Halls Block	Moderate	M	L	M	G	Retain, Low Priority
17	Laurel Camp*	Good	H	VH	L	VH	Develop interpretation
19	Halls Block	Poor	L	L	H	H	Retain for Landscape
21	Green Hills	Moderate	L	L	L	M	Retain
23	Blue Range, Cpt206	Moderate	L	L	H	M	Retain
27	Wombat Creek	Moderate	L	L	H	G	Retain
28	Neds Block	Moderate	M	L	H	L	Retain
30	Pabral	Moderate	M	H	M	H	Retain for landscape

[1] I: Interpretive, R: Recreation, S: Scientific, L: Landscape, *: Heritage, L: Little or no value, M: Some value, G: being used, or some potential, H: Receiving a lot of use or of considerable potential, VH: Outstanding or unigue

6. The Natural Environment of the Arboreta

Topography

The ACT lies on the western fall of Australia's Great Dividing Range at about latitude 35°S and about longitude 148°E. Broadly, the part of the Territory in which most of the arboreta occurred consists of three quite distinct morphological units which lie approximately parallel to each other in roughly a north-south direction:

- The Cullarin Horst (600–800 m asl which lies generally to the east of Canberra City;
- The Canberra Rift, in which the city is located, at an altitude of 500–700 m asl, flanked to the west by the Murrumbidgee River Valley;
- The Brindabella Ranges, west of the Murrumbidgee River, whose summits, rising to about 1700 m asl, mark the western boundary of the Territory.

Drainage

The Murrumbidgee River, located along the western edge of the Rift, and its major tributaries (Cotter, Paddys, Molonglo, Gudgenby and Nass Rivers) provides the major drainage, in a northerly direction. The Cotter River, in whose catchment many of the former arboretum sites occur; rises in the south-west of the Territory near the Brindabella summits and flows in a northerly direction to join the Murrumbidgee River west of the City, upstream from the Molonglo confluence (Figure 6.1).

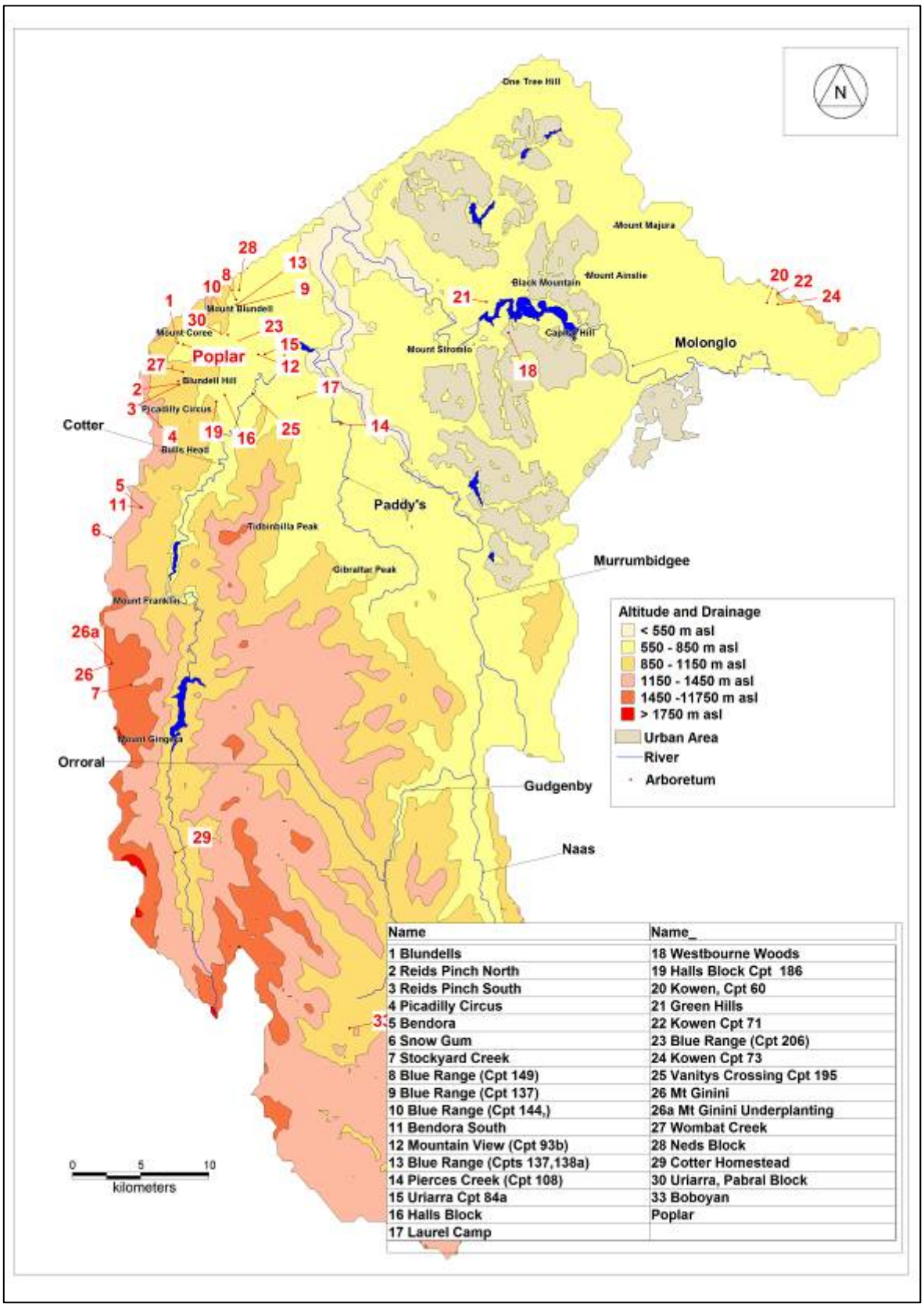
Important environmental factors include low temperatures, especially at higher elevations, and periodic fires:

Top left: Silver birch at Stockyard Ck, early April 1956

Above: The results (April 2003) of intense fire in Blundells arboretum, January 2003

Bottom: Logs from trees (mainly ponderosa pine) killed by fire in January 2003, arboretum 8 Blue Range, March 2004

(Photos: Alan Brown)



Name	Name_
1 Blundells	18 Westbourne Woods
2 Reids Pinch North	19 Halls Block Cpt 186
3 Reids Pinch South	20 Kowen, Cpt 60
4 Picadilly Circus	21 Green Hills
5 Bendora	22 Kowen Cpt 71
6 Snow Gum	23 Blue Range (Cpt 206)
7 Stockyard Creek	24 Kowen Cpt 73
8 Blue Range (Cpt 149)	25 Vanitys Crossing Cpt 195
9 Blue Range (Cpt 137)	26 Mt Ginini
10 Blue Range (Cpt 144,)	26a Mt Ginini Underplanting
11 Bendora South	27 Wombat Creek
12 Mountain View (Cpt 93b)	28 Neds Block
13 Blue Range (Cpts 137,138a)	29 Cotter Homestead
14 Pierces Creek (Cpt 108)	30 Uriarra, Pabral Block
15 Uriarra Cpt 84a	33 Boboyan
16 Halls Block	Poplar
17 Laurel Camp	

Figure 6.1: Altitude and drainage

Altitude

Figures 6.1 and 6.2 show the range of altitude over which the arboreta occurred. The arboreta at Jervis Bay were located about 1 km from the coast, at about 50 m asl.

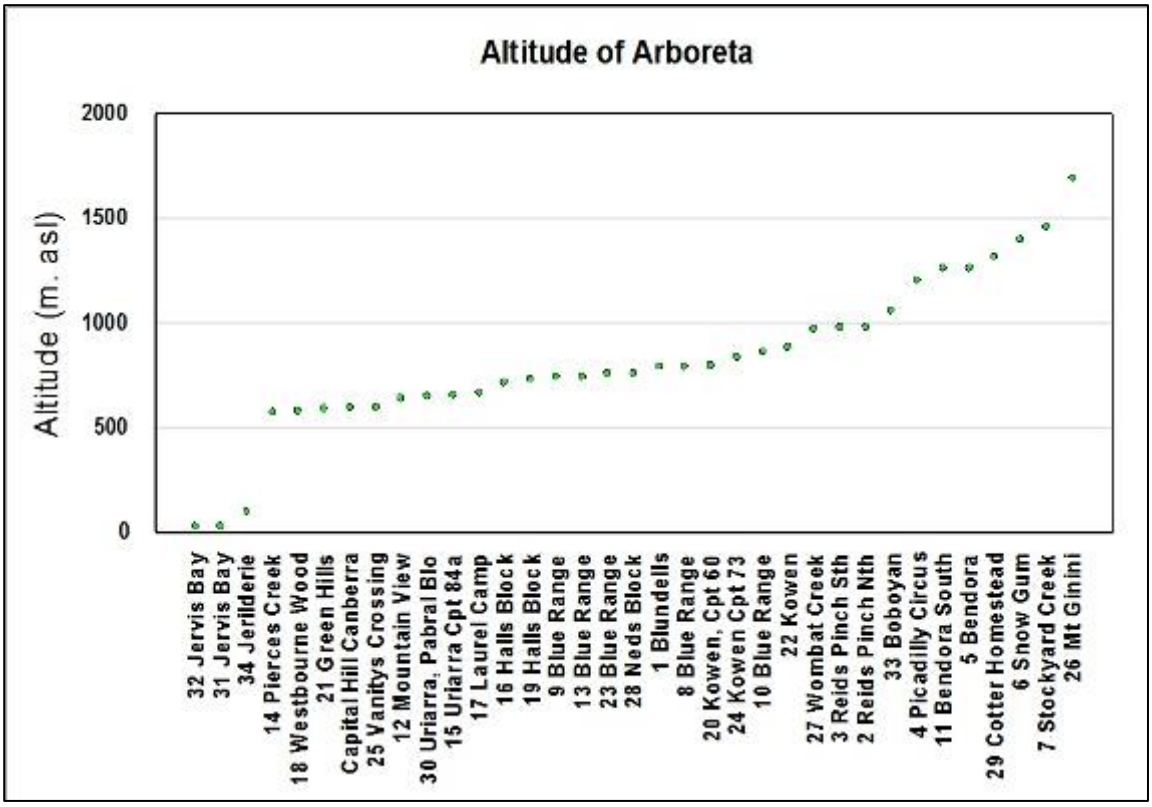


Figure 6.2: Altitude of the arboreta

Temperature

There are few instrumental records of temperature (or rainfall) from arboreta sites, although Bull's Head near Bendora arboretum was monitored for some years (White 1954). However, estimates for each arboretum site can be derived from climatic models.

Figure 6.3 illustrates the estimated average temperature at each arboretum site for the years 1968 to 2003 inclusive. Temperature statistics for Capital Hill in Canberra City are shown for comparison.

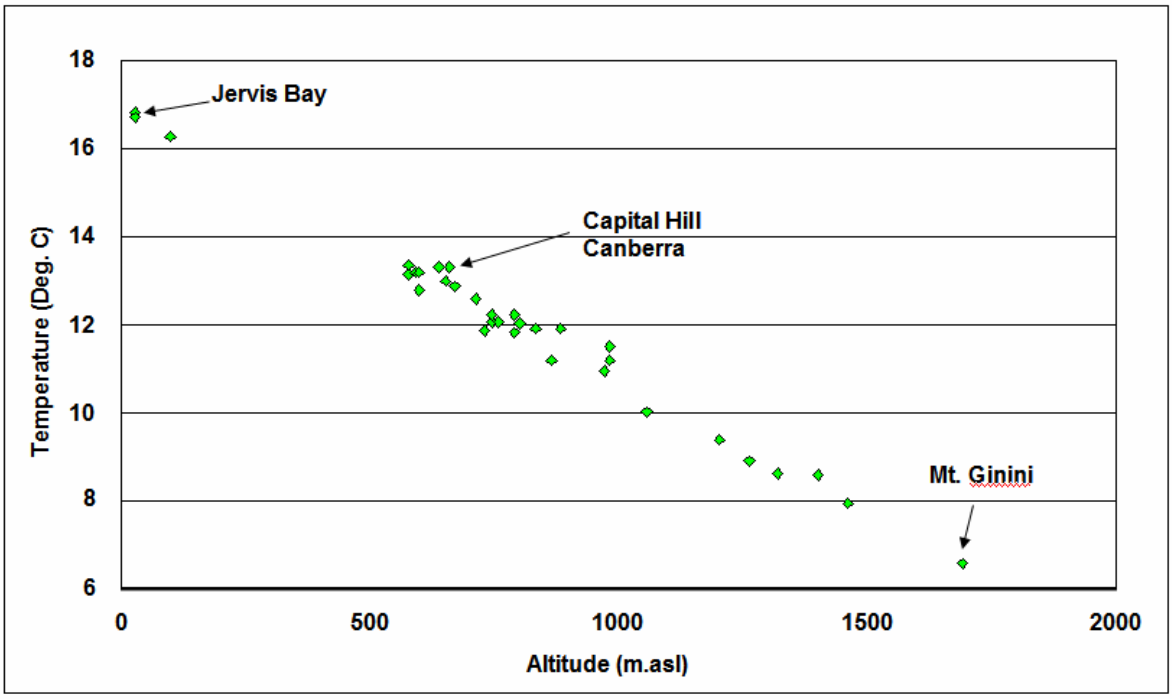


Figure 6.3: Average temperature at each arboretum site

The average temperature at the arboretum sites is clearly correlated with the altitude of the site, but there is probably microclimatic variation at each site which is obscured by the interpolation technique employed to derive the estimates.

Average annual temperature ranges from about 13°C to 16°C at the lower altitudes (but slightly higher at Jervis Bay) and declines steadily with altitude to about 6°C at the Mt Ginini arboretum site at an altitude of about 1700 m asl.

At Capital Hill in Canberra City (600 m asl), the average annual temperature is about 13°C.

The highest average maximum monthly temperature over the period 1968–2003 is estimated at 25°C at Jervis Bay in January and the lowest average minimum monthly temperature, –1°C at Mt Ginini in July.

Snowfall occurs frequently at altitudes above about 1200 m asl and above about 1500 m asl it may persist for 3–4 months (Anon. 1957a).

Rainfall

Figure 6.4 illustrates the estimated average annual precipitation at each arboretum site for the years 1968 to 2003 inclusive. Rainfall statistics for Capital Hill in Canberra City are shown for comparison.

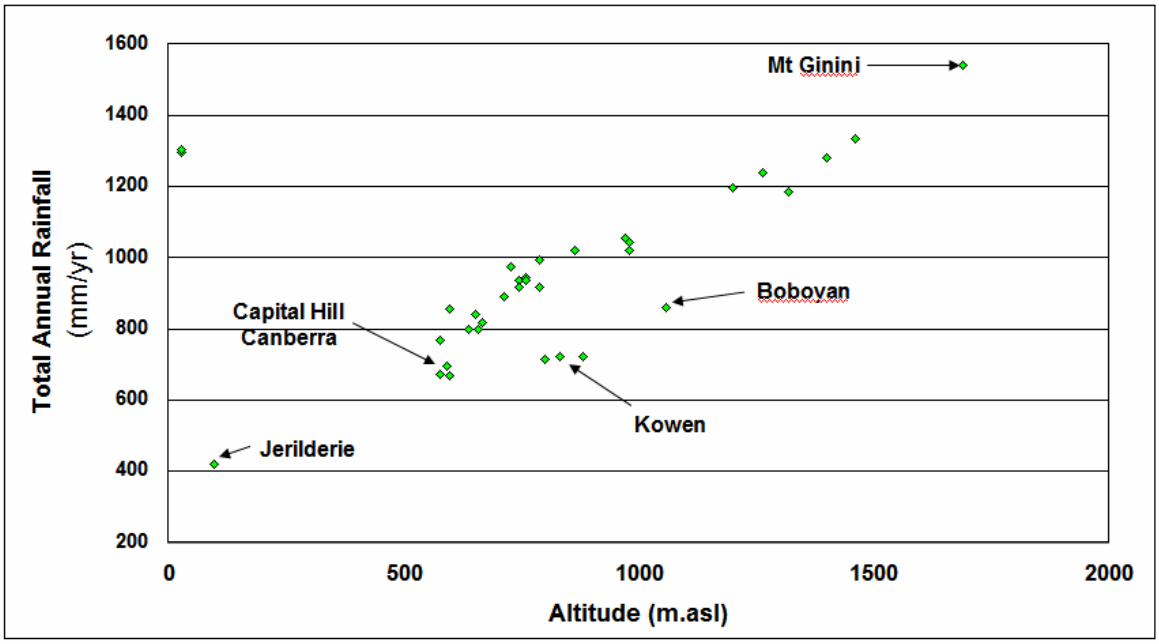


Figure 6.4: Rainfall at each arboretum site

Again there is a clear correlation between rainfall and altitude, with the 1998–2003 average total annual rainfall ranging from about 670 mm/y at Capital Hill to about 1550 mm per year at Mt Ginini.

The arboreta at Kowen Forest (20, 22 and 24) and Boboyan were clearly located on drier sites, and arboretum 20 at Kowen and the Boboyan arboretum both succumbed to drought and were abandoned.

The driest month is predominantly February at about 60 mm to 80 mm/month of rainfall. The wettest month at the higher altitudes is August (80 mm to 160 mm/month) with a distinct peak. At the lower altitudes, winter rainfall is more evenly distributed from July through November ranging from about 60 mm to 100 mm/month.

Soils

The pattern of soil distribution in the ACT is intricate and varies considerably over short distances, especially in areas of strong relief. Geology and microclimate, especially external drainage, contribute to the pattern of spatial variation, but there is little or no correlation with vegetation.

ACT soils occur in several major groups (Brewer 1954; Anon. 1957a):

- Red-vellow podzolic soils which cover the greater part of the Territory;
- Skeletal red-yellow podzolic soils;
- Alpine humus soils and their associated peats and sphagnum bogs;
- Undifferentiated alluvial soils of the river flood-plains;
- Somewhat atypical red loams and terra rossas, occurring in very restricted areas.

Red-yellow podzolics cover most of the Territory below an elevation of about 1100 m asl where the topography is sufficiently subdued to allow the development of mature soils. Their morphology varies considerably in the colour and structure of the B horizon, the

sharpness of boundaries between the A and B horizons, the frequency of ferruginuos concretions in the profile and the degree of bleaching. The surface horizons consist of loams of about 20–50 cm overlying clays of varying colour and depth where ferruginous concretions may occur.

These tableland soils often exhibit unfavourable moisture characteristics which is their most significant feature from a forestry viewpoint (Anon. 1957a). The presence of claypans, heavily textured subsoils and in some cases, cemented ferruginous pans, cause irregular drainage. Mottling of the subsoils occurs and periodically the soil horizons above impermeable layers become saturated causing water to move away from the site laterally rather than horizontally. In flatter areas where concavities exist in the subsoil surface ponding occurs, removing nutrients and destroying the soil structure, both of which are detrimental to tree growth (Anon. 1957a). Periodically the surface soils also dry out excessively which contributes to establishment risk before the roots of newly planted seedlings can reach the underlying more heavily textured moisture-holding layers. Older trees are also susceptible to drought.

Alpine humus soils occur on the high mountain ranges forming the western boundary of the territory, especially above about 1200 m asl. The surface soil is a brown, highly organic sandy loam or clay loam, depending on the parent rock, about 45–60 cm in depth. Peats occur in association with these soils, depending upon the external drainage. Sphagnum bogs are present in the wettest areas (Anon. 1957a).

These alpine soils are predominantly well-drained with slight to negligible development of textural horizons. They are comparatively fertile, deep, permeable, friable and uniform and provide a good medium for tree growth (Anon. 1957a). Because of their favourable moisture-retaining properties and the higher rainfall of the mountains, these forest soils are almost continuously moist. However, they are rarely ‘wet’, even after heavy rain, because of their porosity and structural development, and are ideal for establishment of exotics. Roots ramify evenly through these soils, whereas in tableland profiles root systems tend to be strongly layered and the least-favourable soil strata are traversed by relatively few roots (Anon. 1957a).

On upper slopes the deep red forest loams give way to shallower, gravelly or shaly soils, and on very steep exposed positions profiles almost devoid of true soil material occur. These are the lithosols or ‘rock-soils’. Such sites are comparatively dry and exposed and their lower productivity is evidenced by their cover of short (even stunted) eucalypt forest or woodland. Especially deep profiles (over 180 cm) are commonly found on lower slopes and in colluvial positions, forming the most favourable sites for tree growth in the mountains (Anon. 1957a).

Lower still, along watercourses and where seepage occurs, the water table soils are found. These profiles exhibit dark grey to black organic-rich surface soils (maybe with peaty accumulation) over a mottled (gleyed) subsoil or with a pale-leached layer in between (Anon. 1957a).

The above types of mountain soils are encountered from ‘Five Crossings’ at Uriarra Forest up to 1400 m or so, where the shaley red forest loams merge into transitional alpine humus soils which dominate the higher mountain forests. With increasing altitude organic matter builds up in the surface layers and colours become more drab.

Above 1500 m feet alpine humus soils are associated with highmoor bog soils and shallow rocky ridge soils under alpine vegetation or subalpine woodland.

Mountain forest soils (and the alpine humus soils) have a rich soil fauna (largely worms) and micro-populations which disintegrate, decompose and incorporate organic litter into

the upper 15–30 cm (or more) of soil. This ‘mull-like’ condition reflects the comparatively high nutrient status of these soils.

Undifferentiated alluvial soils occur on the major flood plains, such as those of the Molonglo River, while occurrence of the red loams and terra rossas is quite sparse and associated with ironstone reefs and calcareous parent material, such as limestone.

Notes in the arboretum files record establishment failures of about 10% of plantings, some of which were probably drought related.

The soils in the vicinity of the Jervis Bay arboreta consisted of sands of variable depth overlying sandstone, with the profile typically exhibiting a grey surface sand grading to a bleached A2 horizon at about 45 cm depth and a B horizon at 60–120 cm of yellowish-brown sand stained and sometimes weakly cemented by iron and organic matter (Snowdon 2002).

Figure 6.5 shows typical examples of ACT soil profiles and Figure 6.6 shows a provisional ACT soils map with arboretum locations overlaid.

Jeir Hill
(Photo: J. Shirley)

Roberts Mountain Var. A
(Photo: J. Shirley)

Clear Range (Weathered)
(Photo: J. Shirley)

Figure 6.5: Typical ACT soil profiles

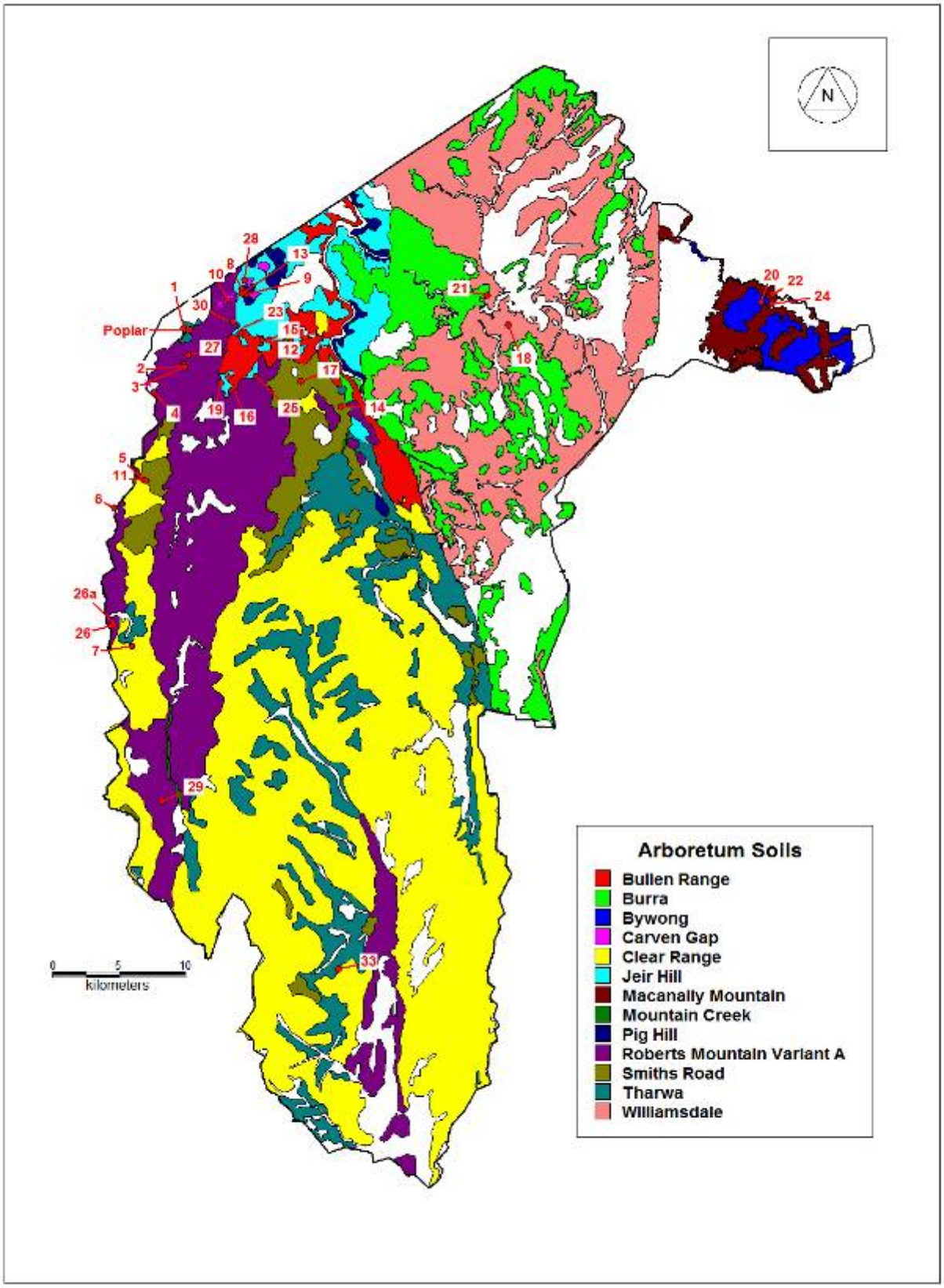


Figure 6.6: ACT soil map with arboretum locations

Table 6.1 summarises the soil type names for the arboreta. Specific soil unit descriptions, not yet published, are available from NSW's Department of Environment and Climate Change and from Jenkins (2000).

Table 6.1: Arboretum soil types

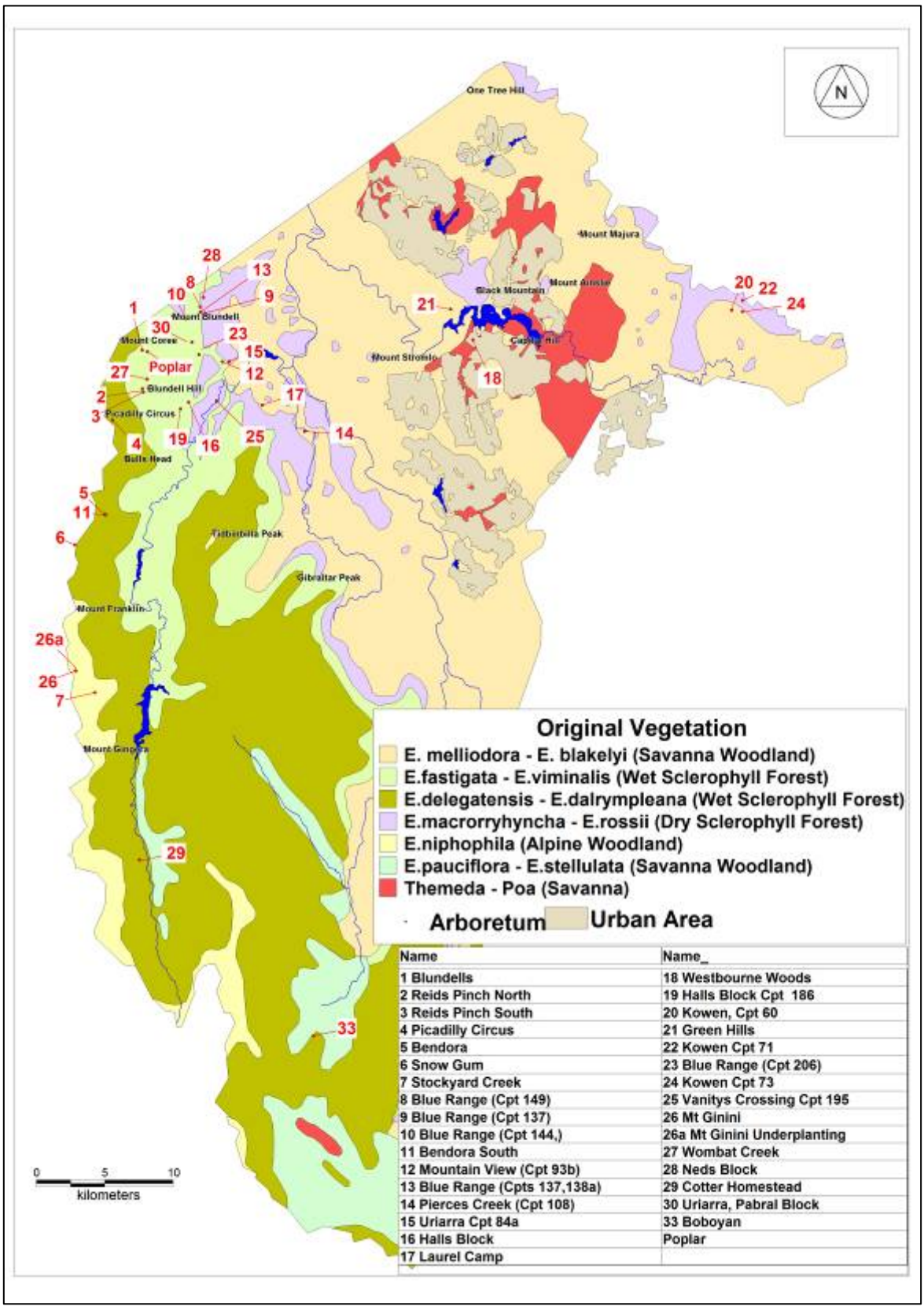
Soil Unit	Arboretum
Bullen Range	12 Mountain View
Burra	21 Green Hills
Bywong	20 Kowen, Cpt 60
Carven Gap	28 Neds Block
Clear Range	33 Boboyan
	7 Stockyard Creek
Jeir Hill	13 Blue Range
	15 Uriarra
	16 Halls Block
	19 Halls Block
	25 Vanitys Crossing
	30 Pabral Block
	8 Blue Range
Macanally Mountain	22 Kowen Cpt 71
	24 Kowen Cpt 73
Pig Hill	9 Blue Range
Roberts Mountain Variant A	10 Blue Range
	2 Reids Pinch North
	23 Blue Range
	26 Mt Ginini
	26a Mt Ginini
	27 Wombat Creek
	29 Cotter Homesteadd
	3 Reids Pinch South
	4 Picadilly Circus
Smiths Road	11 Bendora South
	14 Pierces Creek
	17 Laurel Camp
	5 Bendora
Tharwa	1 Blundells Farm
Williamsdale	18 Westbourne

As noted earlier, the locations of the arboreta are not precisely known, and several apparently occur quite close to soil type boundaries, so there is some doubt that the correct soil type has been assigned in these instances.

Prior Vegetation

Pryor describes the ACT's original plant communities and maps the major plant associations in White (1954).

Figure 6.7 contains a reproduction of the essential features of this map with the locations of the arboreta overlaid.



Name	Name_
1 Blundells	18 Westbourne Woods
2 Reids Pinch North	19 Halls Block Cpt 186
3 Reids Pinch South	20 Kowen, Cpt 60
4 Picadilly Circus	21 Green Hills
5 Bendora	22 Kowen Cpt 71
6 Snow Gum	23 Blue Range (Cpt 206)
7 Stockyard Creek	24 Kowen Cpt 73
8 Blue Range (Cpt 149)	25 Vanitys Crossing Cpt 195
9 Blue Range (Cpt 137)	26 Mt Ginini
10 Blue Range (Cpt 144,)	26a Mt Ginini Underplanting
11 Bendora South	27 Wombat Creek
12 Mountain View (Cpt 93b)	28 Neds Block
13 Blue Range (Cpts 137,138a)	29 Cotter Homestead
14 Pierces Creek (Cpt 108)	30 Uriarra, Pabral Block
15 Uriarra Cpt 84a	33 Boboyan
16 Halls Block	Poplar
17 Laurel Camp	

Figure 6.7: Distribution of original vegetation

Table 6.2 describes the original vegetation that occurred at each arboretum site.

Table 6.2: Prior vegetation at arboretum sites

Formation	Alliance	Arboretum	Altitude (m.asl)	Rainfall (mm/y)	Average temp (°C)
Wet Sclerophyll Forest	*E. delegatensis* *E. dalrympleana*	11 Bendora South	1265	1240	9
		29 Cotter Homestead	1320	1186	9
		33 Boboyan	1060	858	10
		4 Picadilly Circus	1204	1195	10
		5 Bendora	1265	1240	8
		6 Snow Gum	1402	1282	9
	E. fastigata *E. viminalis*	1 Blundells	792	994	13
		10 Blue Range	867	1019	12
		12 Mountain View	640	798	13
		13 Blue Range	747	918	13
		16 Halls Block	716	892	13
		19 Halls Block	732	973	11
		2 Reids Pinch North	983	1021	12
		23 Blue Range	762	945	12
		27 Wombat Creek	975	1055	11
		3 Reids Pinch South	983	1043	11
		30 Uriarra, Pabral Block	655	842	13
		8 Blue Range	792	918	12
		Poplar	760	994	13
Savanna Woodland	*E. melliodora* *E. blakelyi*	14 Pierces Creek	579	767	14
		17 Laurel Camp	671	819	13
		20 Kowen Cpt 60	802	713	12
		21 Green Hills	594	695	13
		24 Kowen	835	143	11
	Themeda – Poa	18 Westbourne Woods	580	673	13
Dry Sclerophyll Forest	*E. macrorhyncha* *E .rossii*	15 Uriarra	660	798	13
		22 Kowen	884	723	12
		25 Vanitys Crossing	600	856	13
		28 Neds Block	762	935	12
		9 Blue Range	747	938	12
Alpine Woodland	*E. niphophila*	26 Mt Ginini	1692	1541	7
		26a Mt Ginini Underplanting	1692	1541	7
		7 Stockyard Creek	1463	1334	7

The vegetation map shows the boundaries of the formations and alliances as distinct boundaries, but there is probably a gradation from one type to the other at the interfaces of the mapped vegetation types.

As noted above, the arboretum locations are also not precisely defined, and a number of the arboreta apparently occur quite close to vegetation type boundaries. The original vegetation at these sites would reflect these transitions and consist of a composite of vegetation types.

The original vegetation in the vicinity of the Jervis Bay arboreta consisted heathland, coastal scrub and woodlands containing of a range of species including *E. sieberi, E. racemosa, E. gummifera* and *Banksia serrata* (Ingwersen 1976).

7. Arboretum establishment and management

The early seed collections

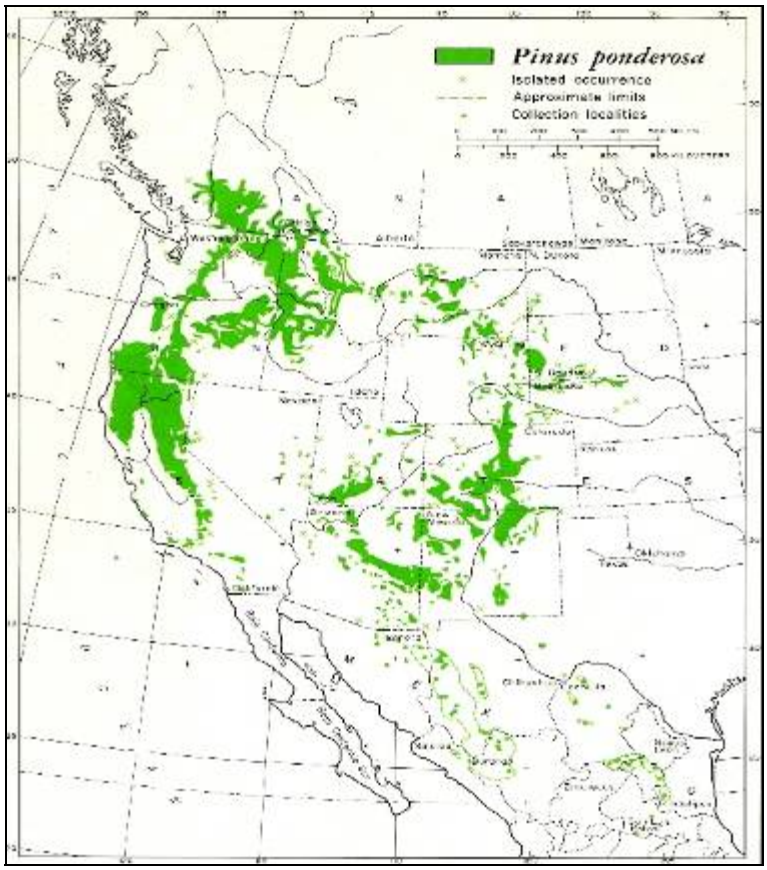
The earliest seeds for the arboreta were probably obtained by Lane Poole through his extensive network of contacts around the world. However, the precise provenance of these seedlots, or the even the country of origin, is sometimes unknown.

Linsday and Jacobs brought back seed from their sojourns in America and Western Europe in the early 1930s, but again the precise geographical location of the sources was often not recorded.

Seed was also often purchased in bulk from the likes of Herbst Brothers in New York, J. Rafn and Sons in Denmark, Vivario et Vezzani in Corsica and Vilmorin et Cie in Paris, with no record of provenance.

However, by 1939, when Jacobs visited California, the importance of provenance was becoming recognised and the geographical locations of his 1940 collections of radiata pine seedlots in coastal California were recorded, as were those collected by Fielding from California in 1949.

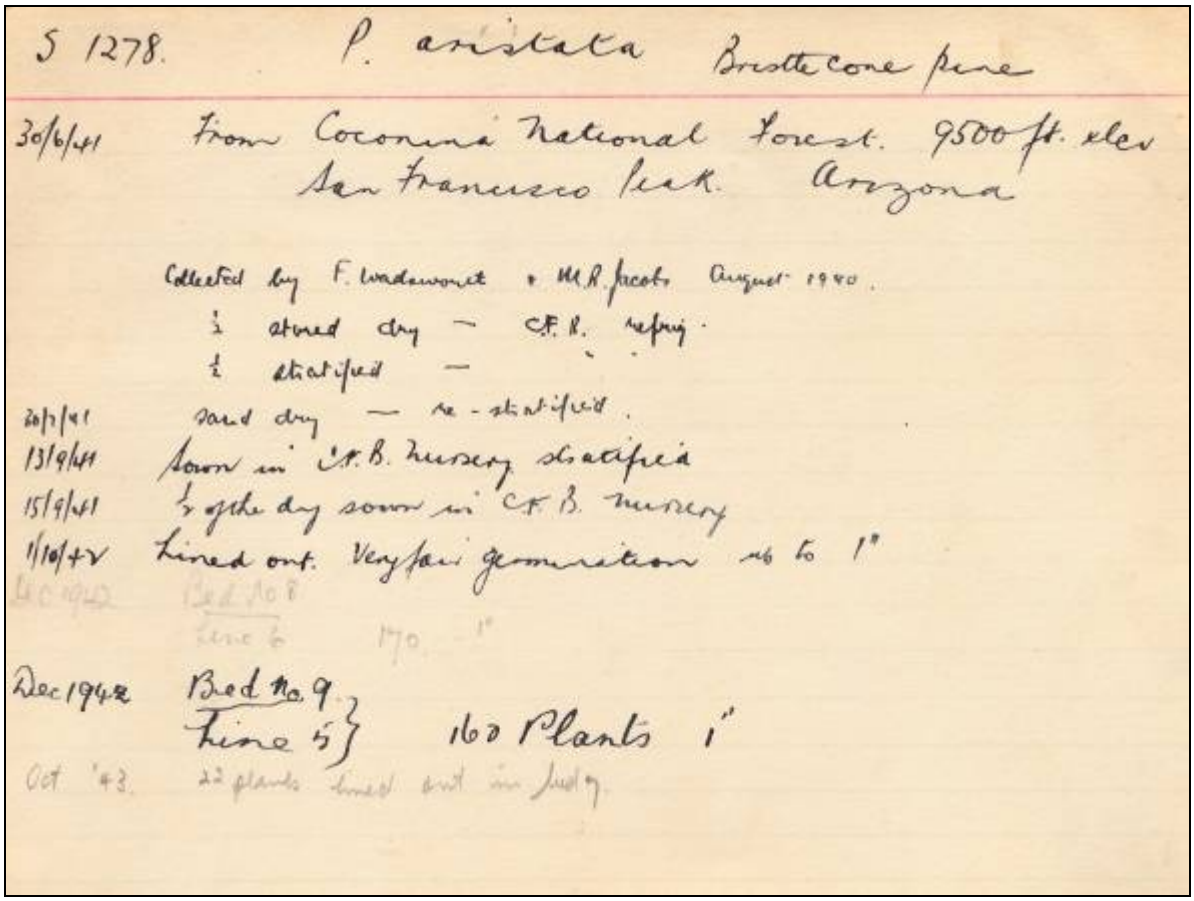
The 'Imperial Preferences' agreement between the British and colonial governments required that first preference for seed purchases be given to British Commonwealth countries. As a consequence much of the ponderosa seed imported from Canada was of strains less well suited than those that might have been imported from more southern provenances in the USA.



Distribution of *P. ponderosa*
(Critchfield and Little 1966)

Seed source records

Most seedlots received into the seed store by the Commonwealth Forestry Bureau and its successors were allocated a unique seed number which was recorded on a 'Seed Card' along with a description of the provenance and characteristics of the seed. Examples of typical seed cards are shown in Figure 7.1.

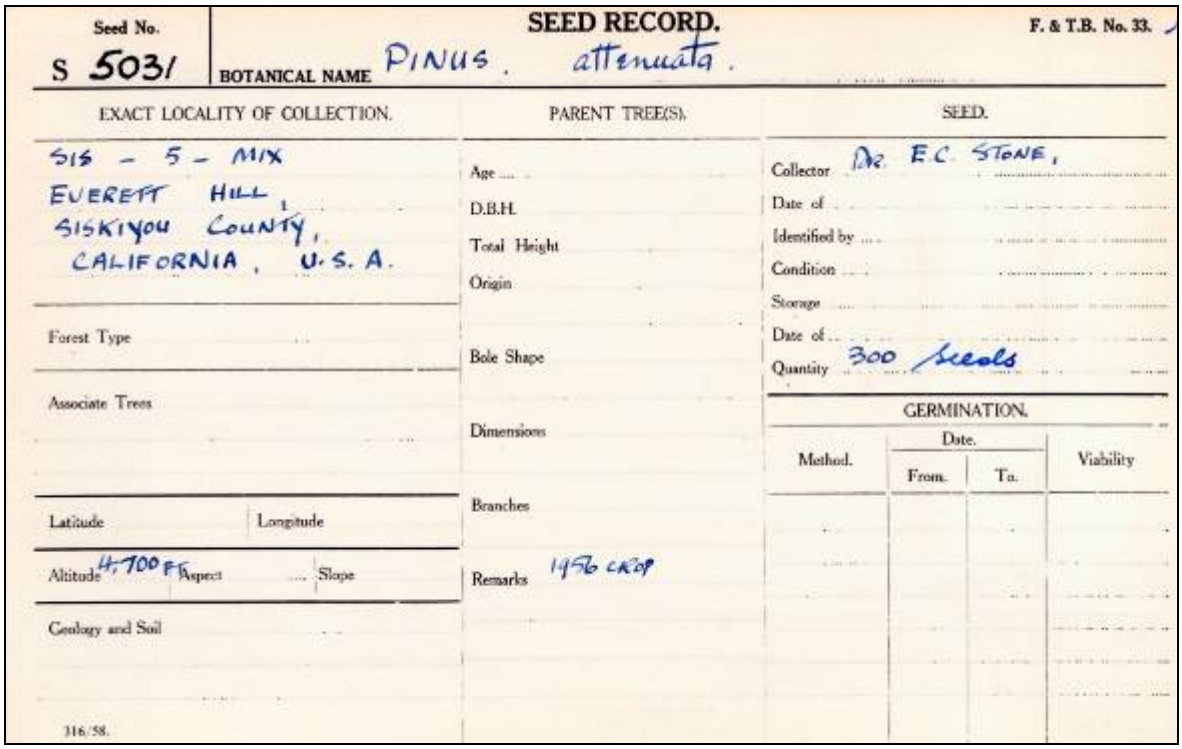


S 1278. P. aristata Bristle cone pine

30/6/41 From Coconino National Forest. 9500 ft. elev San Francisco Peak. Arizona

Collected by F. Wadsworth & M.R. Jacobs August 1940.
½ stored dry — C.F.B. nursery.
½ stratified —
20/7/41 sand dry — re-stratified.
13/9/41 Sown in C.F.B. nursery stratified
15/9/41 ½ of the dry sown in C.F.B. nursery
11/10/41 Lined out. Very fair germination up to 1"

Dec 1942 Bed No. 9
Line 5 } 160 Plants 1"
Oct '43. 22 plants lined out in Judy.



Seed No. S 5031

SEED RECORD.

F. & T.B. No. 33.

BOTANICAL NAME PINUS. attenuata.

EXACT LOCALITY OF COLLECTION.

SIS - 5 - MIX
EVERETT HILL,
SISKIYOU COUNTY,
CALIFORNIA, U.S.A.

Forest Type

Associate Trees

Latitude | Longitude

Altitude 4,700 FT. | Aspect | Slope

Geology and Soil

PARENT TREE(S).

Age

D.B.H.

Total Height

Origin

Bole Shape

Dimensions

Branches

Remarks 1956 CROP

SEED.

Collector Dr. E.C. STONE,

Date of

Identified by

Condition

Storage

Date of

Quantity 300 seeds

GERMINATION.

Method.	Date. From.	Date. To.	Viability

316/58.

Figure 7.1: Typical seed record cards

About 470 unique seedlot numbers were recorded for the 1128 ‘plots’55 planted. About 370 plots have no seedlot recorded. For the remainder, the name of the person who provided the seed (e.g. ‘CEC’, ‘CLP’) or the nursery (e.g. ‘Y.NURS.’) 56 from which the plants were supplied is recorded as the ‘seedlot’, or there is no record.

From notes recorded against each planting on the seed cards it is possible to determine the country of origin for about 70% of the plots planted in all the arboreta. For the remaining 30% of the plots the origin is either unknown or they are plantings representing crosses or special trials of one sort or another. The plots whose seed origin can be traced represent 39 countries as illustrated in Figure 7.3. However 50% of the seed originated from just the five countries shown in Figure 7.457, 58 .

Figure 7.2: Natural radiata pine at Aňo Nuevo (Photo: K. Eldridge 1978)

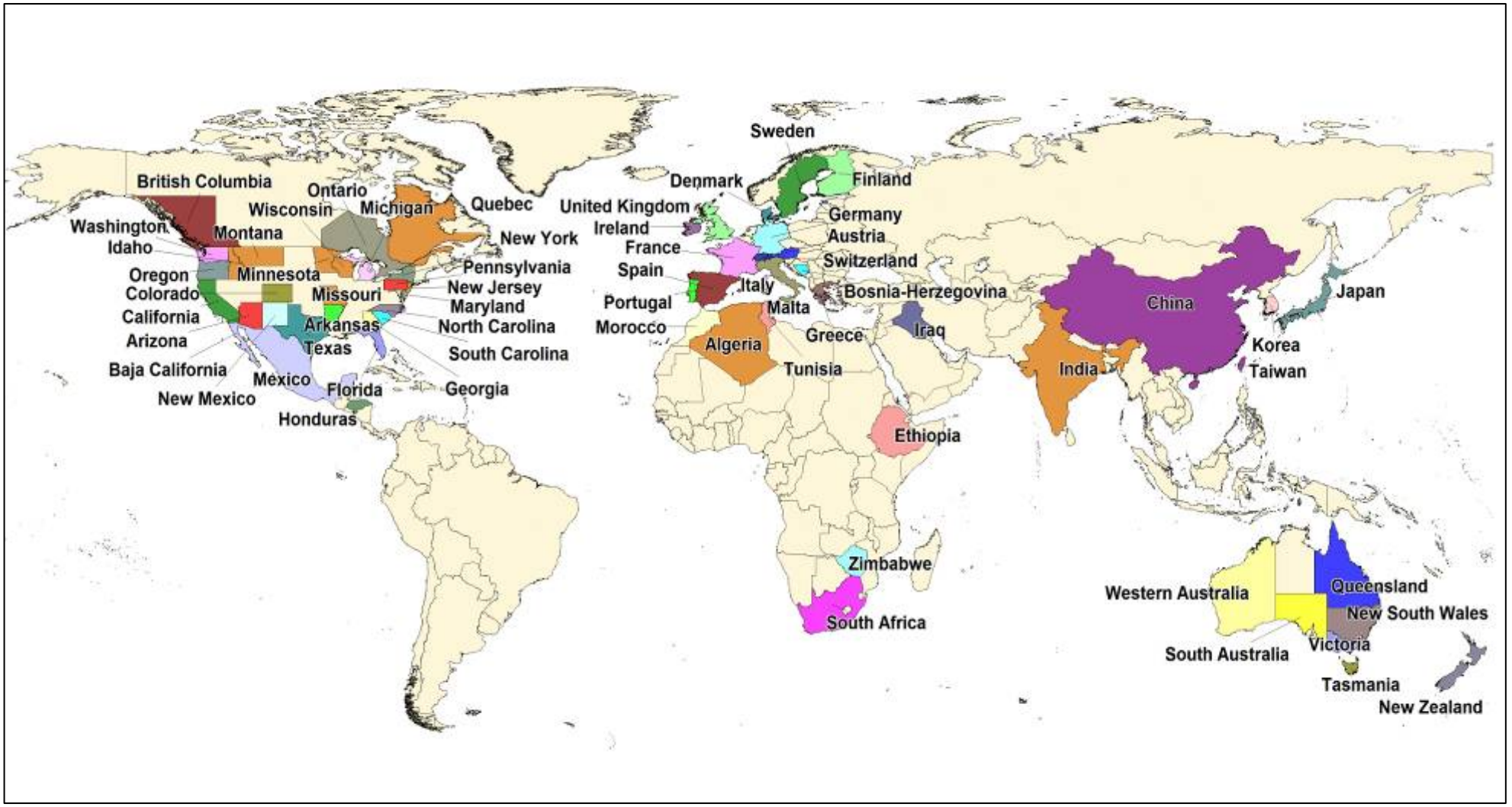


Figure 7.3: Seed origins

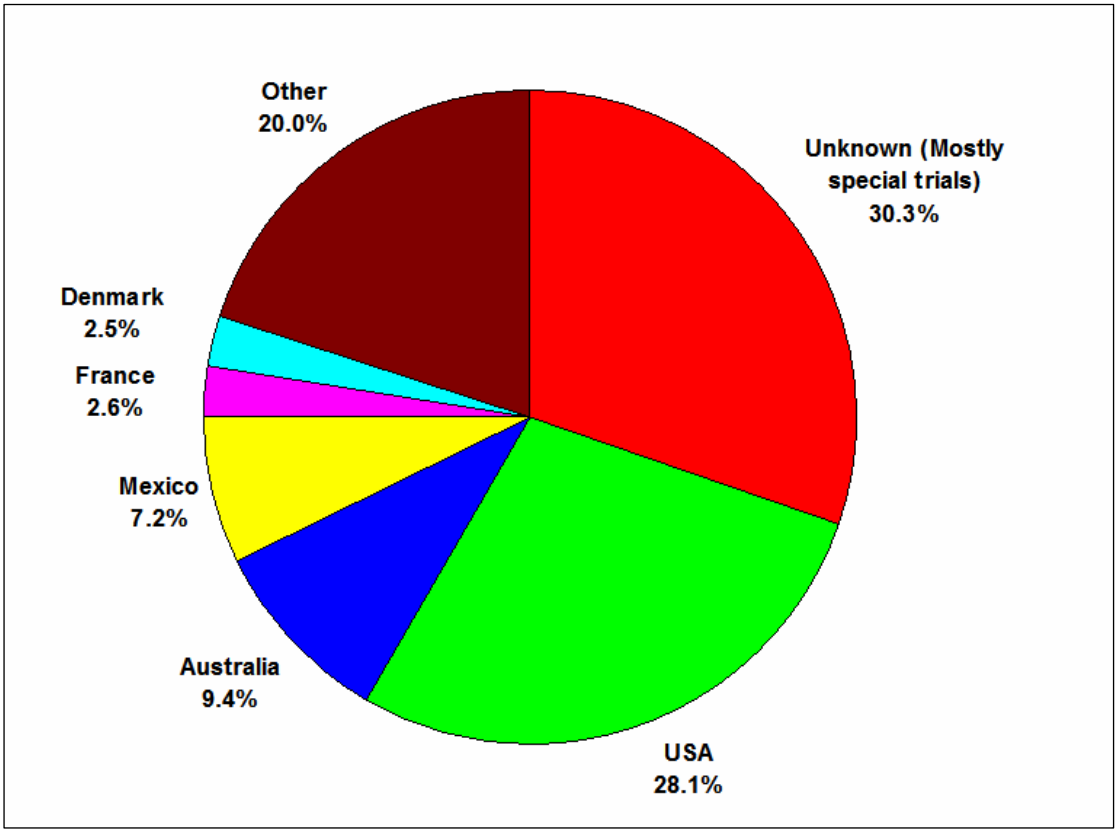


Figure 7.4: Significant country seed origins

The USA was a significant source of seed. Figure 7.5 shows the US counties from which the seed was sourced, for those plots for which the source can be determined.

Pseudotsuga menziesii, Blundells Plot 2, c.1957 (Photo: A. Brown)

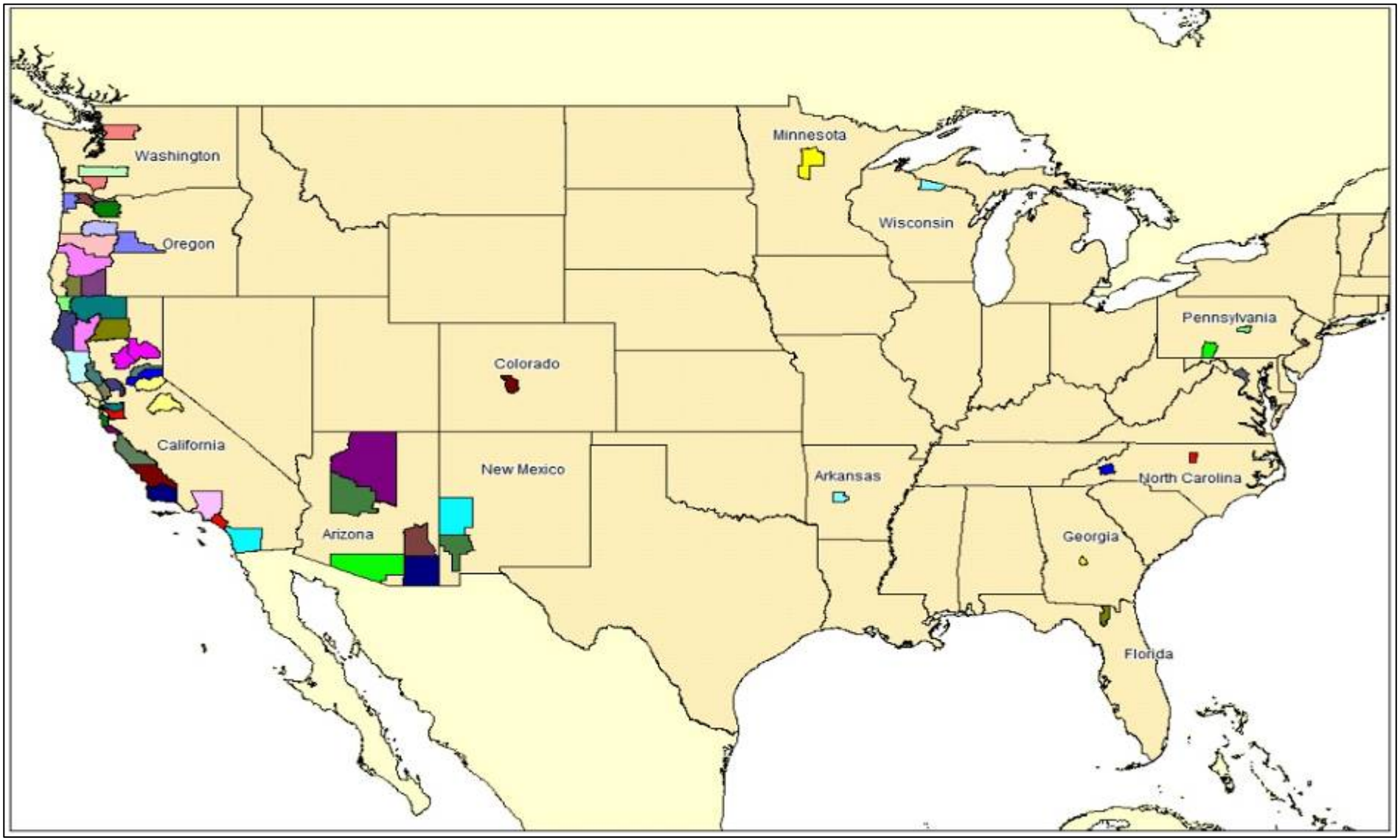


Figure 7.5: USA seed sources showing county of origin

In the US there was an obvious concentration of seed supply along the western seaboard from Washington State south to southern California, but the dryer climates of Arizona and New Mexico were also significant seed sources. The eastern states are represented to a lesser extent although many plantings were from seed supplied by Herbst Brothers Ltd in New York, but neither the state nor county origin was recorded, and it's also possible that some seed supplied originated outside the US.

The planting years

Planting at the first arboretum site, Laurel Camp, began in 1928 along with two others in the vicinity but both the latter were destroyed by fire. Only six arboreta had been established by 1938. However between 1939 and 1968 establishment of a further 30 new arboreta brought the total to 36, including the arboretum at Jerilderie in NSW. The last planting in the ACT arboreta occurred in 1970 at Bendora.

Figure 7.6 illustrates the planting activity between 1928 and 1970 and Figure 7.7 shows the period spanned by planting activity in each arboretum.

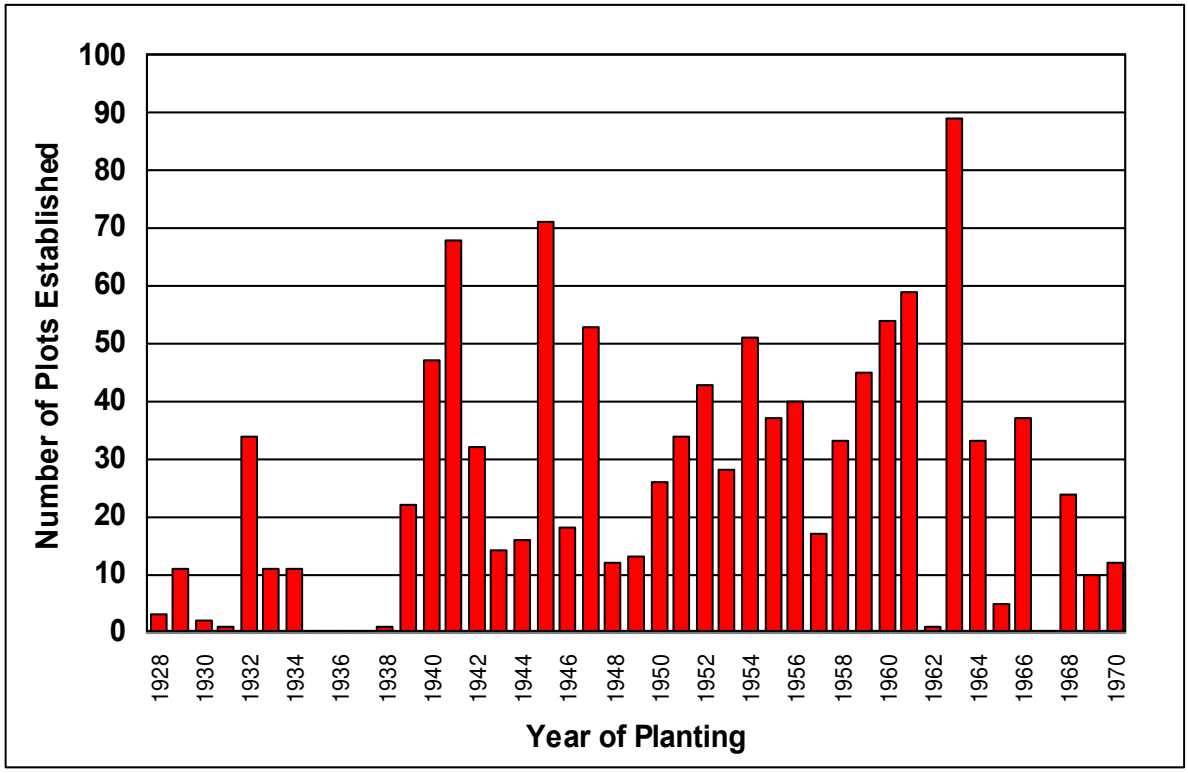


Figure 7.6: Planting activity by year

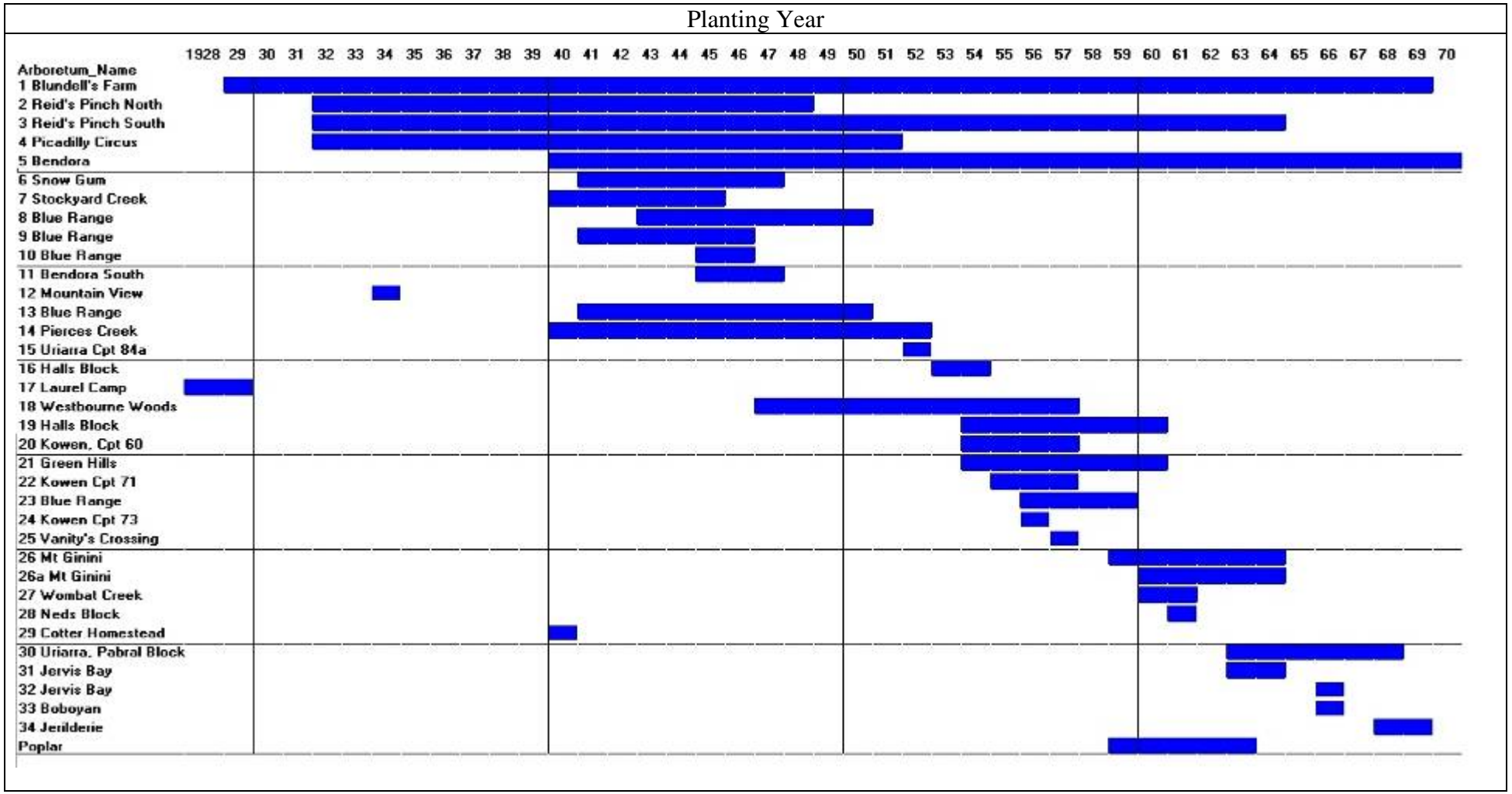


Figure 7.7: Span of planting years

Genera and Species

A total of 242 species, varieties and crosses in 39 genera were represented in the arboreta. Figure 7.8 shows the percentage of plots planted by genus. Nearly 70% of the plantings were of species belonging to the genus *Pinus*.

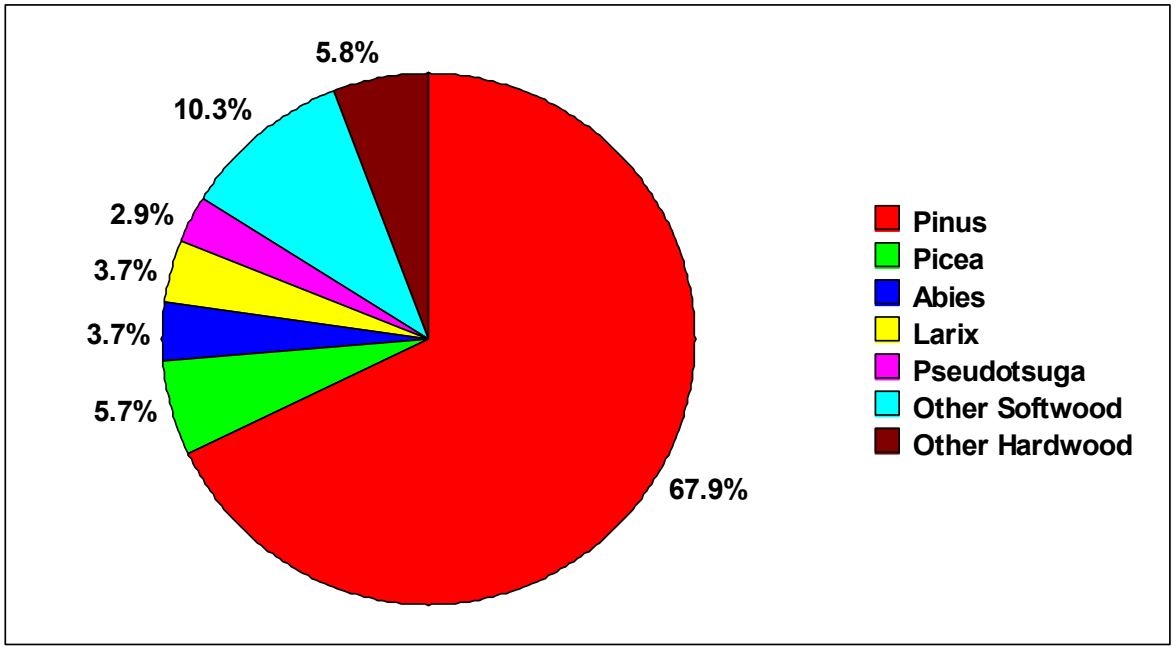


Figure 7.8: Occurrence of genera in the arboreta

Figure 7.9 shows the frequency of *Pinus* species in the arboreta.

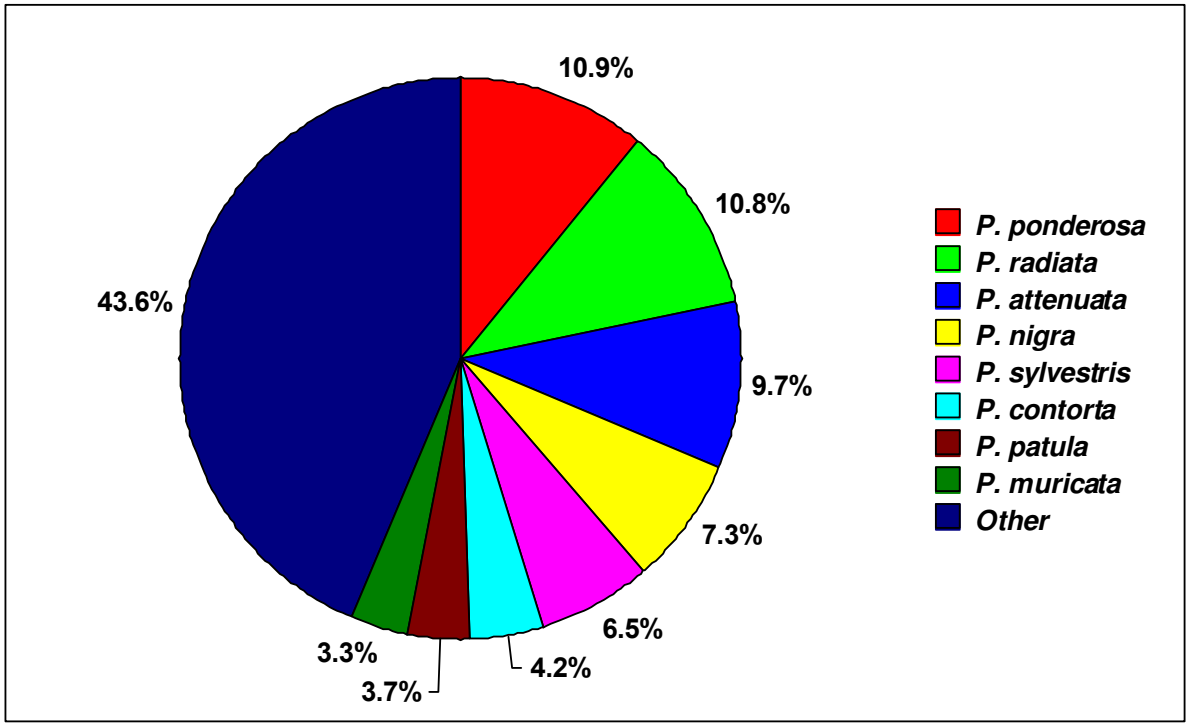


Figure 7.9: Frequency of *Pinus* species

Western yellow pine (*P. ponderosa*), radiata pine (*P. radiata*) and *Pinus attenuata* together made up about 30% of the plantings, but about 45% consisted of a wide range of other species. Despite its promise as an alternative to radiata pine at high altitudes, *Pinus muricata* was represented by only about 3% of plantings, probably because the 'green' strain predominated which did not perform well59.

Figure 7.10 shows the successive occurrence of new species introductions to the arboreta.

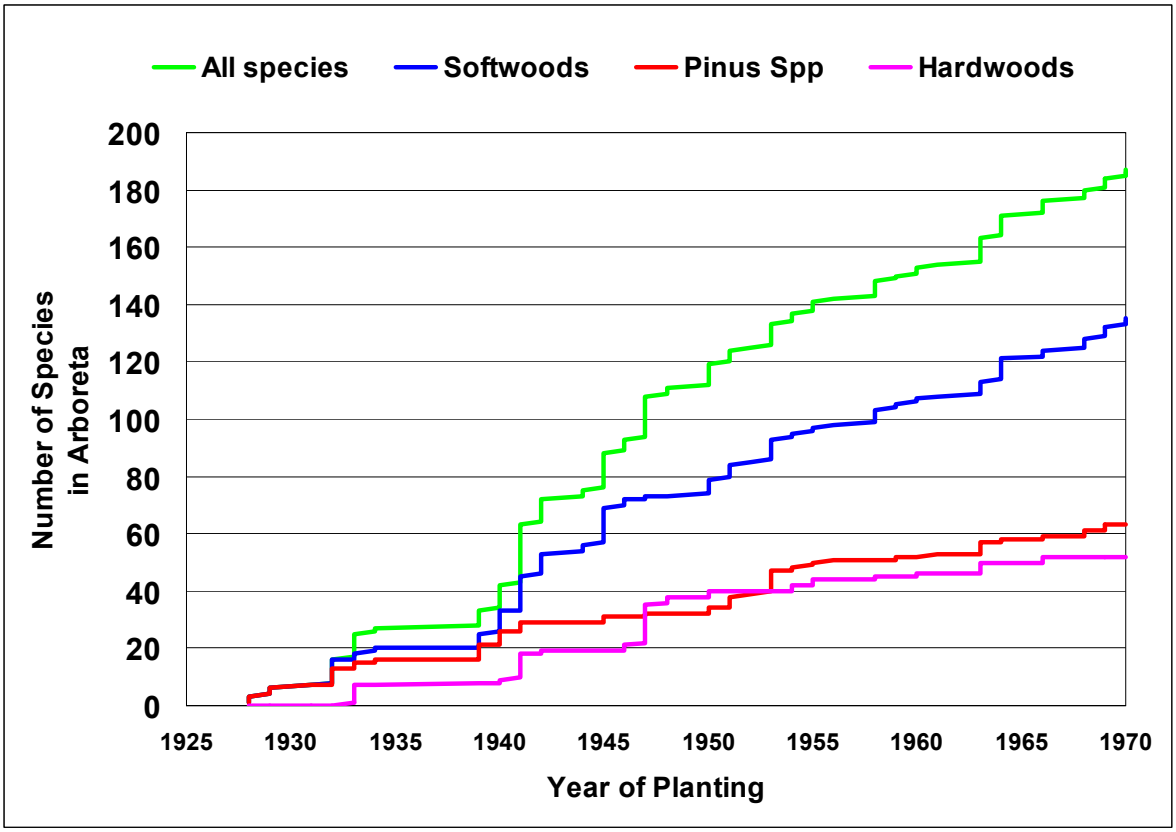


Figure 7.10: Species introductions

The rate of introductions of new species was relatively modest until about 1940. The initial interest was in *Pinus* species, but the first new introduction of a species outside the *Pinus* genus, *Cedrus atlantica*, occurred in 1932, and of the first hardwood (*Acer circinatum*) in 1933. From about 1939, the number of new *Pinus* species introduced was outstripped by introduction of new species from other softwood genera. The period 1940 to 1950 saw the most rapid increase in the rate of new species introductions, but they occurred at a fairly steady rate right up until planting ceased in 1970.

Establishment, Management and Measurement

Day-to-day management of the arboreta was carried out by a field crew attached to the FTB, commonly referred to as 'The Outdoor Gang' (see page 20). It usually consisted of five to eight people.

Preparation of the planting sites at the arboreta usually involved felling of the native vegetation and subsequent burning. In some cases the sites were ripped with a crawler tractor and on one occasion, at 8 Blue Range, dynamite was used to blast stumps.

All planting was by hand, between the stumps, often in quite stony soil. Pits were dug with a forestry mattock to loosen the soil and on one occasion, at Mt Ginini, soil had to be ferried in buckets from the roadside at Bendora to the planting holes to create a suitable planting spot. On another occasion, at Boboyan, the planting crew declined to work in a severe snow storm and the planting was completed by FTB staff.

Post-planting maintenance required 'chipping' around the seedlings to reduce competition for light and moisture from surrounding vegetation. However, it appears that some plantings suffered quite severely from weed competition, resulting in mortality, and many plots required 're-filling' up to three years after the initial planting where suitable stock was available. Drought also contributed to seedling mortality and depredation by wallabies, kangaroos, rabbits and feral pigs often required the arboreta to be fenced.

Cupressus sempervirens.
Roman cypress
(Photo: J. Shirley)

Records of fertilising are sparse, but a few of the plantings apparently did receive some fertiliser. In hindsight it became apparent that some sites were deficient in phosphate and/or boron, and an 'ash-bed' effect was sometimes apparent (A. Brown, *pers. comm.*).

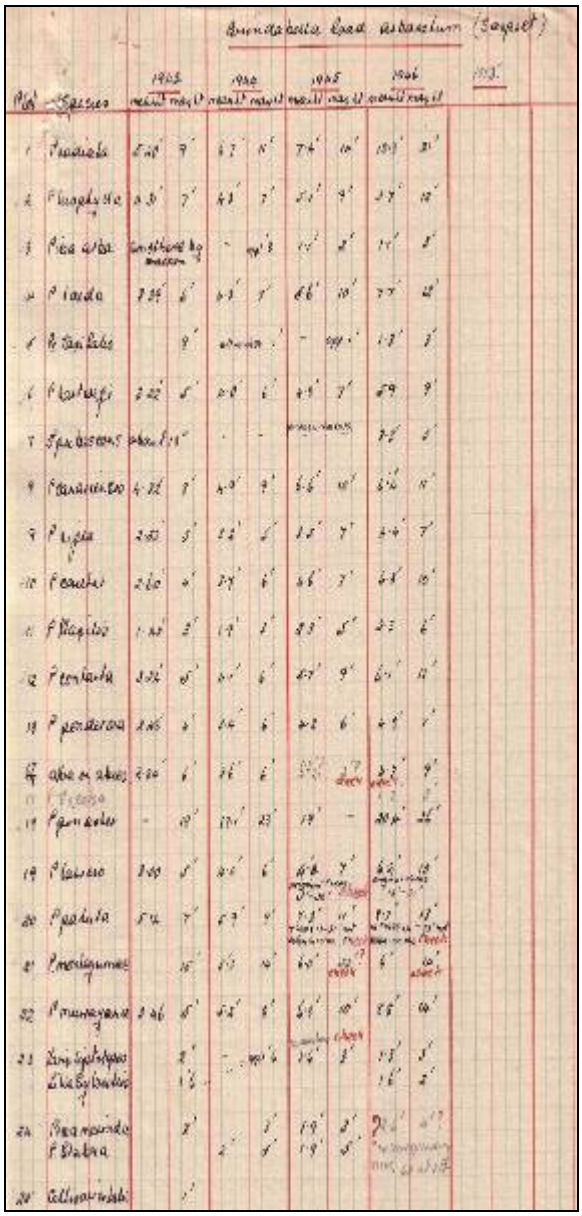
Pruning treatments were applied in a sporadic fashion, primarily as a fire protection measure, but also to improve access for measurement and aesthetic appeal. The treatment was applied using a pruning saw, often in two 'lifts', the first to 4 feet, and the second a year or two later to 7–8 feet.

Thinning occurred infrequently until the 1980s when several arboreta were thinned to reduce inter-tree competition, thus improving vigour and reducing susceptibility to pathogen attack. The choice of trees to be thinned was to the standards of selection of the day, relying on the skill and experience of the crew leader. In general, judged by now-current practice, the plots were overstocked.

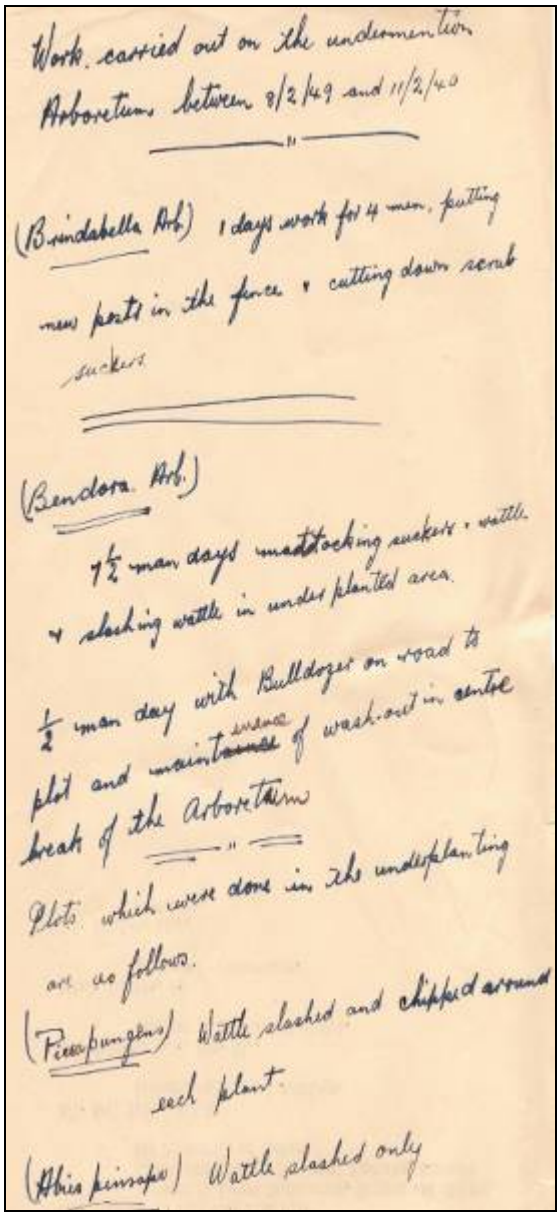
Initially, measurements of height, and when the trees were tall enough, diameter, were carried out annually. But as the number of arboreta increased a three-yearly measurement interval was adopted, with one third of the arboreta measured each year. Edge effects had the potential to bias the measurements in the small plots commonly used in the arboreta. A fixed number (e.g. five) of the tallest trees in the plot were therefore usually measured for height, and diameter measurement was restricted to the 'internal' trees, although the definition of 'internal' probably varied from plot to plot and year to year.

In addition to standard height and diameter measurements, observations of stem straightness, spiral grain, branch size, whorl spacing and branch frequency were made where there was a special interest.

All the measurements were recorded in various formats, by hand, using pencil and paper, and filed in loose-leaved fashion in Bureau files. Measurements were occasionally summarised and used in various topical reports, but no central comprehensive ‘database’ of measurements was created.



Typical field measurement sheet
(Source: FTB files)



Record of work done
(Source: FTB files)

8. Arboretum Design

Each arboretum typically consisted of a series of square bounded plots each nominally of about 'one square chain' (405 m^2) in area and about 'one half chain' (10 m) apart (Anon. 1957b). Triangular, rectangular and line plots were also employed to suit the natural features of the sites and the planting stock available. Sometimes a 'plot' consisted of a single tree.

Rout and Doran (1974) provided estimates of plot areas for 189 of 613 plots measured in 1972–1973. The average plot size was 310 m^2. Seventy percent of plot areas fell between 240 m^2 and 340 m^2, with a maximum plot area (5 plots) of 590 m^2.

Figure 8.1 shows the plot layout for Bendora arboretum in 2007, the sole arboretum remaining after the 2003 fires.

Bark of Canary Island pine
(Photo: J. Shirley)

Figure 8.1: Typical arboretum plot layout (Bendora, 2007 photo)

Typically trees were planted at spacings ranging from 4 ft x 5 ft (1.2 m x 1.5 m) to 12 ft x 12 ft (3.7 m) with 8 ft x 8 ft (2.4 m) and 9 ft x 9 ft (2.7 m) being common. Where planting stock was in short supply only a few trees or, occasionally, only one tree was planted.

Plots were usually planted with seedlings of a single seed source of a single species but occasionally sub-plots were formed of species, or of strains and varieties of one or more species.

Figure 8.2 shows a less typical arboretum layout, that of arboretum 10 in Blue Range Compartment 144.

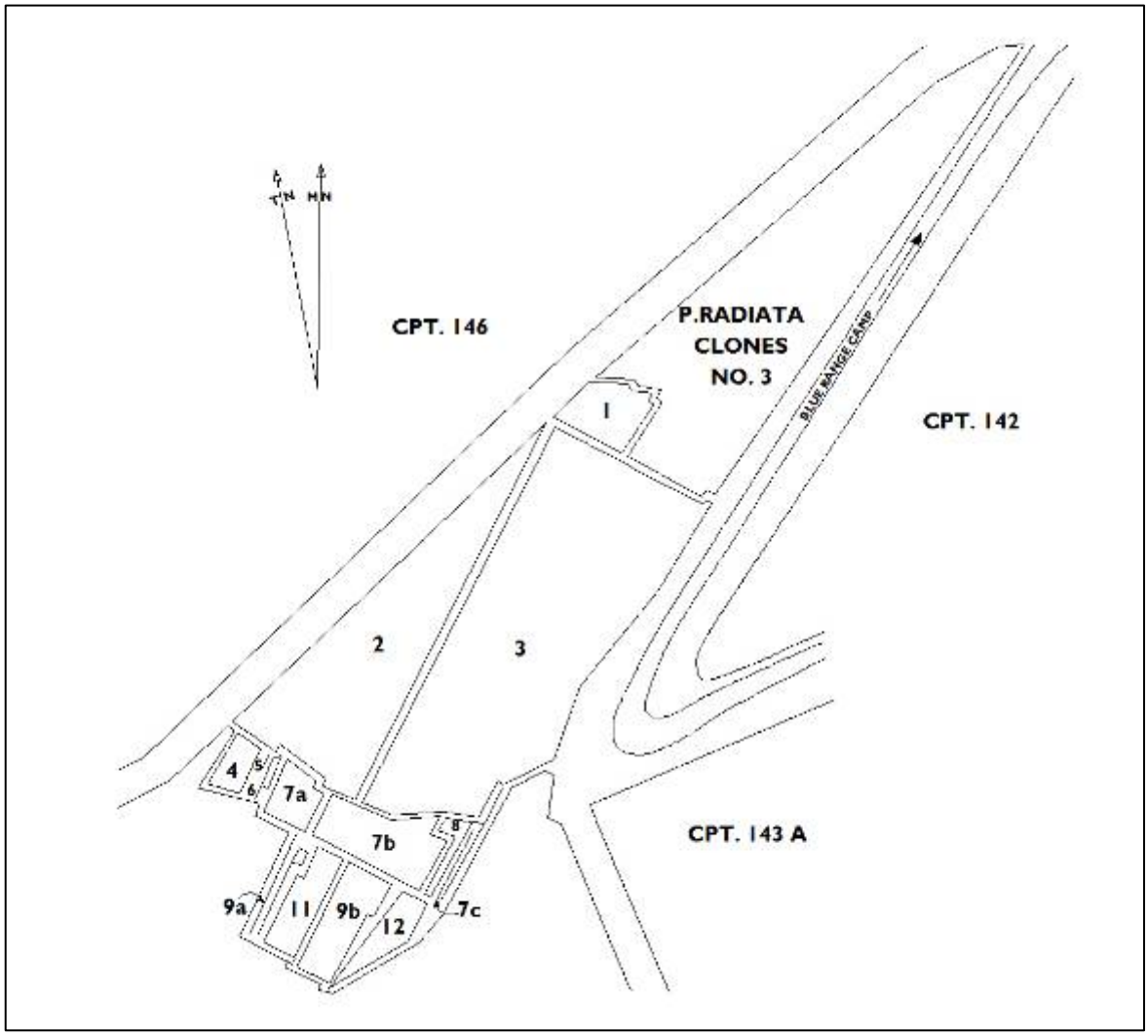


Figure 8.2: Layout of arboretum 10, Blue Range Cpt 144

9. Arboretum Descriptions

1 Blundells

The largest arboretum maintained by the Bureau. It contains many plots of mature trees which will be thinned in 1974. The arboretum has one of the biggest collections of exotic species, outside of Botanic Gardens, in Australia and is used for student instruction by the Forestry Department of the A.N.U.(Rout and Doran 1974).

Table 9.1: Blundells – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Condor Farm	–35.314	148.8277	792
First / last planting	1929 / 1969		
	Rainfall (mm)		**Temperature (° C)**
Mean annual	994		12
Mean maximum monthly	187		20
Mean minimum monthly	15		4
Total number of plots	175		
	Genera		**Species**
Number	21		90
Most frequent	*Pinus* (112 plots)		*Pinus nigra* (16 plots)

This arboretum was established in 1929 at the foot of Mt Coree, on gently sloping land with an easterly aspect acquired from Mr J. Blundell Jr. in 1913 to secure the ACT's water supply catchment. The impetus for its establishment was probably both to test the performance of various species, and to provide an exercise for students of the newly established Australian Forestry School in the design, layout, surveying and planting of an arboretum. (F.R.I. G 2.1, n.d.).

Figure 9.1: Easterly view across Blundells arboretum (Photo: A. Brown 1957)

Blundells arboretum, northerly view. (Photo: J. Turnbull c. 1967)

By 1939 56 plots of 41 species had been established. However, all but 19 plots were destroyed by fire in 1939. The burnt plots were replanted in 1940. *Pinus muricata* recovered well after the fire and two additional plots of this species were later established. One plot was planted with the northern 'blue' (var. *borealis*) form from Trinidad Head in northern California and the other contained several provenances of both 'blue' and 'green' (the southern provenances from south of San Francisco, California) forms.

By 1969 the arboretum contained 175 plots of 90 species, listed in Table 9.2. *Pinus ponderosa, Pinus nigra* and *Pinus muricata* were represented by several varieties and/or crosses and nine species were represented by more than three provenances, notably *Pinus nigra* (14), *Pinus muricata* (6), *Larix kaempferi* (5) and *Pinus contorta* (7).

Pinus roxburghii,
male cones.
(Photo: J. Shirley)

Picea smithiana,
male cones
(Photo: J. Shirley)

P. ponderosa,
immature female Cones.
(Photo: J. Shirley)

Table 9.2: Blundells – species frequency

Species	Number of plots
Abies cilicica	1
Abies homolepis	1
Abies pinsapo	1
Acer circinatum	1
Acer platanoides	1
Acer pseudoplatanus	1
Cedrus atlantica	1
Cedrus libani	1
Chamaecyparis lawsoniana	3
Chamaecyparis obtusa	1
Chamaecyparis thyoides	1
Cupressus arizonica	1
Cupressus macnabiana	1
Fraxinus oxycarpa	1
Fraxinus oxycarpa x raywoodi	2
Fraxinus pubescens	1
Juniperus communis	1
Juniperus virginiana	1
Larix eurolepis	1
Larix kaempferi	5
Larix laricina	1
Libocedrus decurrens	1
Picea abies	1
Picea engelmannii	1
Picea glauca	1
Picea rubens	1
Picea sitchensis	1
Pinus attenuata	1
Pinus banksiana	2
Pinus canariensis	1
Pinus contorta	5
Pinus contorta v latifolia	2
Pinus cooperi	1
Pinus cooperi v orenlasi	1
Pinus coulteri	5
Pinus durangensis	2
Pinus elliottii	3
Pinus engelmannii	1
Pinus flexilis	1
Pinus greggii	2
Pinus hartwegii	1
Pinus jeffreyi	1
Pinus jeffreyi x P. ponderosa	1
Pinus leiophylla	1
Pinus leucodermis	1
Pinus massoniana	1
Pinus michoacana	1
Pinus montezumae	1

Species	Number of plots
Pinus monticola	1
Pinus mugo v mughus	1
Pinus muricata	4
Pinus muricata v borealis	1
Pinus muricata v remorata	1
Pinus nigra	6
Pinus nigra v cebennensis	3
Pinus nigra v laricio	3
Pinus nigra v maritima	1
Pinus nigra v nigra	3
Pinus oocarpa	1
Pinus patula	5
Pinus patula x P. greggii	2
Pinus pinaster	1
Pinus ponderosa	7
Pinus ponderosa v apacheca	2
Pinus ponderosa v arizonica	3
Pinus ponderosa v arizonica x P. montezumae	1
Pinus ponderosa v arizonica x P. ponderosa v scopulorum	1
Pinus pseudostrobus	2
Pinus radiata	13
Pinus resinosa	4
Pinus roxburghii	1
Pinus strobus	3
Pinus sylvestris	2
Pinus sylvestris v rigensis	1
Pinus tabulaeformis	1
Pinus wallichiana	3
Poplar	2
Populus spp	1
Populus tremula x tremuloides	1
Pseudotsuga macrocarpa	1
Pseudotsuga menziesii	3
Quercus palustris	2
Quercus robur	1
Sciadopitys verticillata	1
Sequoia sempervirens	2
Taxodium distichum	1
Taxodium mucronatum	1
Tilia sylvestris	1
Tsuga canadensis	1
Widdringtonia schwarzii	1
Total	175

2 Reids Pinch North

An interesting arboretum which shows the effect of a northerly aspect on the growth of trees in the A.C.T. The site is steep and rocky and the relatively poor growth of some species is probably due to the very hot dry conditions they would be exposed to during the summer. The P. radiata plot is on a more favourable part of the area but the growth is still outstanding. (Rout and Doran 1974)

Table 9.3: Reids Pinch North – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.3399	148.8278	983
First / last planting	1932 / 1948		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1021		12
Mean maximum monthly	191		20
Mean minimum monthly	16		4
Total number of plots	22		
	Genera		**Species**
Number	4		18
Most frequent	*Pinus* (14 plots)		*P. strobus* (2 plots)

The site was steep and rocky and the soil surface was strewn with yellow slate containing iron oxide. Sandstone was also present on the site. The soils consisted of about 30 cm of red-brown sandy loam overlying about 70 cm of stony, yellow-red decomposed rock interspersed with sand and were probably phosphate deficient.

By 1991 the arboretum was reported (Fearnside and Lea 1991) to be in 'poor condition'.

Table 9.4: Reids Pinch North – species frequency

Species	Number of plots
Abies pinsapo	1
Picea pungens	1
Picea rubens	1
Pinus canariensis	1
Pinus contorta v latifolia	1
Pinus flexilis	1
Pinus monticola	1
Pinus muricata	1
Pinus nigra v cebennensis	1

Species	Number of plots
Pinus nigra v maritima	1
Pinus patula	1
Pinus pinaster	1
Pinus ponderosa	4
Pinus radiata	1
Pinus roxburghii	1
Pinus strobus	2
Pinus torreyana	1
Pseudotsuga menziesii	1
Total	22

Most species were represented by a single provenance, except for *P. ponderosa*, of which four provenances were planted.

3 Reids Pinch South

A well stocked arboretum with the P. muricata – P. radiata *provenance comparison of special interest.* (Rout and Doran 1974)

Table 9.5: Reids Pinch South – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
E.P. 21, Brindabella South, Middle Arboretum	–35.3423	148.8286	983
First / last planting	1932 / 1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1043		11
Mean maximum monthly	193		19
Mean minimum monthly	17		4
Total number of plots	88		
	Genera		**Species**
Number	62		53
Most frequent	*Pinus* (23 plots)		*P. muricata & P. attenuata* (7 plots)

Table 9.6 Reids Pinch South – species frequency

Species	**Number of plots**
Abies cilicica	1
Abies nordmanniana	1
Acer circinatum	1
Cunninghamia lanceolata	1
Fraxinus pubescens	1
Juglans regia x J.nigra	1
Picea abies	1
Picea glauca	1
Picea mariana	1
Picea pungens	1
Picea sitchensis	1
Pinus attenuata	7
Pinus attenuata x P. radiata	1
Pinus banksiana	1
Pinus canariensis	1
Pinus contorta	1
Pinus contorta v latifolia	1
Pinus coulteri	5
Pinus densiflora	1
Pinus douglasiana	1
Pinus echinata	1
Pinus elliottii	2
Pinus engelmannii	2
Pinus flexilis	1
Pinus halepensis v brutia	1
Pinus hartwegii	1
Pinus leiophylla	2

Species	**Number of plots**
Pinus massoniana	1
Pinus montezumae	1
Pinus monticola	1
Pinus muricata	7
Pinus nigra v cebennensis	3
Pinus patula	2
Pinus pinaster	2
Pinus ponderosa	3
Pinus radiata	4
Pinus resinosa	1
Pinus rigida	1
Pinus serotina	1
Pinus taeda	1
Pinus teocote	1
Pinus thunbergii	1
Pinus virginiana	1
Pinus wallichiana	1
Pinus yunnanensis	1
*Populus '*Androscroggin*'*	1
Populus 'Frye'	1
Populus 'Rumforde'	1
Pseudotsuga menziesii	1
Sequoia sempervirens	1
Thuja occidentalis	1
Thuja plicata	1
Tilia sylvestris	1
Total	88

The arboretum was situated on a south-easterly aspect adjacent to the Mt Franklin Road, and was subject to frequent snow falls in winter. The soil profile exhibited a top 10 cm of very dark soil containing ash and litter above about 50 cm of red-brown earth of clayey texture and some stone. Below that the soil was yellow clay of poor quality (CSIRO., n.d.)

Reid's Pinch South, 1953 (Photo: J. Fielding)

First planted in 1932, six of the initial 23 plots in this arboretum were also destroyed by wildfire in 1939. Original planting spacing varied from 1.8 m × 1.8 m to 2.7 m × 2.7 m. Some refilling occurred during the first few years after planting.

Reid's Pinch South, 2007 (Photo: J. Shirley)

The most interesting plots in the arboretum were the plots of *Pinus attenuata* (plots 27–28), *P. attenuata* × *P. radiata* (plot 29), *P. muricata* (plots 33–38) and *P. radiata* (plots 30–32) planted in 1950. Table 9.7 gives details of the provenances for these plots and Figure 9.2 shows their geographical locations.

Table 9.7: Reids Pinch South *Pinus radiata* and *P. muricata* provenances

Plot	Species	Provenance
27	*Pinus attenuata*	Marago, California 6,000' asl
28	*Pinus attenuata*	Bartlett Ck, Bridge Lake County, California, 2050' asl
29	*Pinus attenuata* × *P. radiata*	Placerville Arboretum, Placerville, California
30	*Pinus radiata*	Cambria, California
31	*Pinus radiata*	Monterey, California
32	*Pinus radiata*	Swanton (Point Aňo Nuevo) California
33	*Pinus muricata*	Fort Bragg, California
34	*Pinus muricata*	Trinidad Head, California
35	*Pinus muricata*	Inverness, California
36	*Pinus muricata*	Monterey, California
37	*Pinus muricata*	S. Harrison Grade, Lompoc, Santa Barbara County, California
38	*Pinus muricata*	S. Canon de Vincente, Baja California

Figure 9.2: Location of Reids Pinch South provenances

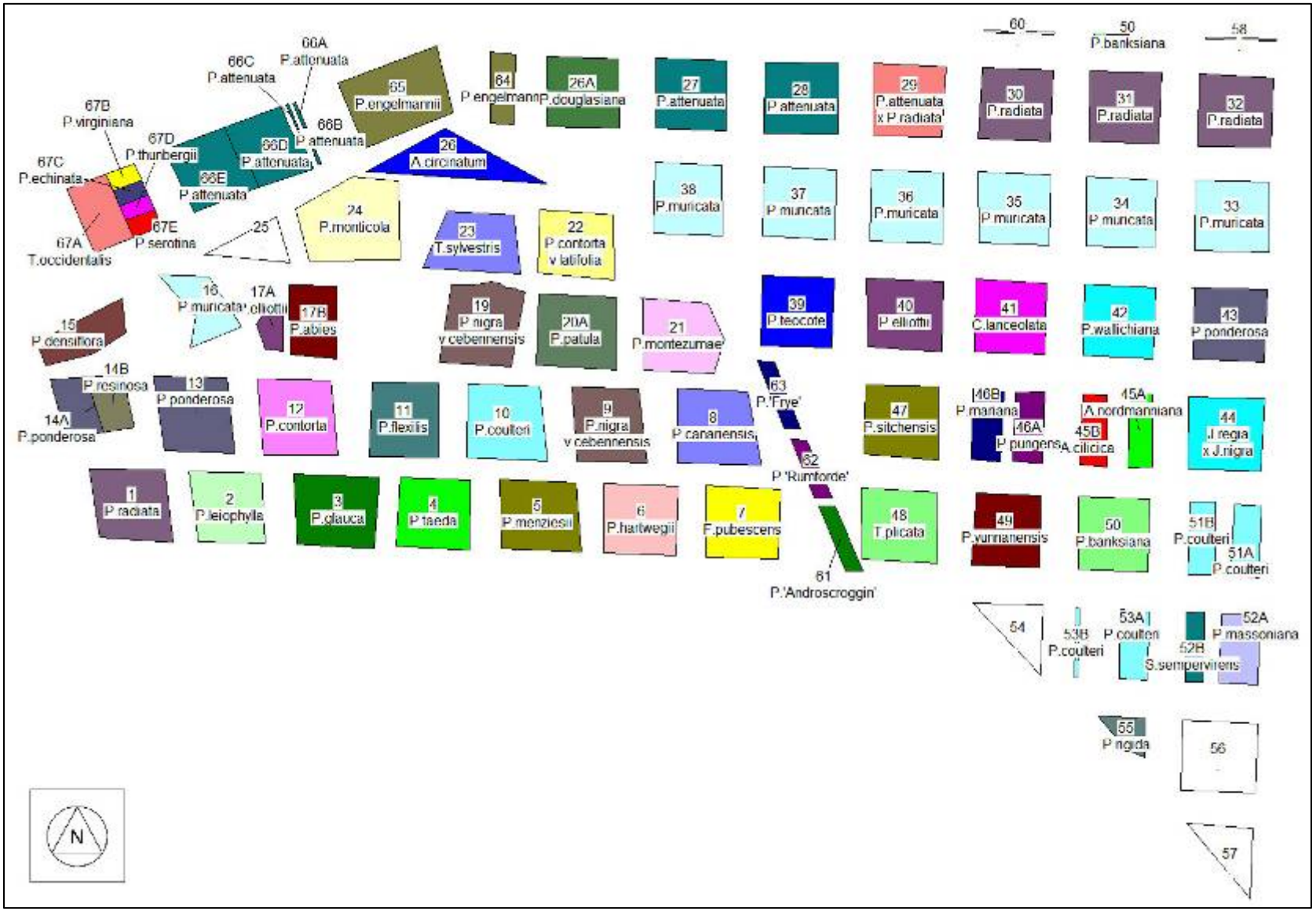


Figure 9.3: Reids Pinch South – species layout

Adjacent to the six provenances of *P. muricata*, planted along the contour of the ridge, were three provenances of *P. radiata*, two provenances of *P. attenuata* and a plot of their hybrid *P. attenuata* × *P. radiata* (see Figure 9.3).

Striking differences in growth and form could be seen both within and between these species. These plots of provenances of *P. radiata* and *P. muricata* were the first of their kind. Both species originate in a fairly limited area on the west coast of the U.S.A. and provenance differences had earlier been thought to be negligible in spite of the discontinuous distribution.

These plots as well as later provenance trials clearly demonstrated the variability of *P. radiata* and *P. muricata* and the importance of the location of the seed source. Various studies on growth, form, morphological characteristics and crossing barriers have been undertaken in these plots of California closed-coned conifers (e.g. Fielding 1961a; Brown 1966).

Doran (1974), using measurements from 1972 at age 22 y, found that the differences between *P. muricata* provenances amounted to 14 m in height, 20 cm in diameter and 61% in basal area production.

Trends reported earlier by Fielding in 1961 were still valid in 1974, with the two northern provenances of *P. muricata* (plots 33 and 34) being superior in growth and form. On this site the height and basal area of the two plots of 'blue' northern *P. muricata* were comparable to the best of the adjacent provenances of *P. radiata*, which, however, were inferior in form. The hybrid between *P. attenuata* and *P. radiata* was clearly more vigorous than *P. attenuata*, but was inferior to *P. radiata* in height.

Table 9.8 summarises measurements from Fielding (1961a) and Doran, taken from Shelbourne (1974, Table 2, page 20).

Table 9.8: Growth of *Pinus muricata* provenances at Reids Pinch South (Shelbourne 1974)

Species and provenance	10 years			23 years			
	No. of branch clusters	Height (m)	Dbh (cm)	Height predom.* (m)	Dbht** (crn)	Stocking (stem/ha)	Basal area (m^2/ha)
P. muricata							
Trindidad Head	21.6	6.46	11.0	18.4	21.5	1548	59.0
Fort Bragg	19.0	7.47	12.7	189	24.1	1587	65.2
Inverness	19.8	6.40	11.4	17.5	21.5	1613	62.6
Monterey	15.9	6.61	11.2	17.3	21.0	1161	42.6
Lompoc	16.1	5.85	11.4	17.1	24.6	1000	52.8
San Vincente	12.1	4.97	8.7	16.6	20.1	1129	40.6
P. radiata							
Monterey	15.6	7.53	11.7	20.1	20.3	1406	53.1
Aňo Nuevo	16.8	7.13	11.6	20.4	20.6	1567	60.3
Cambria	13.4	6.71	10.8	18.6	18.8	1097	33.9

10 year data from Fielding (1961); 23 year data from J.C. Doran (*pers. comm.*)
* defined as the mean height of 124 trees of largest outside bark diameter/ha,
** internal trees only, excluding outer row.

These data show that the Aňo Nuevo and Monterey provenances are similar in height growth and superior to the Cambria provenance in this early unreplicated trial, and this indication has since been confirmed in subsequent replicated trials (K. Eldridge, *pers. comm.*)

Fielding also assessed various morphological characteristics of both species and found a decrease from north to south in the number of branch clusters among the *P. muricata* provenances, from 21.6 clusters at age 10 for the Trinidad Head provenance to 12.1 clusters for the San Vicente provenance. With respect to bole straightness, Trinidad Head was better than Monterey and Lompoc, but a little worse than the Inverness Ridge provenance.

In 1976, 12 plots of *Pinus attenuata*, *P. attenuata* × *P. radiata* (hybrid), *P. muricata* and *P. radiata* were thinned. The thinnings were done with the aim of preserving the specific characteristics of the plots. Thus the number of stems left in the plots after thinning varied from 370 to 630 stems/ha in the *P. attenuata* and *P. radiata* plots, and from 490 to 800 stems/ha in the *P. muricata* plots.

Pinus wallichiana, male catkins
(Photo: J. Shirley)

4 Picadilly Circus

An easily accessible arboretum adjacent to the Mt Franklin Road, containing some interesting provenances of P. ponderosa *and one very attractive plot of* Sequoiadendron giganteum*. Snow damage to some species is quite evident.* (Rout and Doran 1974).

Table 9.9: Picadilly Circus – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Brindabella	–35.3608	148.8036	1204
First / last planting	1932 / 1958		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1195		9
Mean maximum monthly	210		17
Mean minimum monthly	23		2
Total number of plots	32		
	Genera		**Species**
Number	9		26
Most frequent	*Pinus* (9 plots)		P. ponderosa (7 plots)

The soil in this arboretum was a reddish clay loam to a depth of about 7 cm, overlying a 'good clay soil' to a depth in excess of 150 cm.

Table 9.10: Picadilly Circus – species frequency

Species	**Number of plots**
Abies amabalis	1
Abies balsamea	1
Abies nordmanniana	1
Abies pinsapo	1
Abies procera	1
Abies spp	1
Betula alba	1
Castanea vesca	1
Cedrus atlantica	1
Picea abies	1
Picea glauca	1
Picea pungens	1
Picea rubens	1

Species	**Number of plots**
Pinus contorta	1
Pinus densiflora	1
Pinus muricata	1
Pinus nigra v cebennensis	1
Pinus nigra v maritima	1
Pinus patula	1
Pinus pinaster	1
Pinus ponderosa	7
Pinus radiata	1
Pinus torreyana	1
Pseudotsuga menziesii	1
Sequoiadendron giganteum	1
Tilia sylvestris	1
Total	32

5. Bendora

A well-stocked and healthy arboretum with the some very well developed plots (e.g. P. radiata *and* Ps. menziesii*). The growth of* P. radiata *in this aboretum shows the adaptability of the species to unfamiliar conditions. In 1943 it was recommended that* P. radiata *be removed from the arboretum because of snow damage and poor health; now it is the best volume producer in the arboretum, although snow damage is still evident.* (Rout and Doran 1974).

This arboretum is located within the boundary of Namadgi National Park. The site was chosen by Pryor at the request of Lane-Poole, then Inspector- General of the Commonwealth Forestry Bureau. The layout of the arboretum is illustrated in Figure 9.4.

It is situated on a gentle slope with an easterly aspect and is surrounded by native eucalypt forest. Access is from Mt Franklin Road via Chalet Road to a locked gate about 1.3 km from the arboretum.

Table 9.11: Bendora – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Bendoura	-35.4229	148.7971	1265
First/last planting	1940 / 1958		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1240		9
Mean maximum monthly	214		17
Mean minimum monthly	25		2
Total number of plots	86		
	Genera		**Species**
Number	15		65
Most frequent	*Pinus* (38 plots)		*P. ponderosa* (9 plots)

At an altitude of about 1265 m asl the site was considered marginal for *Pinus radiata* and so species considered as alternatives to radiata at high elevations were also planted here. These alternatives included *Pinus pondersoa, P. nigra, P. contorta, P. strobus, P. lambertiana* and *Pseudotsuga menziesii*.

Table 9.13 (F.R.I., G2.3 n.d. c. 1970) compares the growth of these species in their mid-twenties.

Table 9.12: Bendora – species frequency

Species	Number of plots	Species	Number of plots
Abies amabalis	1	*Pinus greggii*	1
Abies pindrow	1	*Pinus lambertiana*	1
Abies pinsapo	1	*Pinus monticola*	1
Acer platanoides	1	*Pinus mugo v mughus*	1
Acer pseudoplatanus	1	*Pinus muricata*	2
Acer rubrum	1	*Pinus nigra*	1
Alnus glutinosa	1	*Pinus nigra v caramanica*	1
Cedrus atlantica	1	*Pinus nigra v maritima*	1
Cedrus brevifolia	1	*Pinus pinaster*	1
Chamaecyparis lawsoniana	1	*Pinus ponderosa*	8
Cupressus arizonica	1	*Pinus ponderosa v apecheca*	1
Cupressus sempervirens	1	*Pinus radiata*	1
Fraxinus americana	1	*Pinus resinosa*	1
Fraxinus excelsior	1	*Pinus rigida*	1
Fraxinus oxycarpa	1	*Pinus rigitaeda*	1
Fraxinus pubescens	1	*Pinus strobus*	1
Fraxinus raywoodii	1	*Pinus strobus v chiapensis*	1
Larix decidua	1	*Pinus sylvestris*	1
Larix eurolepis	1	*Pinus taeda*	1
Larix kaempferi	1	*Pinus wallichiana*	1
Picea glauca	1	*Populus alba*	1
Picea pungens	1	*Populus deltoides*	1
Picea rubens	1	*Pseudotsuga flahaulti*	1
Picea smithiana	2	*Pseudotsuga macrocarpa*	1
Pinus armandii	1	*Pseudotsuga macrolepis*	1
Pinus attenuata x P. radiata	2	*Pseudotsuga menziesii*	2
Pinus banksiana	1	*Quercus cerris*	1
Pinus contorta	1	*Quercus petraea*	1
Pinus contorta v latifolia	1	*Tilia intermedia*	1
Pinus coulteri	1	*Tilia parvifolia*	1
Pinus elliottii	1	*Tilia sylvestris*	1
Pinus flexilis	1	*Widdringtonia juniperoides*	1
Pinus glabra	1	**Total**	86

Table 9.13: Growth of alternative high-elevation species at Bendora (c. 1970)

Species	Age	Height (ft)	Basal area (sq ft)	Dbh (inches)
P.radiata	25	85	292	12.6
P.ponderosa	25	53	294	10.0
P.nigra	25	49	181	8.2
P.contorta	25	48	142	7.0
P.strobus	22	44	117*	7.0*
P.lambertiana	23	36	110+	9.5+
Ps. menziesii	25	53	205	7.7

* Age 19 years, + Age 20 years

At these ages, on this site, radiata pine was clearly growing better than any of the alternatives, even having been subject to snow damage when young.

As the only arboretum remaining after the 2003 fires the arboretum has features which make it unique:

- It is the last remaining arboretum in the Brindabellas and is an example of the scientific thinking prevalent in the search to find plantation species suitable for afforestation in south-eastern Australia;

- It contains examples of well-known northern hemisphere tree species including mature plots of larch, Lawsons cypress, spruce pine and sugar pine, some of which are unique in the ACT;
- It is still used as a teaching tool for forestry students;
- The visual contrast between the conifers and surrounding eucalypt forest is interesting and aesthetically pleasing;
- The nearby Bendora Arboretum Hut (Figure 9.5) is the only remaining shelter hut constructed for arboretum workers by the Commonwealth Forestry Bureau.

Bendora arboretum, Plot 15, *Cupressus arizonica*, October 1951 (Photo: FTB)

Bendora arboretum, 1952 (Photo: J. Fielding)

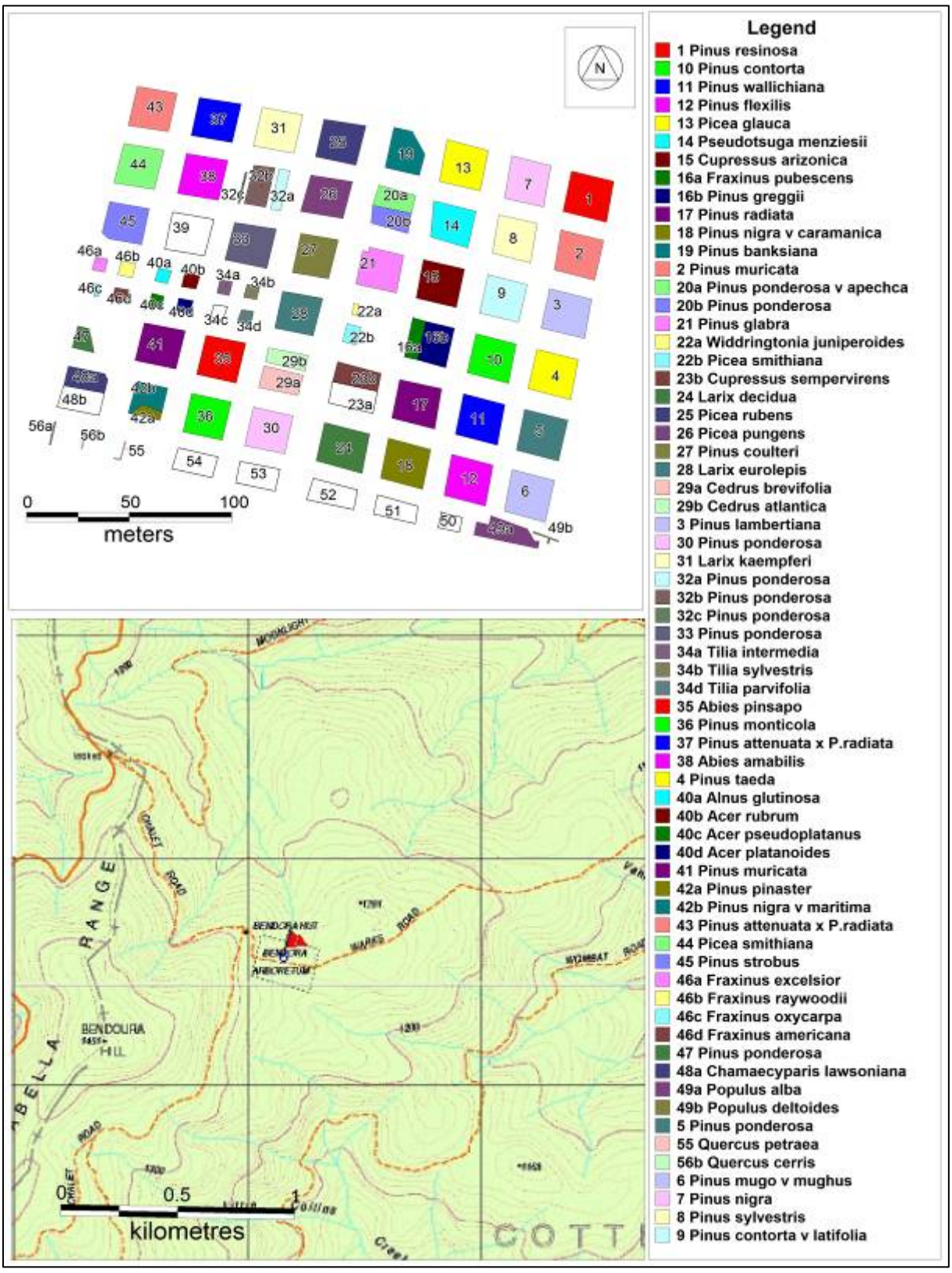


Figure 9.4: Bendora arboretum layout

Figure 9.5: Bendora Hut, 2007 (Photo: J. Shirley)

In 1969 five provenances of *Pinus strobus* were established as were four species of *Pseudotsuga* (*Ps. menziesii* (California)) , *Ps. flauhaulti* (Mexico), *Ps. macrolepis* (Mexico) and *Ps. macrocarpa* (California)), two species from Asia (*Pinus rigitaeda* (Korea) and *Pinus armandii* (West China)) and *Abies pindrow* from India.

Figure 9.6 (ACT Heritage Council 2004) documents the *P. strobus* provenance trial.

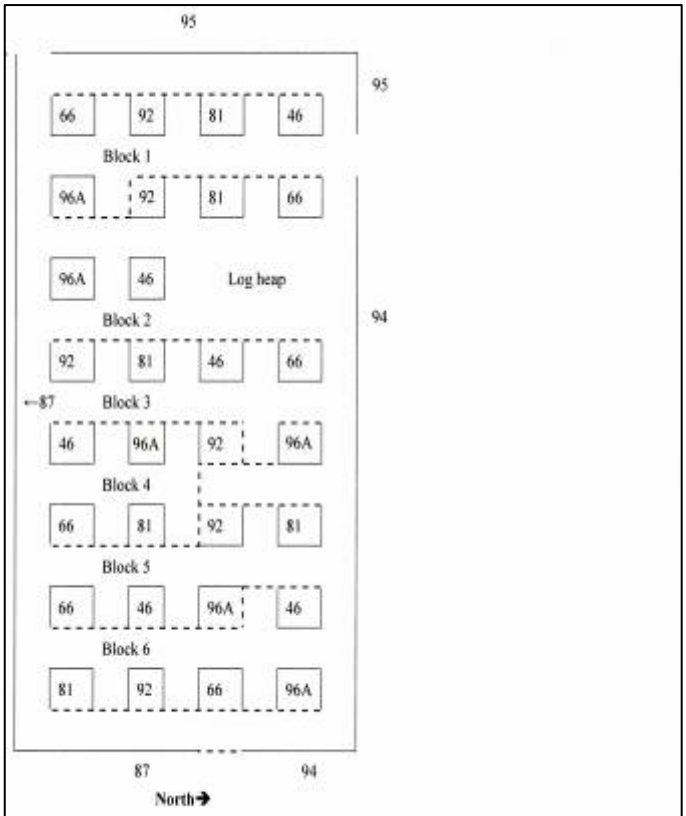


Figure 3. Layout of provenances within Plot 57, *Pinus strobus* (CSIRO file ACT/S/TB2 — Provenance Test 8). Each small square represents four trees. Plots in alternate blocks are shaded. The small plots are surrounded by a single buffer row of stock surplus to the small plots, identified by the associated numbers. Original spacing was 8 ft × 8 ft. A larger trial of these provenances was planted at Mansfield.

Table 4. *Origin of provenances in Plot 57,* Pinus strobus

Provenance No.	State	Locality	Latitude (N)	Longitude (W)	Altitude (ft)
46	West Virginia	5 miles E of St Marys, Pleasant Co.	39°25'	81°07'	
66	Virginia	4 miles SSE of Buchanan, Botetourt Co., Jefferson NF	37°31'	79°37'	1300–1800
81	North Carolina	Burnsville, 10 miles N of Mt Mitchell, Yancey Co.	35°45'	82°25'	1500–2000
92	Georgia	E of Epworth, Farin Co.	34°56'	84°26'	1700–1800
96A	Georgia	Cooper Ck, Farin Co., Chattahoochee NF	34°44'	84°09'	2000

Pinus strobus, Bendora.
(Photo: J. Shirley)

Figure 9.6: *Pinus strobus* provenance trial, Bendora

The five provenances planted here were a small sample of a larger number planted elsewhere. Unlike the provenances of *P. ponderosa* planted in this arboretum, the *P. strobus* provenances are not discernibly different from each other, an impression reinforced by the result of diameter measurements in 2007 when the differences in mean diameter were not nearly significant (A. Brown*, pers. comm).*

The arboretum has been proposed for entry to the ACT's Interim Heritage Places Register (ACT Heritage Council 2004).

6 Snow Gum

This arboretum is on a very rocky site with a westerly aspect. Site quality is poor. (Rout and Doran 1974).

It was located just outside the ACT boundary in NSW on a very exposed site.

Table 9:14: Snow Gum – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Bimberi Nature Reserve	–35.4430	-35.4430	1402
First/last planting	1941 / 1947		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1282		9
Mean maximum monthly	219		17
Mean minimum monthly	27		1
Total number of plots	27		
	Genera		**Species**
Number	5		20
Most frequent	*Pinus* (13 plots)		*Picea rubens* and *Picea glauca* (3 plots)

Table 9.15: Snow Gum – species frequency

Species	**Number of plots**
Cupressus sempervirens	1
Larix decidua	1
Larix eurolepis	1
Larix kaempferi	1
Picea abies	1
Picea glauca	3
Picea pungens	1
Picea rubens	3
Picea sitchensis?	1
Pinus contorta v latifolia	1
Pinus densiflora	1
Pinus jeffreyi	1

Species	**Number of plots**
Pinus mugo v mughus	1
Pinus mugo v rostrata	1
Pinus nigra	1
Pinus nigra v caramanica	1
Pinus pinaster s leira	1
Pinus ponderosa	1
Pinus ponderosa v arizonica	1
Pinus radiata	1
Pinus resinosa	1
Pinus sylvestris	1
Pseudotsuga menziesii	1
Total	27

Snow Gum arboretum, *P. nigra*, Plot 5, October 1951 (Photo: J. Fielding)

Snow Gum arboretum, *P. nigra*, Plot 5, 2003
(Photo: C. Keller)

7 Stockyard Creek

A remote arboretum which has not been particularly well cared for over the years. Well-stocked plots look tidy but there are many sparse plots which would have been removed if the area was more accessible. (Rout and Doran 1974).

Table 9.16: Stockyard Creek – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Namadji	–35.5403	148.7893	1463
First/last planting	1940 / 1945		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1334		8
Mean maximum monthly	223		16
Mean minimum monthly	30		1
Total number of Plots	65		
	Genera		**Species**
Number	16		48
Most frequent	*Pinus* (20 plots)		Various (see table below)

Table 9.17: Stockyard Creek – species frequency

Species	**Number of plots**
Abies balsamea	1
Abies pinsapo	1
Abies procera	1
Abies sachalinensis	1
Abies spectabalis	2
Alnus glutinosa	1
Betula alba	1
Cupressus arizonica	1
Fraxinus pubescens	1
Juniperus communis	1
Larix eurolepis	1
Larix kaempferi	1
Libocedrus decurrens	1
Picea abies	1
Picea glauca	1
Picea mariana	1
Picea omorika	1
Picea orientalis	1
Picea pungens	1
Picea rubens	2
Picea sitchensis	1
Pinus cembra	1
Pinus contorta	1
Pinus contorta v latifolia	1

Species	**Number of plots**
Pinus densiflora	1
Pinus engelmannii	1
Pinus flexilis	1
Pinus hartwegii	1
Pinus jeffreyi	1
Pinus monticola	1
Pinus mugo v mughus	1
Pinus nigra	1
Pinus nigra v caramanica	1
Pinus pinaster s Leira	1
Pinus ponderosa	1
Pinus ponderosa v arizonica	1
Pinus radiata	2
Pinus resinosa	1
Pinus strobus	1
Pinus sylvestris	1
Populus alba v bolleana	1
Pseudotsuga menziesii	1
Salix discolor	1
Salix spp. v 'Basket Willow'	1
Salix spp. v 'Upright willow'	1
Sequoia sempervirens	1
Tilia sylvestris	2
Tsuga canadensis	1
Total	65

Pinus contorta was relatively well suited to this high-altitude, harsh site and spread vigorously into the surrounding eucalypt forest. Incorporation of the arboretum into Namadji National Park increased pressure to contain the spread of contorta wildings. This was strongly resisted by FTB until at least 1992, which although sympathetic to removal of species which were at risk of spread, strongly urged that:

….selected species which are uncommon in Australia and which pose little or no threat of significant spread should be retained.

Stockyard Creek, Plot 6 – *P. contorta*, 1957 (Photo: J. Fielding)

However, the entire arboretum except for two noble firs (*Abies procera*) (*FACTA Newsletter* No. 15, 2008) was felled in 2003.

8 Blue Range (Cpt 149, Uriarra Forest)

A tidy arboretum containing provenances of P. ponderosa *showing marked differences in health and vigour. Easily accessible, it could be of interest to the general public.* (Rout and Doran 1974).

Table 9.18: Blue Range – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.2862	148.8747	792
First/last planting	1943 / 1950		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	918		12
Mean maximum monthly	176		20
Mean minimum monthly	13		5
Total number of plots	35		
	Genera		**Species**
Number	10		27
Most frequent	*Pinus* (23 plots)		*P. ponderosa* (8 plots)

This site was prepared by clearing and burning of bracken and some plots were ploughed to test the effect of site amelioration on growth, though this seems not to have been recorded. Stumps were removed with explosives, and plots were rotary hoed before planting. In 1962, most of the plots were pruned to between 2 m and 8 m depending on the height of the trees. Thinning occurred in 1962, 1966 and 1975.

Table 9:19: Blue Range – species frequency

Species	Number of plots	Species	Number of plots
Abies pinsapo	1	*Pinus ponderosa*	8
Chamaecyparis lawsoniana	2	*Pinus ponderosa v arizonica*	1
Cupressus arizonica v glabra	1	*Pinus radiata*	1
Larix eurolepis	1	*Pinus roxburghii*	1
Picea smithiana	1	*Pinus sabiniana*	1
Pinus canariensis	1	*Pinus strobus*	1
Pinus contorta v latifolia	1	*Pinus torreyana*	1
Pinus coulteri	1	*Pseudotsuga menziesii*	1
Pinus flexilis	1	*Sequoia sempervirens*	1
Pinus gerardiana	1	*Taxodium distichum*	1
Pinus leiophylla	1	*Widdringtonia juniperoides*	1
Pinus monticola	1	*Widdringtonia schwarzii*	1
Pinus nigra	1	*Widdringtonia whytei*	1
Pinus patula	1	**Total**	37

By 1943, when this arboretum was established, the significance of provenance and its relationship to tree growth and form was beginning to be realised. Eight different provenances of *Pinus ponderosa* were planted in 1943 and an additional provenance was planted in 1947. Five of these plots were from seed of trees selected in low-elevation forests near Placerville, California. Each plot of 144 trees was raised from the seed of one select Californian tree. By 1972 the five plots consisted of 'large trees of good form', markedly superior to other provenances from higher elevation and further inland.

Details of the provenances are shown in Table 9.20.

Table 9.20 Growth and form of ponderosa provenances at 8 Blue Range arboretum (Rout and Doran 1974)

Plot No.	Meas. age (y)	Ht (m)	Basal area (m^2/ha)	Dbhob (cm)	Comments	Seed-lot	Notes
1	29	24.1	57.9	24	Large trees of good form.	1277	Diamond Springs, Calif., 1900'. Plot 20E, Tree No. 17, I.F.G*.,1-1, 144
2	29	23.8	63.6	24	Some large trees of good form but not as good as plot 1.	1276	Diamond Springs, Calif., 1900'. Plot 20E, Tree No. 18, I.F.G., 1-1, 144
3	29	22.8	59.7	23	Some large trees of good form but not as good as plot 1.	1264	Diamond Springs, Calif., 1900'. Plot ELD20E, Tree No. 18, I.F.G.,1-1, 144
4	29	21.5	59.7	23	Some large trees of good form but not as good as plot 1.	1265	El Doradao Co. Cal., 2350', 1m N of I.F.G., 1-1, 144
6	29	22.2	79.2	26	Some large trees of good form.	1273	Coloma, Cal., 900'. Plot 24, Tree 1 . I.F.G., 1-1
7	29	16.9		18	Majority of trees are unhealthy runts.	1271	Wheeler, Oregon, Ochoco N.F., 1-1, Mitchell Rd, Sec 34 T125, R20E, 4500'

*: I.F.G = Institute of Forest Genetics, Placerville, USA

Table 9.21 compares the height measurements taken in 1972 and 2003 for these plots, demonstrating the differences in the rate of height growth among these provenances and that the ranking observed at the first measurement in 1972 was essentially maintained in 2003.

Table 9.21: Height growth of ponderosa provenances

Plot number	Age at measurement (y)			
	25	29	56	60
	Height (m)	Height (m)	Height (m)	Height (m)
1		24		40
2		24		
3		23		36
4		22		35
5		19		26
6		22		34
7		17		20
8		23		33
18	11		20	

Ponderosa pine is of major importance in North America, where it grows in areas that are climatically similar to portions of Australia. However, both its growth and wood properties have been disappointing in Australia. Slow growth led to the felling of plantations in the ACT and NSW in the early 1950s and the logs were sold to sawmills that normally processed radiata pine, for example for wooden fruit cases. When the ponderosa wood was used in the same way, however, many of the boards became severely distorted as they dried, to the great dissatisfaction of the users and, in turn, the sawmills. CSIRO's Division of Forest Products examined sample logs, including some from Blundells arboretum, and observed that distortion was associated with spiral grain, compression wood, large fibril angles and high longitudinal shrinkage (up to about ten times 'normal'), and that some of these features persisted over as many as 15 growth rings from the pith. This problem of distortion plagued efforts to sell ponderosa logs, and to replace the species in plantations with radiata pine, for decades (A. Brown, *pers. comm.*).

Fruit cases made of unseasoned ponderosa pine that distorted in drying after manufacture (Photo: FTB)

9 Blue Range (Cpt 137, Uriarra Forest)

The westerly aspect of this arboretum has poor survival with the remaining trees of generally unhealthy appearance. The easterly aspect, however, is quite different with well-developed plots of Pinus radiata*,* P. nigra *and* P. ponderosa. (Rout and Doran 1974).

Table 9.22: Blue Range – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2902	148.8783	747
First/last planting	1940 / 1946		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	938		12
Mean maximum monthly	179		20
Mean minimum monthly	14		5
Total number of plots	32		
	Genera		**Species**
Number	6		21
Most frequent	*Pinus* (23 plots)		*P. radiata* (8 plots)

Table 9.23: Blue Range – species frequency

Species	Number of plots
Cedrus brevifolia	1
Cedrus deodara	1
Cupressus arizonica	1
Cupressus sempervirens	1
Cupressus sempervirens v horizontalis	1
Juniperus communis	1
Juniperus virginiana	1
Larix kaempferi	1
Pinus coulteri	1
Pinus densiflora	1
Pinus flexilis	3

Species	Number of plots
Pinus jeffreyi	1
Pinus nigra	1
Pinus nigra v caramanica	1
Pinus ponderosa	2
Pinus ponderosa v arizonica	2
Pinus radiata	8
Pinus sabiniana	1
Pinus strobus	1
Pinus tabulaeformis	1
Pseudotsuga menziesii	1
Total	32

This arboretum contained several plots of *P. radiata* planted in 1942 grown from seed from various California provenances (Monterey (Sandhills and Peninsula), Point Aňo Nuevo (Swanton) and Cambria) collected by Jacobs in 1939/40 whilst in the USA. These plots were probably the world's first direct comparison of the different provenances of radiata pine (Eldridge, in Higgins. 1995). Table 9.24 contains details of these seedlots and Table 9.25 summarises height growth by 1972.

Table 9.24: Californian *Pinus radiata* provenances in arboretum 9 Blue Range, planted in 1942

Plot number	Seed-lot	Notes
20	1266	See E.M.* 297 for details. Monterey Peninsula, 5 rows of 17, 85 @ 8' × 8'
21	1269	Monterey sandhills, 5 rows of 5, 25 @ 8 '× 8'
22	1267	Cambria, 5 rows of 5, 25 @ 8' × 8'
23a	1266	Monterey Peninsula, 26 @ 8' × 8'
23b	1267	Cambria, 26 @ 8' × 8'
23c	1268	Swanton, 26 @ 8' × 8'
23d	1269	Monterey Sandhills, 26 @ 8' × 8'
24	1270	Hearst Estate, Cambria, 206 @ 8' × 8'

Table 9.25: Height growth of *Pinus radiata* provenances at arboretum 9 Blue Range, planted 1942 and measured in 1972 at 39 y of age

Plot	Number of trees	Height (m)	Comments
23a	20	30.5	Healthy provenance with several very large trees. Poor form.
23b	23	27.6	Unhealthy. Small diameters, small narrow crowns.
23c	20	29.8	Poor form; some double leaders, a few large trees.
23d	15	29.2	Poor form; some double leaders, a few large trees
24	39	31.3	Generally poor in form and vigour; some double trees. leaders several large trees.

Comments made at the measurement in 1972 suggest that the form of these provenances was poor, and the differences in height growth may not have been significant. These plots were not re-measured in 2003.

10 Blue Range (Cpt 144, Uriarra Forest)

Table 9.26: Blue Range – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2902	148.8783	747
First/last planting	1940 / 1946		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1019		11
Mean maximum monthly	188		19
Mean minimum monthly	16		4
Total number of plots	32		
	Genera		**Species**
Number	6		21
Most frequent	*Pinus* (23 plots)		*P. radiata* (8 plots)

Table 9.27: Blue Range – species frequency

Species	Number of plots
Cedrus atlantica	1
Eucalyptus bicostata	1
Larix decidua	1
Larix eurolepis	3
Larix kaempferi	1
Picea rubens	1

Species	Number of plots
Pinus contorta v latifolia	1
Pinus nigra	1
Pinus ponderosa	3
Pinus strobus	1
Tsuga canadensis	1
Total	15

Blue Range camp site, in the vicinity of arboreta 8, 9 and 13, in 2008 (Photo: J. Shirley)

Blue Range Hut and recreation area, 2008 (Photo: J. Shirley)

11 Bendora South

This arboretum was intended to study conifers as understorey species. By 1965 survival was poor and most remaining trees were hard to identify. (Rout and Doran 1974).

This arboretum was adjacent to arboretum 5 Bendora and included some under-planted conifers and plots of eucalypts. Except for the Douglas-fir, Lawson's cypress and thuja, most of the conifers did not grow well (Fearnside and Lea 1991.)

Table 9.28: Bendora South – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
Bendoura Bendora South	–35.4232	148.7982	1265
First/last planting	1945 / 1948		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1240		9
Mean maximum monthly	214		17
Mean minimum monthly	25		2
Total number of plots	22		
	Genera		**Species**
Number	7		21
Most frequent	*Picea* (8 plots)		*Abies grandis* (2 plots)

Table 9.29: Bendora South – species frequency

Species	**Number of plots**
Abies balsamea	1
Abies concolor	1
Abies grandis	2
Abies pinsapo	1
Chamaecyparis lawsoniana	1
Eucalyptus fastigata	1
Eucalyptus gigantea	1
Eucalyptus globulus	1
Eucalyptus obliqua	1
Eucalyptus regnans	1
Picea abies	1

Species	**Number of plots**
Picea glauca	1
Picea mariana	1
Picea omorika	1
Picea pungens	1
Picea rubens	1
Picea sitchensis?	1
Picea smithiana	1
Pseudotsuga menziesii	1
Thuja plicata	1
Tsuga canadensis	1
Total	22

Picea rubens, male cones at Bendora arboretum
(Photo: J. Shirley)

12 Mountain View

Table 9.30: Mountain View – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3224	148.8927	640
First/last planting	1934/1934		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	798		13
Mean maximum monthly	158		21
Mean minimum monthly	11		6
Total number of plots	11		
	Genera		**Species**
Number	5		11
Most frequent	*Pinus* (6 plots)		1 plot of each species

Table 9.31: Mountain View – species frequency

Species	Number of plots	Species	Number of plots
Brachychiton populneum	1	*Pinus radiata*	1
Cedrus atlantica	1	*Pinus sylvestris*	1
Cedrus deodara	1	*Pinus torreyana*	1
Pinus densiflora	1	*Sequoiadendron giganteum*	1
Pinus elliottii	1	*Ulmus* spp	1
Pinus patula	1	**Total**	11

13 Blue Range

This arboretum is located in an attractive setting alongside the old Blue Range camp, which has been developed as a picnic area. It has become useful now as a small park with a few different species for public interest. (Rout and Doran 1974)

Table 9.32: Blue Range – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2895	148.8749	747
First/last planting	1941 /1950		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	918		12
Mean maximum monthly	176		20
Mean minimum monthly	13		5
Total number of plots	22		
	Genera		**Species**
Number	12		19
Most frequent	*Fraxinus* (4 plots)		1 plot per species

This small arboretum was characterised by a preponderance of hardwood species.

Table 9.33: Blue Range – species frequency

Species	Number of plots
Acer rubrum	1
Alnus glutinosa	1
Carya tomentosa	1
Chamaecyparis lawsoniana	1
Fraxinus ornus	1
Fraxinus oxycarpa	1
Fraxinus pennsylvanica	1
Fraxinus raywoodii	1
Juniperus spp.	1
Juniperus virginiana	1

Species	Number of plots
Larix decidua	1
Pinus canariensis	1
Pinus contorta v latifolia	1
Pinus resinosa	1
Populus nigra v italica	1
Pseudotsuga macrocarpa	1
Pseudotsuga menziesii	1
Salix alba v calva	1
Thuja plicata	1
Total	22

A file note by J.M. Fielding in 1945 reported that the *Acer rubrum* and *Alnus glutinosa* had almost all died and recommended that these plots be abandoned. Grass competition was also noted, and chipping of the grass away from the young trees was recommended.

Pinus strobus, male cones
(Photo: J. Shirley)

Larix decidua, female cone
(Photo: J. Shirley)

14 Pierces Creek

A very poor arboretum in both growth and health. The aspect is northerly and the site is susceptible to summer droughts. (Rout and Doran 1974).

Table 9.34: Pierces Creek – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3682	148.9594	579
First/last planting	1940/1952		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	767		13
Mean maximum monthly	153		21
Mean minimum monthly	10		6
Total number of plots	26		
	Genera		**Species**
Number	1		14
Most frequent	Pinus		Pinus ponderosa 6 plots)

Table 9:35: Pierces Creek – species frequency

Species	Number of plots
Pinus banksiana	1
Pinus canariensis	1
Pinus contorta	2
Pinus contorta v latifolia	1
Pinus elliottii	1
Pinus halepensis	3
Pinus monticola	1

Species	Number of plots
Pinus mugo	1
Pinus nigra	1
Pinus patula	1
Pinus ponderosa	6
Pinus radiata	2
Pinus radiata × *P. patula*	1
Pinus resinosa	1
Total	26

This arboretum appears to have had quite a difficult time. In 1947 it was reported that the stocking was particularly low and that part of the area was very wet, resulting in poor establishment and growth of the trees.

Between 1950 and 1952 a part of the arboretum was illegally grazed and the *P. canariensis, P. patula* and *P. monticola* suffered severely, with some trees killed. An inspection in October 1965 noted that all the *Pinus monticola* had died from drought, and dead tops were noted in the *Pinus nigr*a plot.

Finally, the arboretum was destroyed by a wildfire in 1991.

15 Uriarra (Cpt 84a)

Table 9.36: Uriarra Cpt 84a – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3221	148.8983	660
First/last planting	1952/1952		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	798		13
Mean maximum monthly	158		21
Mean minimum monthly	11		6
Total number of plots	34		
	Genera		**Species**
Number	1		11
Most frequent	*Pinus (34 plots)*		*P. radiata (16 plots)*

Table 9.37 Uriarra Cpt 84a – species frequency

Species	Number of plots
Pinus attenuata × P. radiata	1
Pinus banksiana	2
Pinus echinata	2
Pinus halepensis	1
Pinus halepensis v brutia	1
Pinus nigra v calabrica	1

Species	Number of plots
Pinus nigra v caramanica	1
Pinus patula	2
Pinus ponderosa v arizonica	2
Pinus radiata	16
Pinus rigida	2
Total	34

Little is recorded about this arboretum. An inspection report in 1955 (FTB File Note, 1955) noted that there was:

…a high rate of mortality in some clones and some were heavily infested with Chermes.

16 Halls Block (Cpt 171, Uriarra Forest)

Table 9.38: Halls Block – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3490	148.8654	716
First/last planting	1953 / 1954		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	892		13
Mean maximum monthly	173		21
Mean minimum monthly	13		5
Total number of plots	23		
	Genera		**Species**
Number			14
Most frequent	*Pinus* (23 plots)		*Pinus jeffreyi, P. coulteri* (4 plots)

Table 9.39: Halls Block – species frequency

Species	Number of plots
Pinus ayacahuite	1
Pinus coulteri	4
Pinus douglasiana	2
Pinus echinata	1
Pinus greggii	1
Pinus halepensis v brutia	1
Pinus jeffreyi	4

Species	Number of plots
Pinus michoacana v cornuta	2
Pinus oocarpa	1
Pinus patula × P. greggii	1
Pinus pseudostrobus	1
Pinus radiata	1
Pinus tabulaeformis v yunnanensis	1
Pinus teocote	1
Total	23

A note (FTB File Note, 1963) by J.M. Fielding summarises observations on the flowering of the *P. patula* × *P. greggii* cross, shown in Figure 9.7, the interest no doubt due to his attempts to combine the growth characteristics of *P. patula* with the frost tolerance of *P. greggii.*

NOTES ON THE FLOWERING OF THE F1 HYBRID, P. PATULA x P. GREGGII AND P. GREGGII IN ARBORETUM 16 AT HALL'S BLOCK, A.C.T. (TREES PLANTED IN 1953)

April 11, 1958. P. patula x greggii has receptive female flowers and many that evidently were recently receptive. It also has male catkins in various stages of development with some shedding pollen.

P. greggii has female flowers similar to those of the hybrid, but no male catkins.

September 10, 1958. P. patula x greggii has recently-opened female flowers that appear to be receptive. It also has male catkins in various stages of development with some shedding pollen.

P. greggii has female flowers that seem to have been produced only recently and that are probably receptive. It has no male catkins.

December 12, 1961. P. greggii shedding pollen.

March 7, 1962. P. patula x greggii has male catkins that have just shed pollen and others that have not yet begun to shed pollen.

June 8, 1962. P. patula x greggii shedding pollen.

(J. M. Fielding)
12-9-1963

Figure 9.7: Flowering of *P. patula x P. greggii*

17 Laurel Camp

This is the oldest arboretum maintained by Forestry and Timber Bureau. The site is relatively poor and growth has been slow. (Rout and Doran 1974)

This arboretum was the first planted in 1928, by Cyril Cole, who was managing the plantation program in the ACT at the time.

Table 9.40: Laurel Camp – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–5.3509	148.9249	671
First/last planting	1928 / 1928		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	819		13
Mean maximum monthly	161		21
Mean minimum monthly	11		5
Total number of plots	11		
	Genera		**Species**
Number	1		6
Most frequent	*Pinus* (10 plots)		*P. ponderosa, P. jeffreyii* (3 plots each)

Table 9.41: Laurel Camp – species frequency

Species	**Number of plots**
Pinus canariensis	1
Pinus coulteri	1
Pinus jeffreyi	3
Pinus nigra	1
Pinus ponderosa	3
Pinus radiata	1
Total	10

Bark of *Pinus sylvestris*. (Photo: J. Shirley)

18 Westbourne Woods (CSIRO, Yarralumla)

These plantings were originally part of the original 'Westbourne Woods' arboretum planted by Weston at Yarralumla commencing 1913, most of which are now incorporated into the Royal Canberra Golf Club.

Table 9.42: Westbourne Woods – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3224	148.8927	640
First/last planting	1947 / 1958		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	673		13
Mean maximum monthly	138		21
Mean minimum monthly	9		6

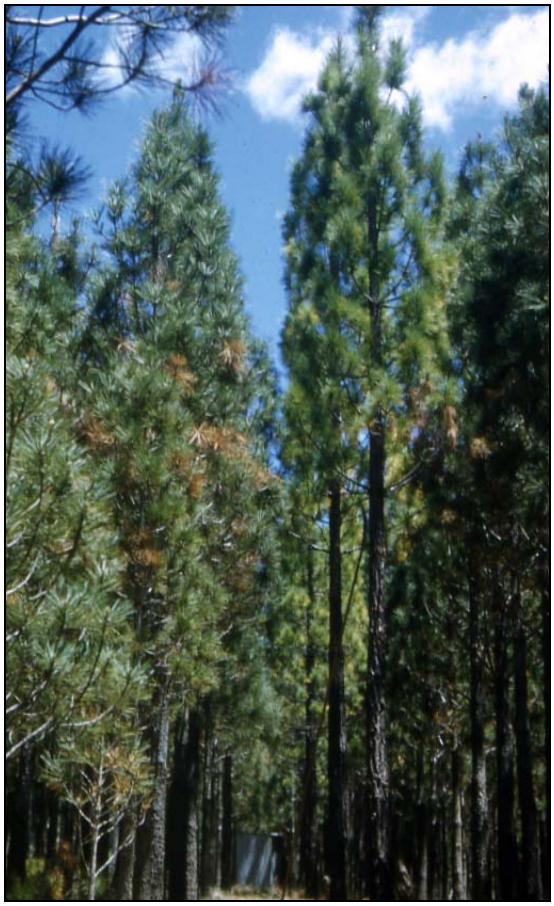
The remainder of the arboretum is now represented by scattered groups of trees in the vicinity of CSIRO's Yarralumla campus and the buildings which were formerly part of the AFS.

A number of the original plantings were felled to accommodate the AFS principal's residence in 1931 ('Westridge', in Banks St), a new accommodation block for students in 1951, and a new Forestry building for CSIRO in 1967.

However, many of the original trees have survived and the locations of some are shown in Figure 9.8.

The '*Pinus radiata* Tower Plot' was so-called because a tower was erected in the 1930s, by the newly-formed Commonwealth Forestry Bureau, to obtain measurements and observations such as season of flowering in the crowns of the trees. Pits were also dug to study root development and function.

Ten-year-old trees from the *Cedrus atlantica* plot in the south-east of the campus between Banks St and CSIRO's car park were removed and transplanted to the vicinity of Old Parliament House in preparation for the opening of that building in 1927.



Pinus coulteri (left), *P. canariensis* (right), Laurel Camp, aged 24 in 1953 (Photo: J. Fielding)

Figure 9.8: Some CSIRO forestry campus trees

Additional plantings have also occurred in more recent times. The plots of *Acacia* and *Eucalyptus* near the entrance to CSIRO's Forestry Building were planted to symbolize CSIRO's Australian Tree Seed Centre's ongoing involvement in the exploration and use of the genetic resources of Australian trees, including an ACIAR-supported initiative with China and South-East Asian countries.

19 Halls Block (Cpt 186, Uriarra Forest)

Table 9.43: Halls Block – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.3533	148.8588	732
First/last planting	1954 / 1960		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	973		12
Mean maximum monthly	185		20
Mean minimum monthly	14		4
Total number of plots	35		
	Genera		**Species**
Number	3		
Most frequent	*Pinus* (30 plots)		*Pinus attenuata* (11 plots)

This arboretum was situated on a gentle slope with an easterly aspect. It contained a number of provenances of *P. attenuata* (Six rivers N.F., McCloud, Hayfork, Highway 299, Bartlett Springs, Pt Aňo Nuevo, Felton and Bonny Doon). It also contained plots of *P. radiata* of uncertain origin, but probably from Monterey, as well as a group of trees from Cedros Island, supplied as *P. muricata v cedrosensis* (Fielding 1961b) but closely resembling *P. radiata v. binata* (Brown 1966).

19 Hall's Block. (Photo: A. Brown)

Table 9.44: Halls Block – species frequency

Species	Number of plots
Cupressus arizonica v glabra	1
Cupressus guadalupensis v forbesii	1
Cupressus macnabiana	1
Pinus attenuata	11
Pinus attenuata × P. radiata	7
Pinus douglasiana	1
Pinus michoacana	1
Pinus montezumae	1
Pinus patula	1

Species	Number of plots
Pinus patula × P. greggii	2
Pinus pseudostrobus	1
Pinus radiata	1
Pinus radiata v binata	1
Pinus radiata v fastigates	1
Pinus radiata × P. attenuata	1
Pinus radiata × P. attenuata?	1
Quercus bicolor	1
Quercus lobata	1
Total	35

20 Kowen (Cpt 60)

Failed because of drought. (Rout and Doran 1974)

In 1958 it was reported that this arboretum had failed badly because of drought. The site was also badly drained and became very wet in wet seasons. It was abandoned in 1958 and replanted with *P. radiata*.

Table 9.45: Kowen Cpt 60 – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2883	149.3055	802
First/last planting	1954 / 1957		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	713		12
Mean maximum monthly	140		20
Mean minimum monthly	11		5
Total number of plots	14		
	Genera		**Species**
Number	1		11
Most frequent	*Pinus* (14 plots)		*P. attenuata × P. radiata* (3 plots)

Table 9.46 Kowen Cpt 60 – species frequency

Species	Number of plots
Pinus attenuata × P. radiata	3
Pinus contorta	1
Pinus halepensis v brutia	1
Pinus massoniana	1
Pinus nigra	1
Pinus patula × P. greggii	1

Species	Number of plots
Pinus pinaster s Leira	1
Pinus pseudostrobus	1
Pinus radiata	2
Pinus sabiniana	1
Pinus sylvestris	1
Total	14

21 Green Hills, Stromlo Forest

This is a poor arboretum of untidy, slow-growing plots. The site is rocky and site quality as indicated by the growth of P. radiata *is poor*. (Rout and Doran 1974)

Table 9.47: Green Hills – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
Stromlo	–35.2876	149.0777	594
First/last planting	1954 / 1960		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	695		13
Mean maximum monthly	141		21
Mean minimum monthly	9		6
Total number of plots	15		
	Genera		**Species**
Number	1		15
Most frequent	*Pinus* (15 plots)		Several

FTB file notes in 1958 and 1969 recorded that the site was very dry and in 1958 the drought tolerance of various species was evident. By 1958 50% of the *P. patula* had died.

The arboretum was eventually cleared to allow the construction of the Tuggeranong Freeway.

Table 9.48: Green Hills – species frequency

Species	Number of plots
Pinus canariensis	1
Pinus douglasiana	1
Pinus halepensis v brutia	2
Pinus michoacana v cornuta	2
Pinus montezumae	1
Pinus patula	1
Pinus pinaster s Leira	2
Pinus ponderosa	1

Species	Number of plots
Pinus ponderosa v apacheca	1
Pinus ponderosa v arizonica	1
Pinus ponderosa v scopulorum	1
Pinus pseudostrobus	2
Pinus radiata	1
Pinus teocote	1
Pinus torreyana	1
Total	19

Larix decidua, female cones (Photo: J. Shirley)

22 Kowen (Cpt 71)

A poor site with very slow-growing plots, the tallest being a plot of P. attenuata × P. radiata *which was only 7.4 m high at 13 years of age.* (Rout and Doran 1974).

Table 9.49: Kowen Cpt 71 – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2818	149.3144	884
First/last planting	1955 / 1958		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	723		12
Mean maximum monthly	141		20
Mean minimum monthly	11		5
Total number of plots	16		
	Genera		**Species**
Number	1		10
Most frequent	*Pinus* (16 plots)		*P. attenuata* (6 plots)

Table 9.50: Kowen Cpt 71 – species frequency

Species	Number of plots
Pinus attenuata	6
Pinus attenuata x P.radiata	2
Pinus cembroides	1
Pinus contorta	1
Pinus cooperi v ornelasi	1

Species	Number of plots
Pinus halepensis	1
Pinus muricata v remorata	1
Pinus nigra	1
Pinus ponderosa x P.ponderosa v latifolia	1
Pinus torreyana	1
Total	16

This arboretum escaped the 2003 fires.

23 Blue Range

Table 9.51: Blue Range – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3093	148.8680	762
First/last planting			
	Rainfall (mm)		**Temperature (°C)**
Mean annual	945		12
Mean maximum monthly	160		20
Mean minimum monthly	14		5
Total number of plots	17		
	Genera		**Species**
Number	1		12
Most frequent	*Pinus* (17 plots)		Several

Table 9.52: Blue Range – species frequency

Species	Number of plots
Pinus attenuata × *P. radiata*	1
Pinus densiflora	2
Pinus halepensis v brutia	2
Pinus massoniana	1
Pinus nigra	2
Pinus nigra v maritima	1

Species	Number of plots
Pinus nigra v maritima × *P. halepensis*	1
Pinus nigra v maritima × *P. nigra v nigra*	2
Pinus nigra v nigra	1
Pinus nigra v nigra × *P. densiflora*	2
Pinus teocote	1
Pinus thunbergii	1
Total	**17**

24 Kowen (Cpt 73)

This arboretum was abandoned in 1971 because of the difficulty in identifying the various plots with most of the original marker pegs gone. (Rout and Doran 1974)

Table 9.53: Kowen Cpt 73 - key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.2891	149.3143	835
First/last planting	1956 / 1956		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	723		12
Mean maximum monthly	141		20
Mean minimum monthly	11		5
Total number of plots	22		
	Genera		**Species**
Number	1		11
Most frequent	*Pinus* (22 plots)		*P. pinaster* (6 plots)

Table 9.54: Kowen Cpt 73 – species frequency

Species	Number of plots
Pinus attenuata	4
Pinus canariensis	1
Pinus jeffreyi × *P. ponderosa*	1
Pinus pinaster	6
Pinus pinaster s Leira	1
Pinus ponderosa	1

Species	Number of plots
Pinus ponderosa v scopulorum	1
Pinus ponderosa × *P. arizonica*	1
Pinus ponderosa × *P. montezumae*	1
Pinus radiata	3
Pinus radiata × *P. canariensis*	1
Total	22

25 Vanitys Crossing

Only a few scattered trees remained in 1968. The area is subject to waterlogging and initial survival is very poor. (Rout and Doran 1974).

Table 9.55: Vanitys Crossing – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3479	148.8879	600
First/last planting	1957 / 1957		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	856		13
Mean maximum monthly	167		21
Mean minimum monthly	12		5
Total number of plots	2		
	Genera		**Species**
Number	1		2
Most frequent	*Pinus* (2 plots)		1 plot each

Table 9.56: Vanitys Crossing – species frequency

Species	Number of plots
Pinus massoniana	1
Pinus sylvestris	1
Total	2

Pinus strobus, Bendora (Photo: J. Shirley)

26 Mt Ginini

The highest elevation arboretum established by the Bureau and the only one where P. radiata *is not the dominant species although survival of that species has been good. The site is very poor, being mainly exposed weathered rock. Snow covers the area for one to six months of the year.* (Rout and Doran 1974)

Table 9.57: Mt Ginini – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.5260	148.7737	1692
First/last planting	1959 / 1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1541		7
Mean maximum monthly	253		15
Mean minimum monthly	37		-1
Total number of plots	50		
	Genera		**Species**
Number	9		28
Most frequent	*Pinus* (29 plots)		*P. sylvestris* (16)

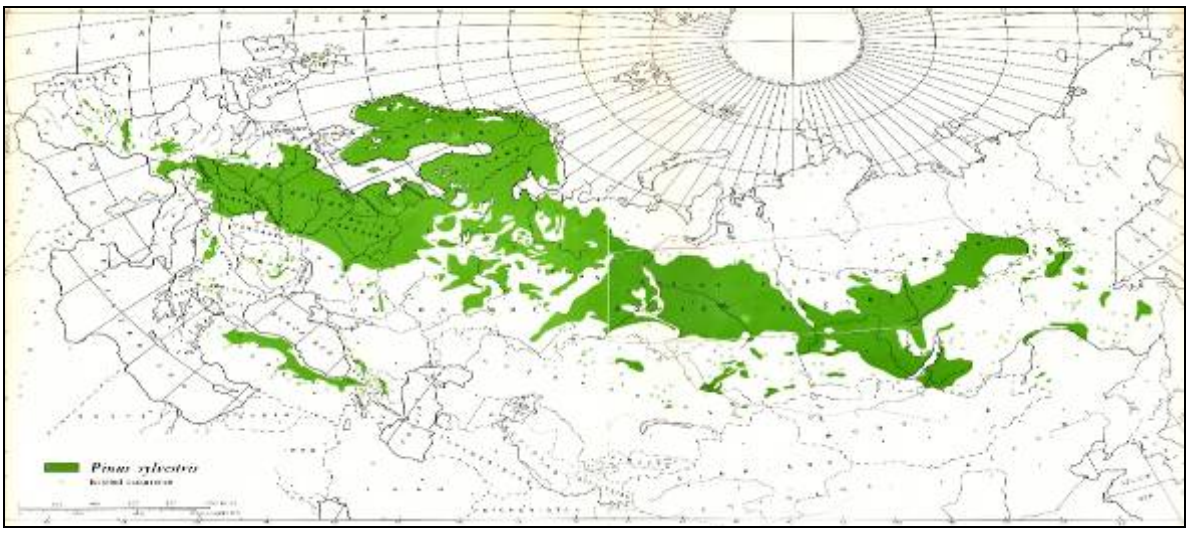
Table 9.58: Mt Ginini – species frequency

Species	**Number of plots**
Abies magnifica	2
Abies nordmanniana	1
Abies pinsapo	1
Abies procera	1
Abies religiosa	1
Betula alba	1
Larix decidua	1
Larix eurolepis	1
Larix kaempferi	2
Libocedrus decurrens	1
Picea abies	2
Picea orientalis	1
Picea polita	1
Pinus contorta v latifolia	1

Species	**Number of plots**
Pinus monticola	1
Pinus mugo	1
Pinus nigra	2
Pinus nigra v cebennensis	1
Pinus nigra v maritima	1
Pinus nigra v nigra	1
Pinus ponderosa	1
Pinus pseudostrobus v oaxacana	1
Pinus radiata	1
Pinus rudis	1
Pinus strobus	1
Pinus sylvestris	16
Pseudotsuga menziesii	4
Thuja orientalis	1
Total	**50**

This arboretum contained several plots of *Pinus sylvestris*. This species has an extensive natural range, extending from Scotland through southern Spain, northern Greece and northern Turkey to northern Manchuria and the Sea of Okhotsk (Critchfield and Little 1966). It is the most widely distributed of all pines and was the subject of the first published account of a provenance trial.

The wood has been extensively traded as ‘deal’ or ‘Baltic pine’. The species is also the source of Stockholm tar, widely used in sheep-shearing as a wound dressing.



World distribution of *Pinus sylvestris* (Critchfield and Little 1966)

The first planting in the ACT forests of this species, of an unknown provenance, occurred at Mountain View in 1934, flowed by single-plot plantings in Stockyard Creek, Blundells and Bendora in 1940, again at Snow Gum in 1941 and Vanitys Crossing and Kowen in 1957.

The plot in Blundells arboretum performed very poorly (Turnbull, in Higgins 1995), which probably curtailed interest in this species in the ACT.

However, interest in its use in Australia was revived by its selection as a candidate for high-country erosion control and seed was imported by European foresters employed by the Snowy Mountains Authority, from a much wider range of provenances including southern Europe. Some of that seed was planted at Mt Ginini and demonstrated that the southern provenances were much more suited to the ACT's higher elevations than the northern provenances planted earlier.

Pinus sylvestris, Switzerland
(Photo: M. Frankis)

Pinus sylvestris, female cone
(Photo: J. Shirley)

26a Mt Ginini underplanting

Initially intended as an underplanting study similar to arboretum 11. Survival and growth has been poor and the identity of many plots is doubtful. (Rout and Doran 1974).

Much of the high country eucalypt forest in the ACT and southern NSW was considered by some to have potential for plantation development and this arboretum appears to have been established to test the shade tolerance of various conifer species considered for planting at higher altitudes. However most of the species planted failed to thrive and the arboretum was abandoned some time prior to 1974.

Table 9.59: Mt Ginini Underplanting – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.5261	148.7740	1692
First/last planting	1960 / 1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1541		7
Mean maximum monthly	253		15
Mean minimum monthly	37		-1
Total number of plots	50		
	Genera		**Species**
Number	6		17
Most frequent	*Pinus* (38 plots)		*P. sylvestris* (26)

Table 9.60 Mt Ginini Underplanting – species frequency

Species	**Number of plots**
Abies nordmanniana	1
Abies pinsapo	1
Cedrus atlantica	1
Larix decidua	1
Larix kaempferi	1
Picea abies	4
Picea pungens	1
Picea smithiana	1
Pinus contorta	3

Species	**Number of plots**
Pinus flexilis	1
Pinus lambertiana	1
Pinus radiata	4
Pinus sylvestris	26
Pinus sylvestris v rigensis	1
Pinus taiwanensis	1
Pinus wallichiana	1
Pseudotsuga menziesii	1
Total	**47**

High-altitude eucalypt forest near Mt Ginini. (Photo: J. Shirley)

27 Wombat Creek

Table 9.61: Wombat Creek – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3337	148.8316	975
First/last planting	1960/1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1055		11
Mean maximum monthly	194		19
Mean minimum monthly	17		4
Total number of plots	27		
	Genera		**Species**
Number	4		7
Most frequent	*Larix* (11 plots)		*Larix kaempferi* (11 plots)

9.62: Wombat Creek - species frequency

Species	Number of plots
Larix kaempferi	11
Pinus douglasiana	1
Pinus pseudostrobus	1
Pinus radiata	2
Pinus wallichiana	1
Pseudotsuga menziesii	10
Quercus alba	1
Total	**27**

28 Neds Block

Table 9.63: Neds Block – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
Two Sticks	**–35.2798**	**148.8771**	762
First/last planting	1960/1961		
	Rainfall (mm)		**Temperature (° C)**
Mean annual	935		12
Mean maximum monthly	178		20
Mean minimum monthly	14		5
Total number of plots	8		
	Genera		**Species**
Number	3		7
Most frequent	*Pinus* (6 plots)		*Pinus taiwanensis* (2 plots)

Table 9.64: Neds Block - species frequency

Species	Number of plots
Larix decidua	1
Pinus michoacana	1
Pinus muricata v remorata	1
Pinus tabulaeformis	1

Species	Number of plots
Pinus taiwanensis	2
Pinus wallichiana	1
Sequoiadendron giganteum	1
Total	**8**

29. Cotter Homestead

There are only four plots in this rather remote arboretum planted near the headwaters of the Cotter River. The date of planting is uncertain and no assessments have been carried out on the plots. (Rout and Doran 1974)

Table 9.65: Cotter Homestead – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.6500	148.8166	1320
First/last planting	1940 / 1940		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1186		9
Mean maximum monthly	201		17
Mean minimum monthly	25		1
Total number of plots	4		
	Genera		**Species**
Number	1		4
Most frequent	*Pinus (4 plots)*		

Table 9.66: Cotter Homestead – species frequency

Species	Number of plots
Pinus contorta	1
Pinus nigra	1
Pinus pondersoa	1
Pinus radiata	1
Total	**4**

Bark of ponderosa pine (Photo: J. Shirley)

30. Pabral Block

A small arboretum containing some interesting plots of Mexican pine species. (Rout and Doran 1974*)*

Table 9.67: Pabral Block - key descriptors

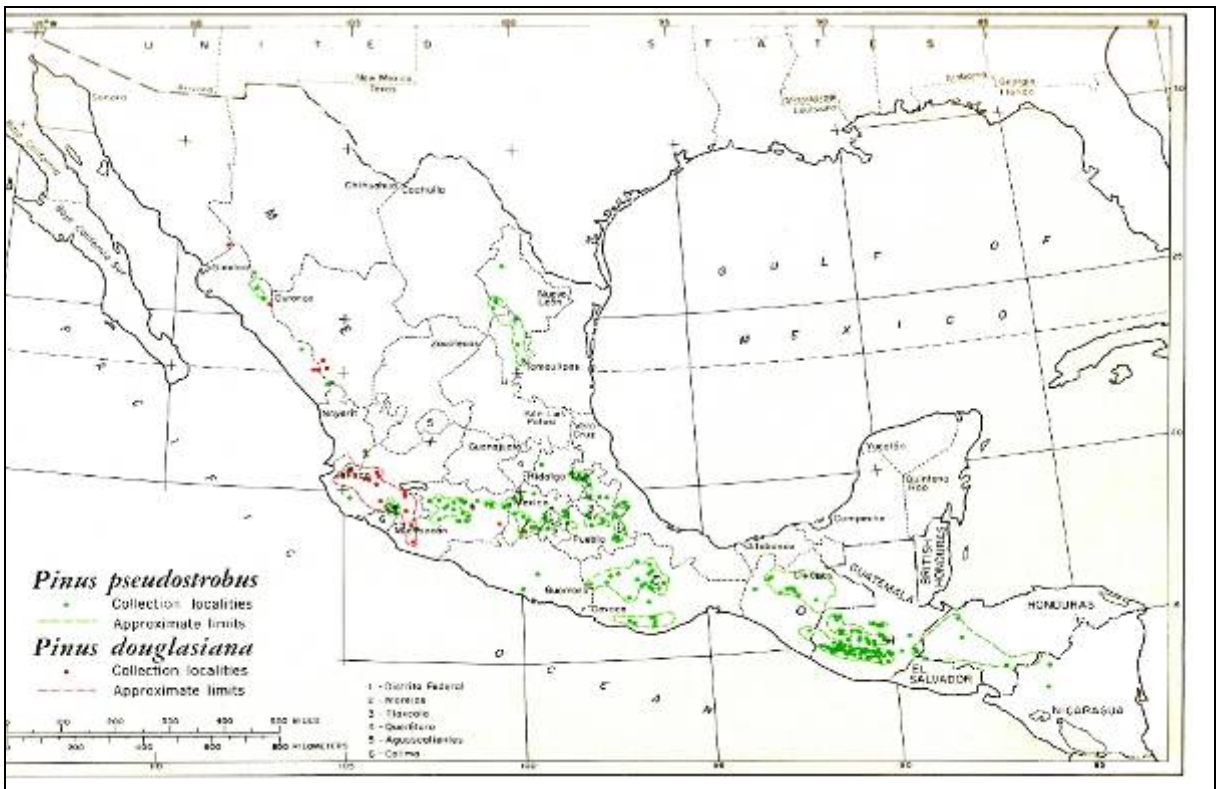
Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.3176	148.8737	655
First/last planting	1963 / 1968		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	842		13
Mean maximum monthly	164		21
Mean minimum monthly	12		6
Total number of plots	30		
	Genera		**Species**
Number	5		19
Most frequent	*Pinus* (15 plots)		Several

Table 9.68: Pabral Block – species frequency

Species	**Number of plots**
Abies religiosa	1
Juniperus procera	1
Pinus ayacahuite	3
Pinus douglasiana	1
Pinus montezumae	2
Pinus patula	2
Pinus pringlei	1
Pinus pseudostrobus	1
Pinus pseudostrobus v oaxacana	2
Pinus rudis	1

Species	**Number of plots**
Pinus tenuifolia	1
Pinus virginiana	1
Populus angulata	1
Populus canadensis	1
Populus deltoides	1
Populus euramericana	1
Populus yunnanensis	1
Pseudotsuga menziesii	1
Thuja orientalis	1
Total	**30**

Pinus lambertiana, Bendora (Photo: A. Fearnside)



Distribution of *P. pseudostrobus* and *P. douglasiana* (Critchfield and Little 1966)

31 Jervis Bay

This arboretum (and also arboretum 32) was established on the recommendation of Fielding to:

…study the growth of conifers likely to succeed in the south coast region of NSW,

where a significant area of coastal land had been identified for possible plantation development. The soils consisted of shallow sands, deficient in nitrogen, overlying sandstone (Ingwersen 1976).

Table 9.69 Jervis Bay – key descriptors

Alternative names	**Latitude**	**Longitude**	**Altitude (m.asl)**
	–35.1494	150.7478	30
First/last planting	1963 / 1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1304		17
Mean maximum monthly	300		22
Mean minimum monthly	19		12
Total number of plots	79		
	Genera		**Species**
Number	7		36
Most frequent	*Pinus* (73 plots)		*Pinus attenuata* (27 plots)

Table 9.70: Jervis Bay – species frequency

Species	Number of plots
Callitris columellaris	1
Cryptomeria japonica	1
Cunninghamia lanceolata	1
Cupressus macrocarpa	1
Picea pungens	1
Pinus attenuata	27
Pinus ayacahuite v vetchii	1
Pinus douglasiana	1
Pinus echinata	1
Pinus elliottii	2
Pinus glabra	1
Pinus greggii	1
Pinus halepensis v brutia	2
Pinus leiophylla	1
Pinus michoacana	1
Pinus montezumae	2
Pinus muricata	6
Pinus oocarpa	2

Species	Number of plots
Pinus oocarpa v ochoterenai	1
Pinus patula	3
Pinus patula x P. greggii	1
Pinus pinaster	1
Pinus pringlei	3
Pinus pseudostrobus	1
Pinus pseudostrobus v oaxacana	2
Pinus radiata	2
Pinus radiata v binata	1
Pinus rigida	2
Pinus rudis	1
Pinus serotina	1
Pinus strobus	1
Pinus taeda	1
Pinus tenuifolia	1
Pinus thunbergii	1
Pinus virginiana	1
Pinus yunnanensis	1
Total	**79**

An inspection in early 1969 reported the arboretum as 'in good health', though *Chermes* was attacking the *P. attenuata* and the Mexican pines appeared to be suffering wind and/or salt burn. However, late in 1969 a number of plots were declared as failed and were replanted in various species including *P. michoacana, Auracaria angustifolia* and a number of provenances of *Pinus halepensis, P. contorta* and *P. pinaster* from Western Australia.

The arboretum was destroyed by fire in 1972 and in 1975 only eight plots (*P. serotina, P. leiophylla, P. ayacahuite, P. oocarpa, P. pinaster, P. echinata* and *P. rigida*) showed signs of regeneration. It was recommended that the area be left for a further five years in order to fully observe the rate of recovery after fire.

32 Jervis Bay, 'Hole in the Wall'

This small arboretum was also established to test species' suitability for planting on the south coast. The soils consisted of deep sands that were deficient in nitrogen.

Table 9.71: Jervis Bay Hole in the Wall - key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.1328	150.7532	30
First/last planting	1963 / 1964		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	1297		17
Mean maximum monthly	299		22
Mean minimum monthly	19		12
Total number of plots	10		
	Genera		**Species**
Number	6		8
Most frequent	*Abies* (3 plots)		*Abies religiosa* (3 plots)

Table 9.72: Jervis Bay – species frequency

Species	Number of plots
Abies religiosa	3
Araucaria bidwillii	1
Cunninghamia konishii	1
Cunninghamia lanceolata	1
Ginkgo biloba	1
Picea polita	1
Pinus ayacahuite	1
Pinus pinaster	1
Total	**10**

Prior to the 1972 fire, part of the arboretum had been removed to build a road to a proposed nuclear power plant site. After the fire only the *P. pinaster* showed any signs of survival and the arboretum was abandoned.

Jervis Bay Arboretum 32, c. 1976, from Ingwersen 1976

33. Boboyan

There were severe losses in the 1967–68 drought in this arboretum. In 1969 the area was cultivated and replanted with a P. radiata *progeny trial. This site carried* Eucalyptus pauciflora *and* E. stellulata *woodland.* (Rout and Doran 1974)

Table 9.73: Boboyan – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	--35.7666	148.9666	1060
First/last planting	1968 / 1969		
	Rainfall (mm)		**Temperature (°C)**
Mean annual	858		10
Mean maximum monthly	158		18
Mean minimum monthly	16		3
Total number of plots	27		
	Genera		**Species**
Number	6		17
Most frequent	*Pinus* (22 plots)		*Pinus lambertiana* (6 plots)

Table 9.74: Boboyan – species frequency

Species	Number of plots
Abies procera	1
Abies religiosa	2
Libocedrus decurrens	1
Picea abies	2
Picea omorika	1
Pinus ayacahuite	1
Pinus contorta	1
Pinus lambertiana	6
Pinus monticola	1

Species	Number of plots
Pinus ponderosa	3
Pinus pseudostrobus	1
Pinus radiata	2
Pinus radiata × P.attenuata	1
Pinus strobus	1
Pinus thunbergiana	1
Pseudotsuga menziesii	1
Quercus garrayana	1
Total	**27**

34 Jerilderie

Little can be said about this arboretum at present as the area has had favourable seasons since establishment. The effects severe summer droughts, which are common in this semi-arid zone, will have on the survival and growth of the various species, particularly the P. radiata*, have still to be observed.* (Rout and Doran 1974).

The purpose of this arboretum was to:

……find suitable species and provenances of introduced conifers for farm-forestry in the semi-arid environment of south-eastern Australia. (FRI, G.2.4, n.d.).

It was established on land made available by the W. Caughey Memorial Institute.

Table 9.75: Jerilderie – key descriptors

Alternative names	Latitude	Longitude	Altitude (m.asl)
	–35.3228	145.5568	100
First/last planting			
	Rainfall (mm)		**Temperature (°C)**
Mean annual	420		16
Mean maximum monthly	90		25
Mean minimum monthly	6		9
Total number of plots	35		
	Genera		Species
Number	5		19
Most frequent	*Pinus* (18 plots)		*Pinus sabiniana* (6 plots)

Table 9.76: Jerilderie – species frequency

Species	Number of plots
Callitris glauca	3
Callitris intratropica	1
Cupressus arizonica	2
Cupressus atlantica	2
Cupressus sempervirens	4
Cupressus sempervirens v horizontalis	1
Cupressus torulosa	1
Pinus canariensis	3
Pinus coulteri	2
Pinus edulis	1

Species	Number of plots
Pinus eldarica v brutia	1
Pinus leiophylla	1
Pinus radiata	1
Pinus roxburghii	2
Pinus sabiniana	6
Pinus torreyana	1
Tetraclinis articulata	1
Widdringtonia juniperoides	1
Widdringtonia schwarzii	1
Total	**35**

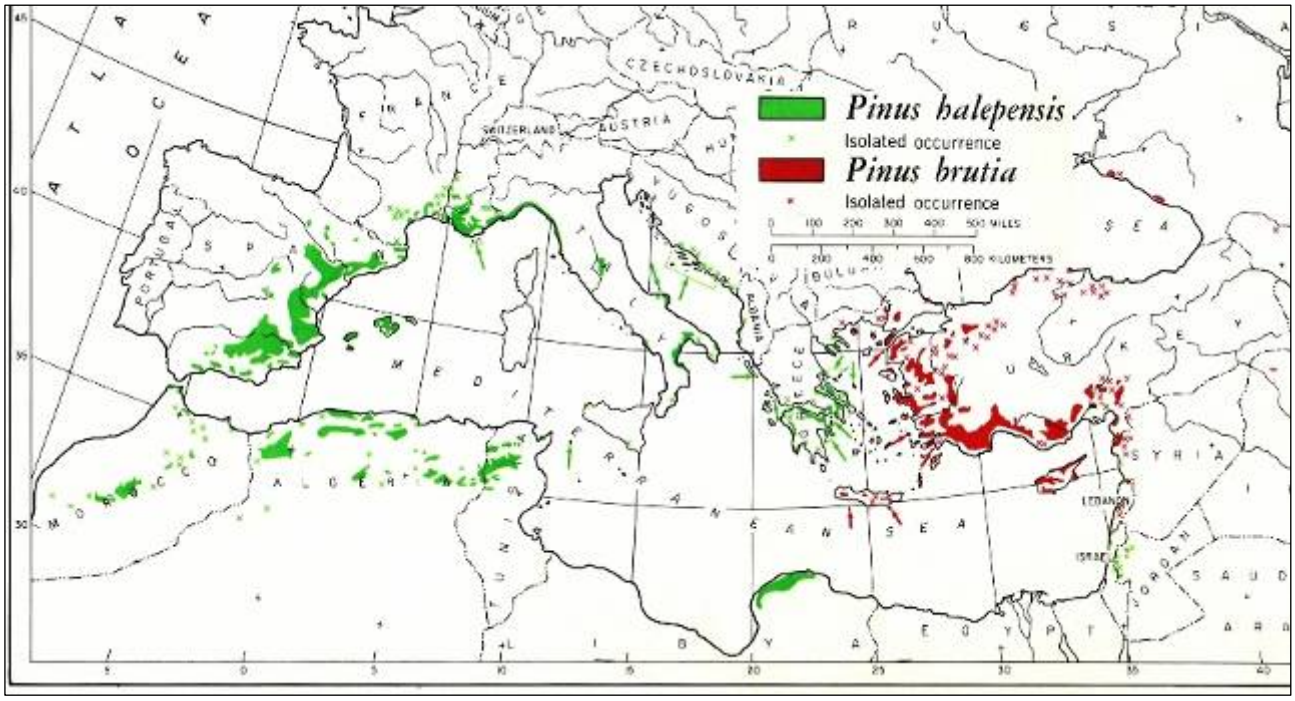
The soil type consisted of mixed red-brown and brown earths of heavy texture. The eastern part of the arboretum was subject to flooding.

Survival was quite variable. The plots of *Cupressus atlantica, C. arizonica, C. sempervirens, Pinus sabiniana* and *P. roxburgii* were still fully stocked in May 1970, but the plots of *Callitris glauca, Widdringtonia juniperoides* and *Pinus coulteri* were reduced to one or two plants of the 16 planted in each plot.

Height measurements in May 1970 showed that *P. radiata* was the fastest growing, at 103 cm, and *P. edulis* was the slowest at 17 cm.

Provenance trials *of Pinus halepensis* and *Pinus brutia* including seed from throughout the natural ranges of these species (Palmberg1975; Spencer 1985) were also established immediately adjacent to the arboretum.

In 1974 it was reported that weed growth was ‘abundant’ in the arboretum and in most cases the trees were badly suppressed. However, the *P. radiata* had out-performed all other species, including the *P. halepensis* and *P. brutia* in the adjacent provenance trial.



Natural range of *P. halepensis* and *P. brutia* (Critchfield and Little 1966)

Jerilderie arboretum in 1979 (Photo: FTB)

Poplar Arboretum

The poplar genus consists of about 40 exclusively northern hemisphere species. One of the first introductions to Australia, in the early 19th century, was of Lombardy poplar (*P. nigra* var. *italica*). Other species commonly planted by the early settlers included *P. alba* (silver poplar), *P. monilifera* (black poplar), *P. deltoides* (eastern American cottonwood) and *P. yunnanensis* (Yunnan poplar).

Lane Poole introduced several clones of inter-specific hybrids, produced by Stout and Schreiner in the USA, to Australia in about 1939. However, these trial plantings were not successful due to a lack of appreciation of the requirement for good site selection and cultivation (Pryor and Willing 1982).

By 1958 Australian companies manufacturing safety matches were attempting to develop a local supply of poplar timber for match splints, because of the loss of European supply during the second world war and the increasing cost of importation.

In 1959 FTB established a small arboretum of poplars near Blundells arboretum, to test species with potential for both match splints and veneer.

Figure 9.9: Poplar arboretum near Blundells arboretum (Photo: Unknown)

Table 9.77 shows details of the clones, species and varieties planted.

Table 9.77: Poplar arboretum plantings

Clone No.	Clone	Section*	Estab. year	Origin
9	*P. simonii* cv. 'Fastigata'	Tacamahaca	1959	P and G Canberra**
10	*P. yunnanensis (suaveolens)*	Tacamahaca	1959	P and G Canberra
11	*P. candicans (tacamahaca)*	Tacamahaca	1959	P and G Canberra
16	*P. trichocarpa v. hastata*	Tacamahaca	1959	Frazer R. Br. Columbia
17	*P. Maximowieii x trichocarpa* cv 'Andrscroggin'	Tacamahaca	1959	U.S.F.S.
18	*P. ngra x trichocarpa* cv 'Roxbury'	Aigeiros x Tac	1959	U.S.F.S.
21	*P. maximoweii x nigra v plantierensis* cv 'Rochester'	Tac. x Aigeiros	1959	U.S.F.S.
27	*P. nigra*	Aigeiros	1959	P and G Canberra
28	*P. nigra* cv 'Italica'	Aigeiros	1959	P and G Canberra
29	*P. nigra x euramericana*	Aigeiros	1959	P and G Canberra
31	*P x euramericana* cv 'Serotina'	Aigeiros	1959	Tasmanian F.C.
33	*P x euramericana* cv 'Regenerata'	Aigeiros	1959	P and G.
34	*P x euramericana* cv 'Eugenei'	Aigeiros	1959	P and G.
39	*P. deltoides* ssp. *angulata (robusta A.E.)*	Aigeiros	1959	P and G.
40	*xP. robusta, Dode*	Aigeiros	1959	P and G.
43	*P x euramericana* cv 'I-214'	Aigeiros	1959	P and G.
54	*P x tacamahaca*	Tacamahaca	1959	P and G.
55	*P. eucalyptoides* (v like *P. robusta*)	Aigeiros	1959	P and G.
57	*P. candicana*	Tacamahaca	1959	P and G.
63	*P. euramericana* cv 'I-455'	Aigeiros	1959	New Zealand (P. N.53)
65	*x P generosa (P. dilitata)*	Aigeiros x Tac	1959	P and G Canberra
77	*P. deltoides* cv 'Angulata' -smooth bark form	Aigeiros	1959	A.C.T.
59	*P. nigra* cv 'Italica' - semi evergreen form	Aigeiros	1960	New Zealand (P. N.20)
50	*x P. rubra* Poiret *(P. deltoides* cv 'Angulata' v *nigra)*	Aigeiros	1960	U.K.F.C.
13	*P. trichocarpa C.F.*	Tacamahaca	1960	U.K.F.C.
35	*P. deltoides*	Aigeiros	1960	P and G
60	*P. x euramericana* cv 'Eugenei' P. U.	Aigeiros	1960	New Zealand (P. N. 8)
70	*P. x euramericana* cv 'I-45/51'	Aigeiros	1960	A.N.M.
62	*P. x euramericana* cv 'I-788'	Aigeiros	1960	New Zealand (P. N.51)
44	*P. x euramericana* cv 'I-290'	Aigeiros	1960	Shroeck
52	*x P. laevigiata*	Aigeiros	1960	U.K.F.C
68	*P. deltoides 'monifera'*	Aigeiros	1960	P and G Canberra
42	*P. x euramericana* cv 'Robusta H'	Aigeiros	1960	U.K.F.C.
20	*P. tacamahaca* cv 'Trichocarpa 37'	Tacamahaca	1960	U.K.F.C.
69	*P. euramericana* cv 'I-154'	Aigeiros	1960	A.N.M
58	*P. nigra x P. betulifolia*	Aigeiros	1960	New Zealand (P. N.17)
68	*P x euramericana* cv 'Robusta'	Aigeiros	1961	P and G Canb.

Clone No.	Clone	Section*	Estab. year	Origin
48	*P x euramericana* cv 'I-488' Cascale	Aigeiros	1961	U.K.F.C.
51	*P x euramericana* cv 'Gelrica H.A.'	Aigeiros	1961	U.K.F.C.
47	*P x euramericana* cv 'Serotina V.B.'	Aigeiros	1961	U.K.F.C.
152	*P x euramericana* cv 'Serotina'	Aigeiros	1963	C.S. Brown South Africa
150	*P. deltoides* cv 'Angulata'	Aigeiros	1963	C.S. Brown Sth Africa

* The genus *Populus* is divided into these sections. ** Parks and Gardens

FTB publications by Brown (1971, 1973), and Doran, Matheson, Eldridge and Brown, (1974) provide summaries of work by FTB on poplar growth in eastern NSW.

A poplar plantation on the River Murray. From about 1960, match companies established small plantations to provide logs for match splints. The main plantations were on northern coastal rivers of NSW, near Tumut and near Albury and Yarrawonga. A decline in the domestic match industry and the advent of fungal diseases in the 1970s has greatly lessened interest in poplar growing.

10. Data Synthesis

Plot Establishment Table

Records of plot establishment, taken from the map prepared for each arboretum by Brown (example in appendix 1) have been assembled into a table in a Microsoft Access database. The field definitions of this table are shown in Table 10.1.

Table 10.1: Plot establishment table

Field Name	Data type	Description
Arb_ID	Text	Unique arboretum identier, assigned by FTB, essentially the arboretum number
Arboretum_Name	Text	Arboretum Name
Short_Name	Text	Truncation of arboretum name
PlotNum	Text	Plot Number within arboretum
PlotKey	Text	Concatenation of Arb_Id and PlotNum
PlotKey_EstabYr	Text	Concatenation of Plotkey and EstabYr
Genus	Text	Genus name (e.g. 'Pinus')
Species	Text	Specific name (e.g. 'radiata')
SpecificName	Text	Concatenation of Genus and Species
Variety	Text	Name of species 'variety'. Prefixed by 'x' (species cross), 'v' (species variety) or 's' (species strain)
FullName	Text	Concatenation of Genus, Species and Variety
PlotKey_FN	Text	Concatenation of PlotKey and FullName
EstabYr	Number	Year of planting
Seedlot	Text	Seedlot identifier
Notes	Text	Often contains seed source, provenance, number of trees planted, trees spacing, tree age at planting
RefillYr	Text	Year of refilling
RefillNotes	Text	Notes on refilling, often number of seedlings

Plot Measurements Table

Prior to production of the Rout and Doran reports (Rout and Doran 1974) individual tree measurements were recorded on paper in imperial units.

These data were summarised periodically for particular purposes such as the report to the 7th Commonwealth Forestry Conference (Anon. 1957b), but there was no central 'database' of measurement records.

The measurement obtained by Rout and Doran in 1972–73 and presented in their 1974 report was the first comprehensive measurement in metric units. This report contains plot-by-plot measurement summaries for 23 of the 35 arboreta.

A measurement of Stockyard Creek was taken by FACTA, in 2002, prior to its felling, and a measurement of a number of arboreta was also obtained by FACTA after the January 2003 fires. Table 10.2 summarises the number of plots measured in each arboretum.

Table 10.2: Number of plots measured

	Measurement year				
	2002	2003	2004	1972–73	
Measured by	**FACTA**	**FACTA**	**FACTA**	**FTB**	**Total**
Arboretum	**Number of plots measured**				
1 Blundells		85		106	191
2 Reids Pinch North		22		21	43
3 Reids Pinch South		37		61	98
4 Picadilly Circus		26		23	49
5 Bendora			49	44	93
6 Snow Gum		13		23	36
7 Stockyard Creek	49			37	86
8 Blue Range		25		30	55
9 Blue Range				25	25
10 Blue Range		2		6	8
12 Mountain View				9	9
13 Blue Range				7	7
14 Pierces Creek				16	16
16 Halls Block				10	10
17 Laurel Camp		5		5	10
19 Halls Block				16	16
21 Green Hills				16	16
23 Blue Range		12		16	28
26 Mt Ginini				38	38
27 Wombat Creek		4		17	21
28 Neds Block				6	6
30 Pabral Block				16	16
31 Jervis Bay				57	57
34 Jerlderie				21	21
Total	**49**	**231**	**49**	**626**	**955**

These plot measurement records have also been assembled into a single table. The field definitions of the table are shown in Table 10.3.

Table 10.3: Plot measurements table

Field name	Data type	Description
Arb_ID	Text	Unique arboretum identier, assigned by FTB, essentially the arboretum number
PlotNum	Text	Plot number within arboretum
PlotKey	Text	Concatenation of Arb_Id and PlotNum
Source	Text	'R&D': Rout & Doran (1974); 'M2002':Measured in 2002; Ditto for measured in 2003 and 2004
Genus	Text	Genus name
Species	Text	Specific name
Variety	Text	Name of species 'variety'. Prefixed by 'x' (species cross), 'v' (species variety) or 's' (species strain')
Specific Name	Text	Concatenation of Genus and Species
Full Name	Text	Concatenation of Genus, Species and Variety
PlotKey_FN	Text	Concatenation of PlotKey and FullName
MeasAge	Number	Age of trees at measurement
NumTrees	Number	Number of trees in plot
Area	Number	Area of plot (ha)
Dbhob	Number	Average dbhob of sample trees
BaHA	Number	Basal area (m^2/ha)
Height	Number	Average total height of sample trees
MeasY	Number	Year of measurement
Comments	Text	Recorded for the Rout & Doran measurement only

The plot establishment table and the plot measurements table are contained in the Microsoft Access database on the accompanying CD, which also contains these tables exported in comma-separated format.

Data limitations

The most significant limitation of the data for growth analysis is that, except in a few cases, the plots are unreplicated which precludes statistical analysis of the significance of differences of the growth of species across sites and provenance. In addition, many of the plots were subject to variable pruning and thinning treatments at various ages. These treatments will have impacted predominantly on basal area development, again confounding comparisons across sites and species, but height growth is likely to have been largely unaffected.

Other 'errors' were noted in the data:

- In some cases a number of provenances were planted in subplots but the 1972 measurement did not distinguish the measurement for each provenance in each subplot. For example, measurements of subplots a, b and c of plot 1/63 planted in provenances of *P. muricata* are not reported separately;
- Where a plot has been re-filled, the measurement does not distinguish the age class measured. In these cases, the oldest age class (i.e. the year of original planting) is assigned to the measurement;
- In other cases the number of trees measured in the plot in 2004 exceeds the number of trees recorded as being in the plot in 1972 (e.g. 5/42a and 5/42b);
- Elsewhere, a sample of dbhob's in the plot was measured, but the sampling fraction is unknown;
- In the measurement database Table 6 plot records occurred with no corresponding matching plots in the plot establishment table, nor was the age of the plot at measurement or the year of establishment recorded. There was no choice but to discard the measurement for these plots; and
- The methods used to select trees to measure for height and diameter (to avoid edge effects) have probably varied over time, which will add to the measurement error where a plot has been measured on more than one occasion, and thus to the error in any growth estimate.

11. Height Growth Trends

As noted earlier, the nature of the 'experiment' represented by the arboreta precludes any rigorous analysis comparing the growth of the various species. The combinations of provenance, site (and all its influences, such as exposure, temperature, rainfall, nutrient availability, etc.), and management, are essentially un-replicated. In addition, the small size of the plots, with concomitant 'edge effects', together with the error arising from the need to sample trees for height and diameter measurement, precludes all but the most general analysis. Further, measurements of height and diameter alone do not convey information about the shape of the stem or the branching and coning characteristics, which all significantly affect wood quality.

A key statistic of interest in comparing provenances for possible inclusion in an afforestation program is the rate of volume growth. However, tree volume was not measured in the arboreta.

Nevertheless, for most plantation species, volume growth and height growth show a reasonable degree of correlation and a comparison of height growth within and among species across a range of sites can serve as a useful preliminary screening tool in ranking suitable species, although it ignores differences in volume due to basal area and tree shape. Height growth is also largely unaffected by tree stocking level, except at the extremes, which offsets to some extent the confounding effects introduced by the variable thinning treatments employed in the arboreta.

Of the multitude of species represented in the arboreta, only a few probably had any realistic chance of selection as the species of choice for plantation development, or as an alternative to radiata pine in the event of catastrophe.

Figures 11.1 to 11.7 compare the height growth of these several key species with that of radiata pine across all the arboreta in which the species occurred. Each point represents a height-age pair for a plot measurement, extracted from the measurement table described in section 10. Thus, plots which were measured more than once appear more than once in the relevant chart.

Cunninghamia lanceolata (Photo: J. Shirley)

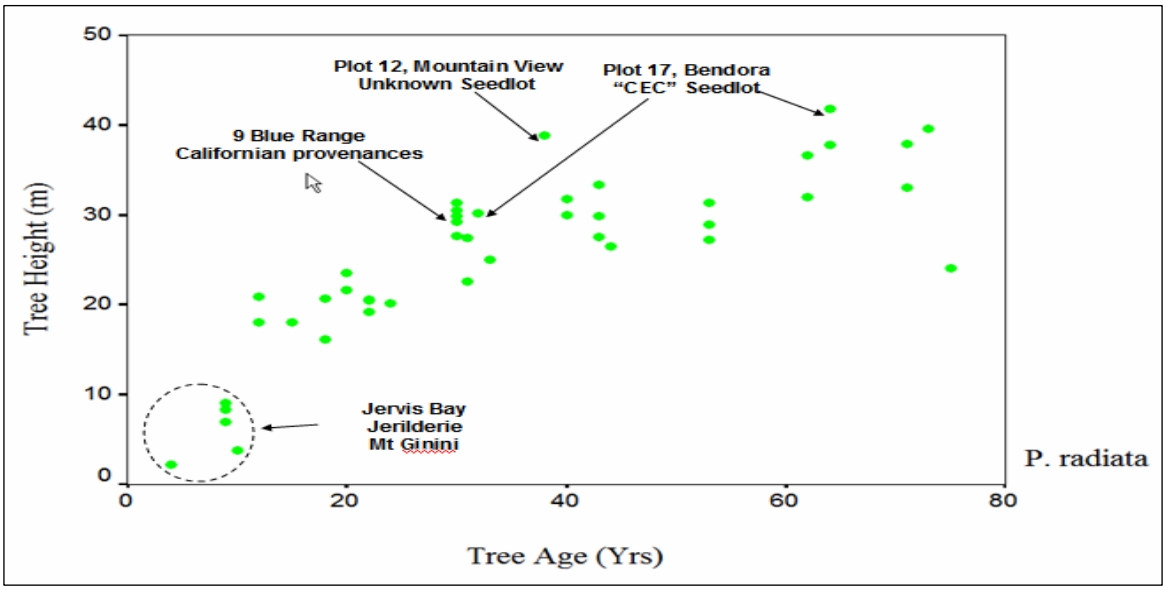


Figure 11.1: Radiata pine height growth

The 9 Blue Range plots, which were planted with seed from Swanton, Monterey and Cambria, were measured by Rout and Doran in 1972 but were not re-measured in 2003. Although they exhibited a relatively high growth rate in 1972, they were of very poor form but there were some notably large trees (Rout and Doran 1974). The provenance planted in Plot 17 at Bendora was noted by Rout and Doran in 1974 as being the largest trees in any of the arboreta at the time, but most of them also exhibited poor form.

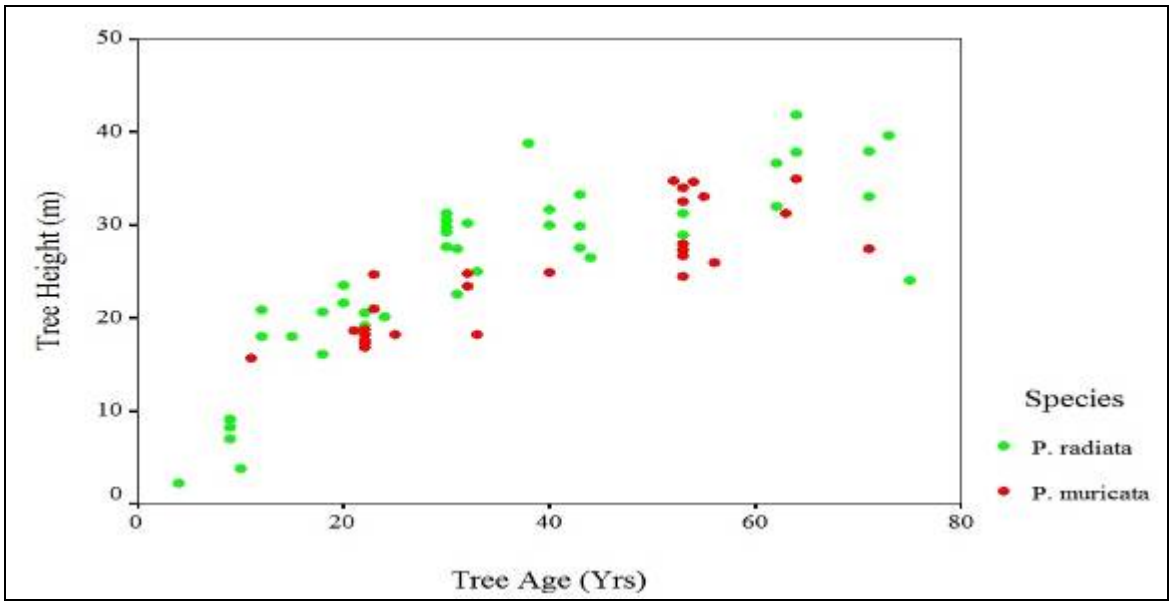


Figure 11.2: Comparative height growth – *P. radiata* vs *P. muricata*

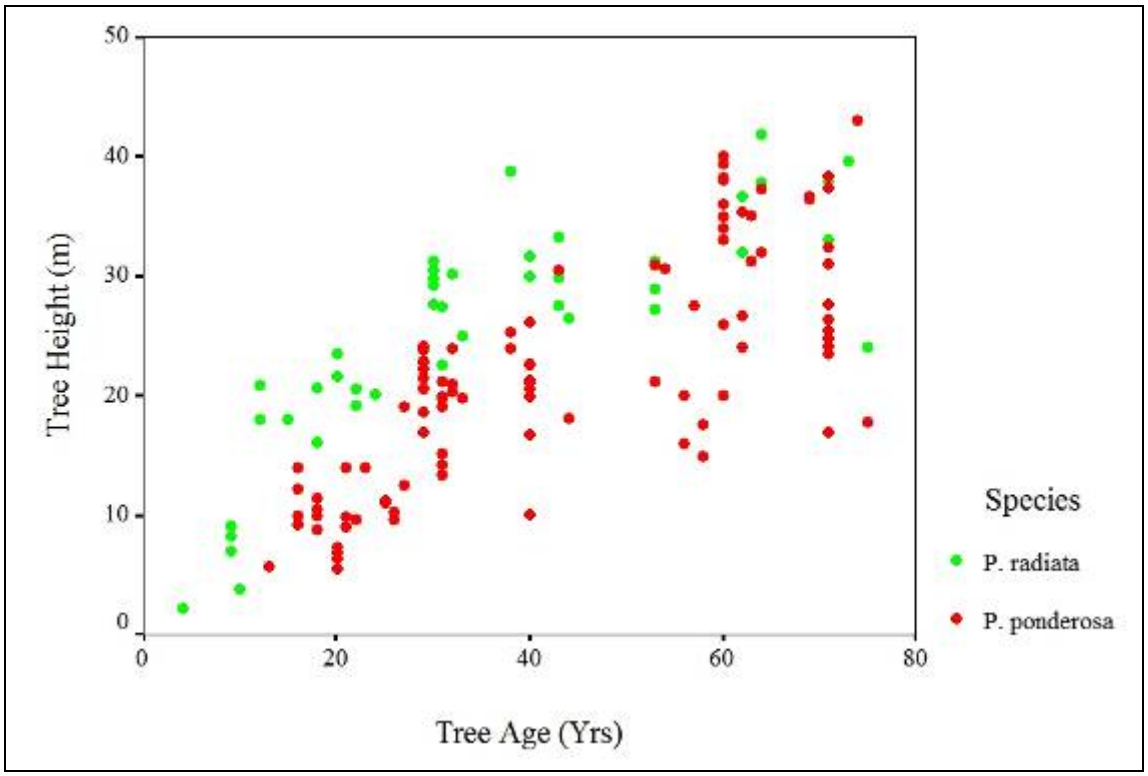


Figure 11.3: Comparative height growth – *P. radiata* vs *P. ponderosa*

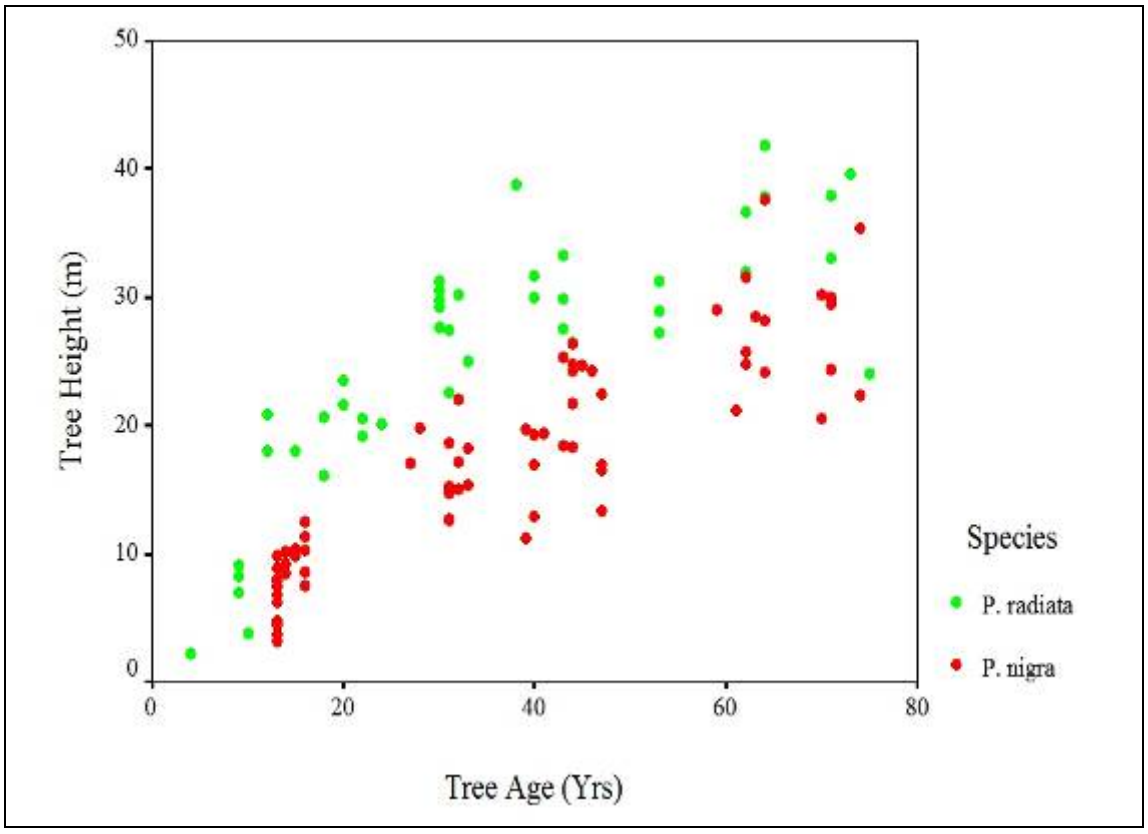


Figure 11.4: Comparative height growth – *P. radiata* vs *P. nigra*

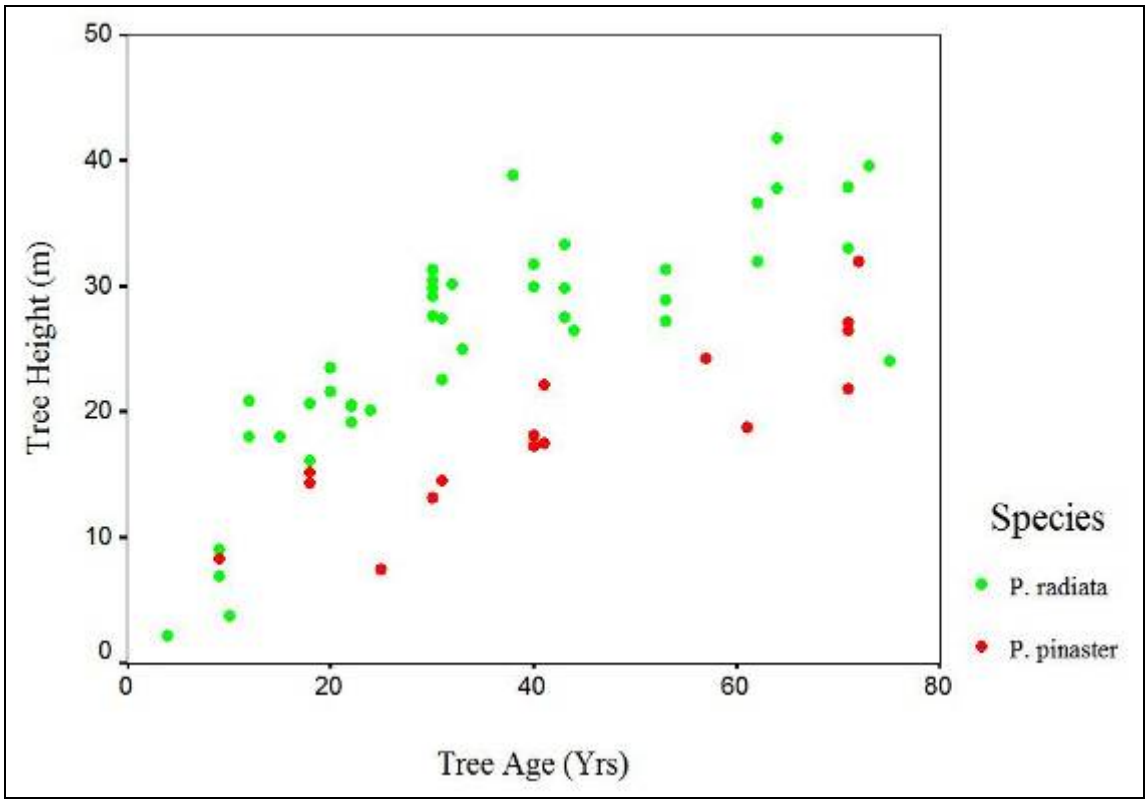


Figure 11.5: Comparative height growth – *P. radiata* vs *P. pinaster*

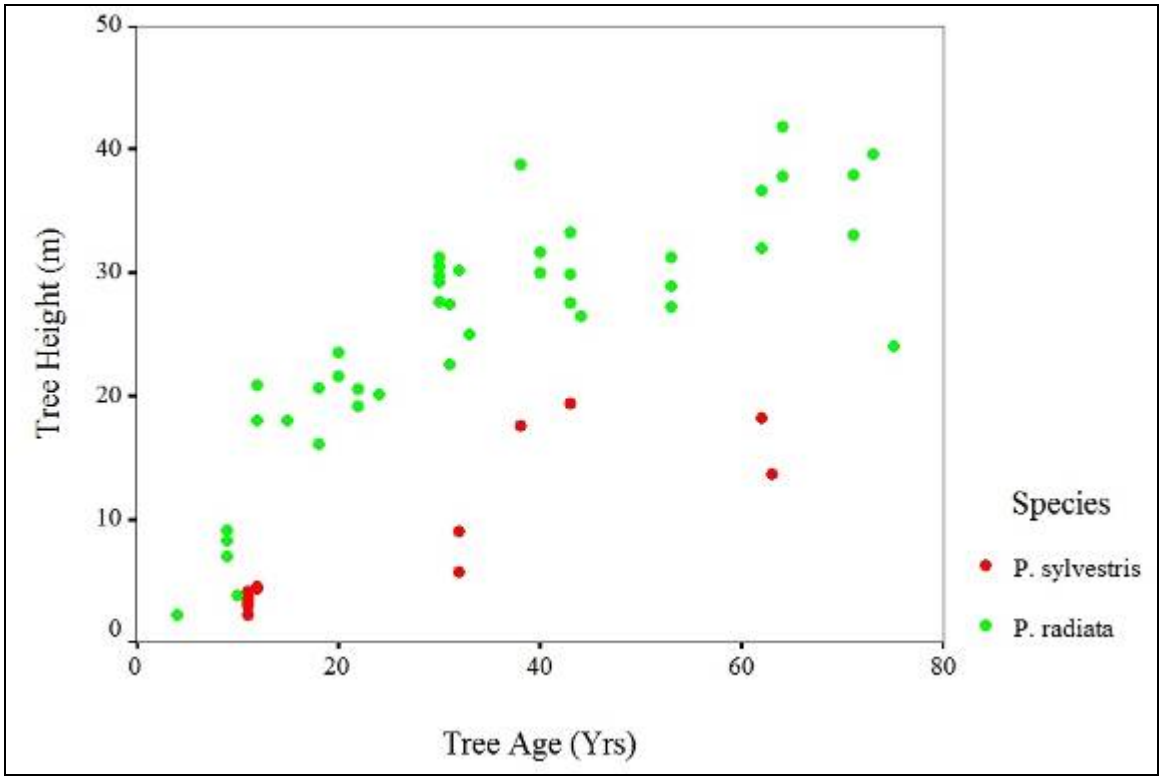


Figure 11.6: Comparative height growth – *P. radiata* vs *P. sylvestris*

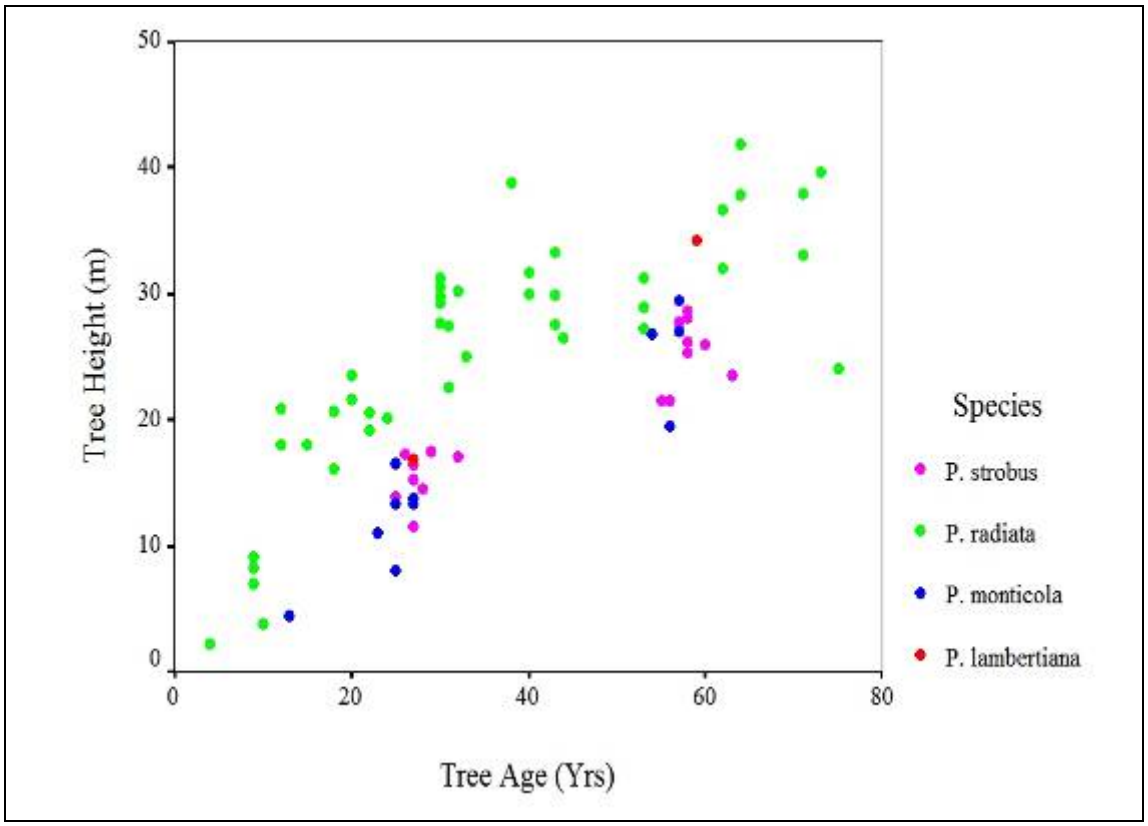


Figure 11.7: Comparative height growth – *P. radiata* vs white pines

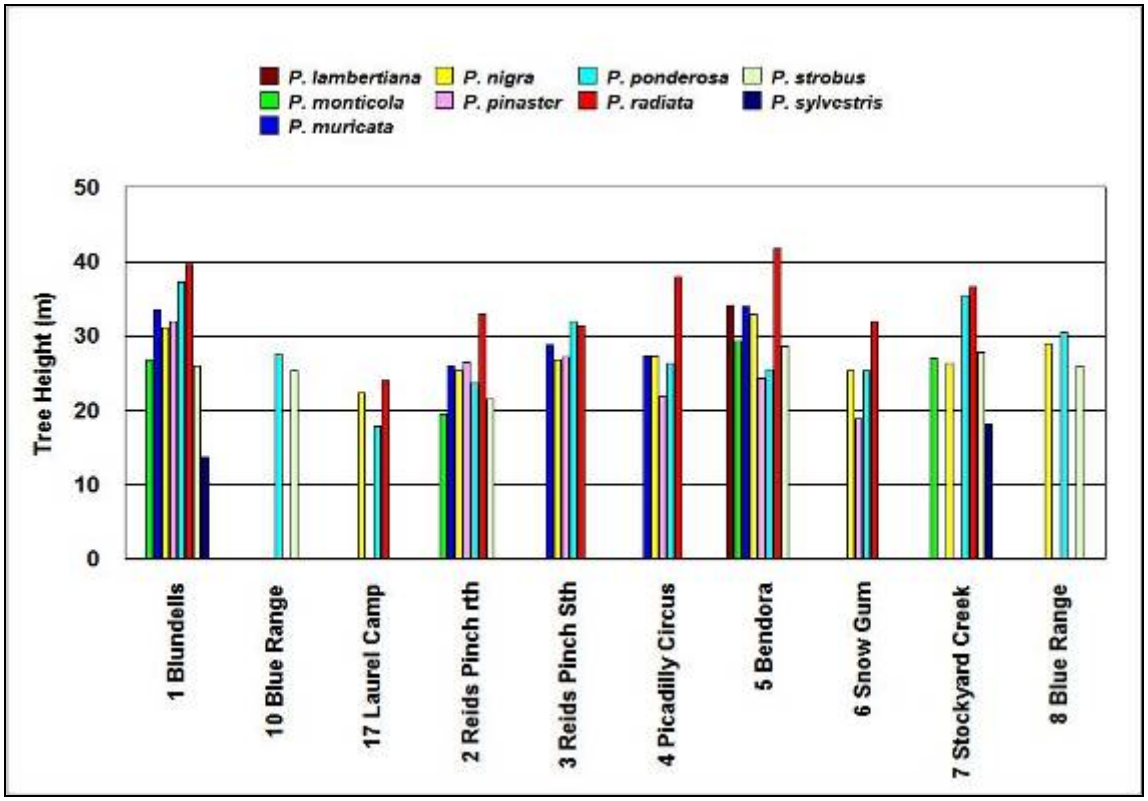


Figure 11.8: Average tree height in plots older than 50 years

These figures clearly show the generally superior height growth of radiata pine compared to a range of other likely contenders, confirming the conclusion of Rout and Doran. It appears that the height growth of *P. muricata*, *P. ponderosa* and *P. nigra* may be comparable to that of *P. radiata* at ages above about 50 years. However, this result may be more apparent than real, as the best-performing radiata plots in terms of height growth were not re-measured in 2004. Furthermore, rotation lengths of 50 years or more are highly unlikely to be economic for any species.

A poor provenance of *Pinus ponderosa* (left) and 66-year-old *Larix decidua* (right), Bendora arboretum (Photo: Alan Brown)

Noble fir (*Abies procera*) planted as early as 1940 at Stockyard Creek. These are the only two trees of the whole arboretum remaining in September 2007. One tree has a fire scar on the butt, and the diameter of both is more than 60 cm. (Photo: Steve Thomas)

12. The 2003 Bushfires

In January 2003, widespread bushfires occurred throughout eastern Australia with loss of livestock and property. In the ACT the fires were particularly devastating. On 8 January, electrical storms ignited five fires in the Brindabella Ranges, but these remained relatively small, burning about 70 km^2 in the eight days following their ignition. However, on the 18 January fires, fanned by wind speeds of about 100 kph and hot, dry conditions, burned about 1650 km^2, affecting about 80% of the ACT, with loss of life and destruction of residential property in Canberra.

Although the intensity of the fires varied in different locations, all the arboreta in the Brindabellas, except for Bendora, were destroyed.

Picadilly Circus arboretum, *P.pinaster* 6/12/03. Tree breeding has now transformed this species' poor stem form, very evident in this plot.
(Photo: A. Brown)

Picadilly Circus arboretum, *Sequoia* 6/12/03 (Photo: A. Brown)

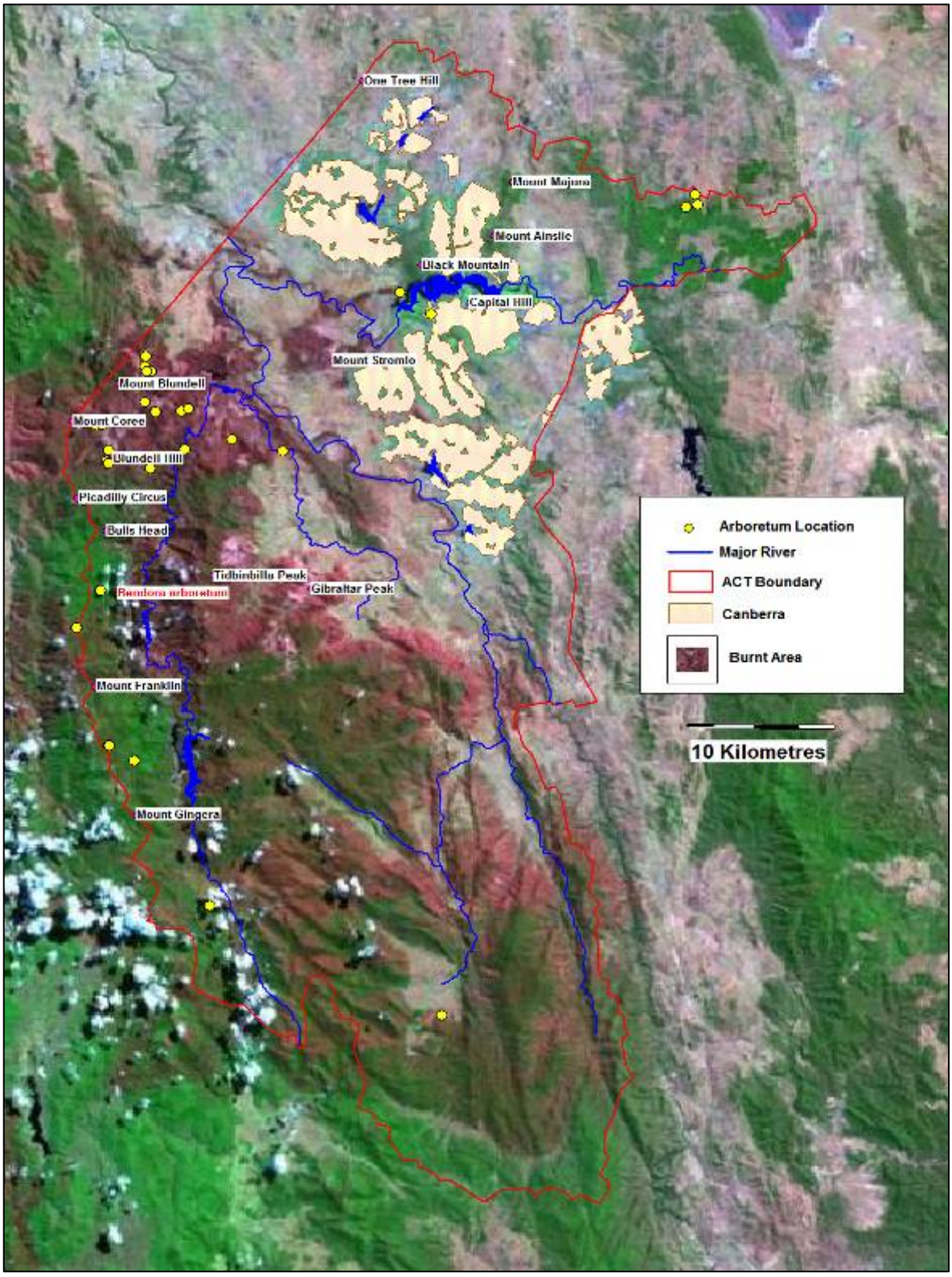


Figure 12.1: 2003 bushfires

13. Discussion

Selection of species for a plantation development program in the 21st century is a complex task, requiring the weighing-up of a host of factors, including not just the rate of tree growth but also considerations such as susceptibility to disease, drought tolerance, nutrient requirements, ease of propagation, silvicultural requirements, intrinsic wood properties, market competitiveness of the potential final product range, and log shape and size, to name but a few.

The ACT arboretum program, commencing as it did in the second decade of the 20th century, could not hope to address all these issues, and indeed, selection of radiata pine as the preferred species for large-scale afforestation in south-eastern Australia had already been made prior to commencement of the arboretum program, although ponderosa pine was still being planted in the ACT until the 1950s.

When the ACT's first arboretum was planted by Weston in 1913 there was little knowledge of how the growth and form of other species would compare across a range of sites with that of radiata pine, which by that time was being planted quite widely, especially in Victoria, NSW and SA.

*Pinus cembra, p*age 977, Arboretum et Fruticetum Britannicum (abridged), Loudon 1869

However, the initial reaction of sawmillers to radiata pine was unfavourable. The relative immaturity of the first harvests and the concomitant high proportion of juvenile wood of low density and stiffness in the logs caused problems in seasoning and machining, and in its use for structural purposes. It was not a foregone conclusion that radiata pine would retain its favoured status as southern Australia's primary plantation species. North American species such as *Pinus lambertiana, P. monticola, P. strobus, P. ponderosa* and Douglas-fir already had a reputation as superb softwood timbers, and were being imported to Australia. There was a real interest in determining how well these species, and others, would grow in southern Australia.

Radiata pine was also known to be susceptible to snow damage and not well suited to higher elevations. Parts of the high-altitude country in southern NSW and north-eastern Victoria were perceived by some, at the time, as being a candidate for conversion to exotics. *P. contorta, P. muricata* and *P. sylvestris* were of interest for this purpose and planting under a eucalyptus canopy was attempted in the high-elevation arboreta at Mt Ginini and Bendora.

Fielding and Nicholson stated in 1954 that the main objectives of the arboretum program were to:

- *identify species suitable for the south-eastern tablelands,*
- *provide material for a breeding program, and*
- *identify species which could replace radiata pine in the event of biological catastrophe.*

There was also an implied objective, not clearly stated, to identify species which might be suited to afforestation on high-altitude sites, replacing native eucalypt forest.

With respect to the first objective the essential final result of the arboretum program was to confirm that no other species tested could consistently out-perform radiata pine on south-eastern Australian sites. That conclusion was effectively summed up by Pryor (in Higgins 1995):

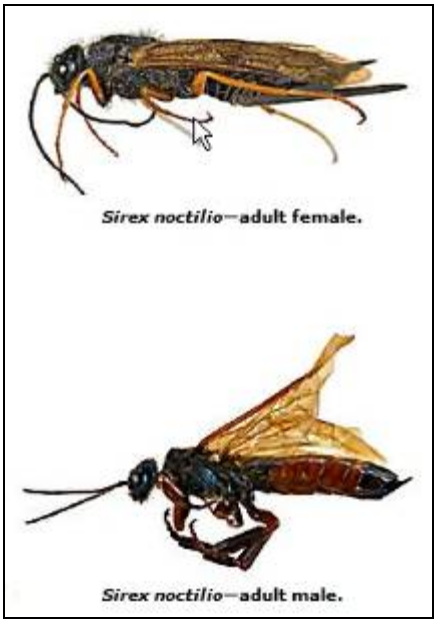
…the most significant thing is that they've [i.e. the arboreta] given a negative answer absolutely clearly in deciding that many species of conifer are not as good as Pinus radiata*… There was nothing tried that was a … challenger to* Pinus radiata*.*

Eldridge (1998) summarises the major seed collections for Australia of radiata pine from California, noting that seed from the collections of Jacobs in1940 from Aňo Nuevo, Monterey and Cambria, S.B. Benson in 1954 from Cedros Island, and Fielding in 1949, also from Aňo Nuevo, Monterey and Cambria, were represented in the arboreta at 3 Reids Pinch South, 19 Halls Block and 9 Blue Range.

Fielding, in about 1960 (as reported by Eldridge 1998), was of the opinion that these plots demonstrated clearly that:

Australian plantations already had the best provenances, a mixture of Aňo Nuevo and Monterey, with Monterey predominating.

With the knowledge gained by observation of the growth of these provenances in the ACT's arboreta, Eldridge's subsequent seed collections in these Californian stands provided the material for a series of radiata pine provenance trials throughout southern Australia, although none of this material was included in Australia's radiata pine breeding population (K. Eldridge, *pers. comm.*). Eldridge (1998) provides details of 67 provenance trials and genetic conservation plantings established from 1933 to 1994, including those in the ACT's arboreta.



Source: http://www.na.fs.fed.us/spfo/pubs/pest_al/sirex_woodwasp/sirex_woodwasp.htm

In the early phase of radiata pine plantation development, *Diplodea*, *Chermes* and incipient *Sirex noctilio* were regarded as the main biological threats. In the event, the most serious pathogens of radiata pine to become established in southern Australia were *Sirex* and *Dothistroma pini*.

However, the substantial investment in radiata pine plantations in Australia (about 700 000 ha by 2006 — Parsons *et al.* 2007) and the parallel program of state and company-funded research on the genetics, breeding, nutrition, epidemiology, silvicultural management, and utilisation of the species, has cemented its place as the species of choice. *Sirex* and *Dothistroma*, although present in Australian radiata pine plantations, do not pose a serious threat.

Indeed, many of the species which were considered as alternatives, such as *Pinus ponderosa*, *P. attenuata* (and its hybrids), Douglas-fir, *P. contorta* and *P. nigra*, for example, have exhibited greater susceptibility to insects and diseases, paralleling New Zealand's experience where, with the exception of Douglas-fir, many of the same species were tested, found to be susceptible to pathogens, notably *Dothistroma*, and discarded for large-scale afforestation.

By the 1970s, as noted in the FTB's 1970 annual report, and in Rout and Doran's 1974 report, the scientific life of the arboreta had about ended. The superiority of radiata pine had been confirmed and FTB's research activity was focused on breeding to improve its performance, although the Jerilderie arboretum, with its emphasis on dry-land species selection, remained of scientific interest.

In subsequent years increasing acknowledgement was made of the aesthetic and recreational values of the arboreta. Eldridge in a 1985 CSIRO file note summed up the evolving sentiment:

Sit down in one of the arboreta for half an hour, lean your back on a tree, look around, and see if you agree that it is a place for human enjoyment and spiritual reward.

During the ensuing 25 years, work in the arboreta was mainly confined to removal of species with potential to spread into surrounding native forest, including the felling of most of Stockyard Creek which was perceived to be of high risk from that perspective, access maintenance, and fire-protection activities in a selected few arboreta. Labelling of species in those arboreta was undertaken as well as the preparation of explanatory leaflets and other material for the general public, which came to increasingly value the arboreta for recreational purposes.

Planning, predominantly by precursors of FACTA, to ensure preservation of several arboreta for their historic, aesthetic, recreational and residual scientific values, through heritage listing, was abruptly curtailed by the 2003 fires, which destroyed all but Bendora arboretum.

However, in 2004, in acknowledgement of the historic significance of Bendora, a proposal to include it on the ACT's Interim Heritage Places Register was prepared by the ACT Heritage Council and a conservation plan for its management was prepared by FACTA. As of April 2008 the proposal is awaiting acceptance.

As the last remaining arboretum in the Brindabellas, and containing magnificent examples of trees that were typical of the arboretum program as a whole, it is worthy of preservation as an enduring, living monument to those who devoted so much effort and dedication to furthering the very significant role of plantation forestry in the economy and landscape of south-eastern Australia.

Figure 13.1: Bendora arboretum from Mt Franklin Road, 1260 m asl, radiata pine predominant (Photo: J. Shirley)

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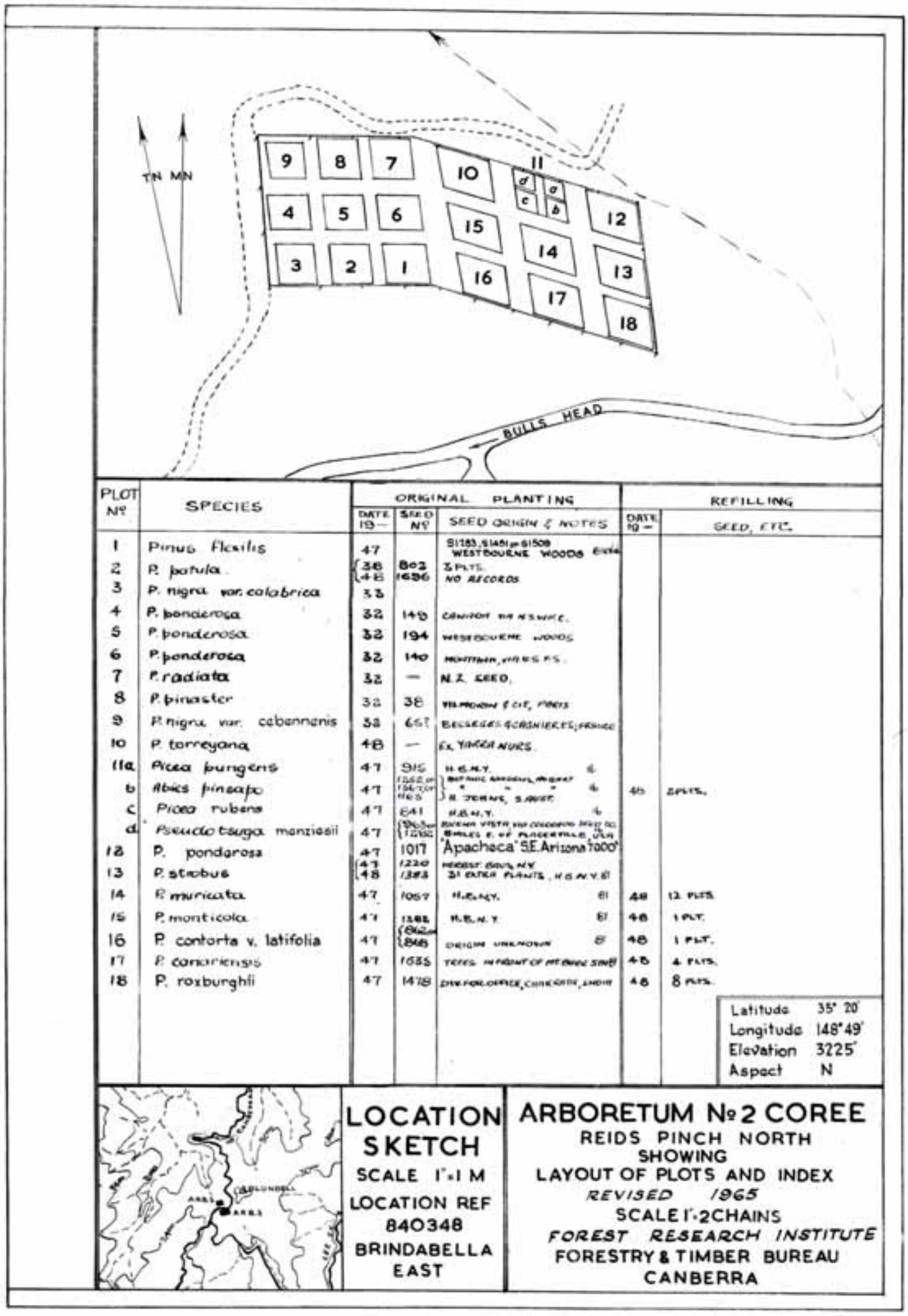
Appendix 1: Typical Arboretum Map

Figure A1.1: Typical Arboretum Map



Appendix 2: Common Names of Species

Table A2.1: Species' common names

Species	Code	Common Name	Class[1]
Abies amabalis	ABAMB	Pacific silver fir	SFWD
Abies balsamea	ABBAL	Balsam fir	SFWD
Abies cilicica	ABCIL	Cilicica fir	SFWD
Abies concolor	ABCON	White fir	SFWD
Abies grandis	ABGRA	Grand fir	SFWD
Abies homolepis	ABHOM	Nikko fir	SFWD
Abies magnifica	ABMAG	Californian.red fir	SFWD
Abies nordmanniana	ABNOR	Caucasian fir	SFWD
Abies pindrow	ABPIW	Pindrow fir	SFWD
Abies pinsapo	ABPIN	Spanish fir	SFWD
Abies procera	ABPRO	Noble fir	SFWD
Abies religiosa	ABREL	Sacred fir	SFWD
Abies sachalinensis	ABSAC	Sachalin fir	SFWD
Abies spectabalis	ABSBS	Himalayan silver fir	SFWD
Abies spp	ABSPP	Fir	SFWD
Acer circinatum	ACCIR	Vine maple	HDWD
Acer platanoides	ACPLA	Norway maple	HDWD
Acer pseudoplatanus	ACPSE	Sycamore	HDWD
Acer rubrum	ACRUB	Red maple	HDWD
Alnus glutinosa	ANGLU	Black alder	HDWD
Araucaria bidwillii	ARBID	Monkey puzzle tree	HDWD
Betula alba	BTALB	European birch	HDWD
Brachychiton populneum	BRPOP	Whiteflower kurrajong	HDWD
Callitris columellaris	CACOL	White cypress pine	SFWD
Callitris glauca	CAGCA	White cypress pine	SFWD
Callitris intratropica	CAITA	Northern cypress pine	SFWD
Carya tomentosa	CYTOM	Mockemut hickory	HDWD
Castanea vesca	CAVES	Sweet chestnut	HDWD
Cedrus atlantica	CEATL	Atlas cedar	SFWD
Cedrus brevifolia	CEBRE	Cyprus cedar	SFWD
Cedrus deodara	CEDEO	Deodar	SFWD
Cedrus libani	CELIB	Lebanon cedar	SFWD
Chamaecyparis lawsoniana	CHLAW	Lawson cypress	SFWD
Chamaecyparis obtusa	CHOBT	Hinoki	SFWD
Chamaecyparis thyoides	CHOBA	Atlantic white cedar	SFWD
Cryptomeria japonica	CRJAP	Japanese cedar	SFWD
Cunninghamia konishii	CNKON	China fir	SFWD
Cunninghamia lanceolata	CNLAN	Chinese fir	SFWD
Cupressus arizonica	CUARZ	Arizona cypress	SFWD
Cupressus atlantica	CUATL	Morrocan cypress	SFWD
Cupressus guadalupensis	CRGUA	Guadalupe Island cypress	SFWD
Cupressus macnabiana	CUMNB	MacNab cypress	SFWD
Cupressus macrocarpa	CUMAC	Monterey cypress, macrocarpa	SFWD
Cupressus sempervirens	CUSEM	Mediterranean.cypress	SFWD
Cupressus torulosa	CUTOR	Bhutan cypress	SFWD
Eucalyptus bicostata	EUBIS	Southern blue gum	HDWD
Eucalyptus fastigata	EUFAS	Brown barrel	HDWD
Eucalyptus delegatensis	EUDEL	Alpine ash	HDWD
Eucalyptus globulus	EUGLO	Blue gum	HDWD
Eucalyptus obliqua	EUOBL	Various	HDWD
Eucalyptus regnans	EUREG	Mountain ash	HDWD
Fraxinus americana	FRAME	White ash	HDWD
Fraxinus excelsior	FREXC	European ash	HDWD

[1] "SFWD": Softwood; "HDWD": Hardwood

Species	Code	Common Name	Class[1]
Fraxinus ornus	FRORN	Flowering ash, Manna ash	HDWD
Fraxinus oxycarpa	FROXY	Raywood ash	HDWD
Fraxinus pennsylvanica	FRPEN	Green ash	HDWD
Fraxinus pubescens	FRPUB	Red ash	HDWD
Fraxinus raywoodii	FRRAY	Claret ash	HDWD
Ginkgo biloba	GIBIL	Ginkgo, Maidenhair	SFWD
Juglans regia	JUREG	English walnut	HDWD
Juniperus communis	JUNCOM	Common juniper	SFWD
Juniperus procera	J.PRO	African juniper	SFWD
Juniperus spp	J.SPP	Juniper	SFWD
Juniperus virginiana	J.VIR	Pencil cedar	SFWD
Larix decidua	L.DEC	European larch	SFWD
Larix eurolepis	L.EUR	Dunkeld larch	SFWD
Larix kaempferi	L.KAE	Japanese larch	SFWD
Larix laricina	L.LAR	Tamarack	SFWD
Libocedrus decurrens	LIDEC	Incense cedar	SFWD
Metasequoia glyptostroboides	MSGLY	Dawn redwood	SFWD
Picea abies	PIABI	Norway spruce	SFWD
Picea engelmannii	PIENG	Engelmann spruce	SFWD
Picea glauca	PIGLA	White spruce	SFWD
Picea mariana	PIMAR	Black spruce	SFWD
Picea omorika	PIOMO	Serbian spruce	SFWD
Picea orientalis	PIORI	Oriental spruce	SFWD
Picea polita	PIPOL	Alcock spruce, Tigertail spruce	SFWD
Picea pungens	PIPUN	Colorado spruce	SFWD
Picea rubens	PIRUB	Red spruce	SFWD
Picea sitchensis	PISIT	Sitka spruce	SFWD
Picea smithiana	PISMI	Western.himalayan spruce	SFWD
Pinus armandii	P.ARM	David's pine	SFWD
Pinus attenuata	P.ATT	Knobcone pine	SFWD
Pinus ayacahuite	P.AYA	Mexican white pine	SFWD
Pinus banksiana	P.BAN	Jack pine	SFWD
Pinus brutia	P.BRU	Turkish pine	SFWD
Pinus canariensis	P.CAN	Canary Islandpine	SFWD
Pinus cembra	P.CEM	Cembran pine	SFWD
Pinus cembroides	P.CMD	Mexican pinyon	SFWD
Pinus contorta	P.CON	Lodgepole pine	SFWD
Pinus cooperi	P.COO	Cooper's pine	SFWD
Pinus coulteri	P.CUL	Coulter pine	SFWD
Pinus densiflora	P.DEN	Japanese red pine	SFWD
Pinus douglasiana	P.DGL	Douglas pine	SFWD
Pinus durangensis	P.DUR	Durango pine	SFWD
Pinus echinata	P.ECH	Shortleaf pine	SFWD
Pinus edulis	P.EDU	Two needle pinyon	SFWD
Pinus eldarica	P.ELD	Mondell pine	SFWD
Pinus elliottii	P.ELL	Slash pine	SFWD
Pinus engelmannii	P.ENG	Apache pine	SFWD
Pinus flexilis	P.FLX	Limber pine	SFWD
Pinus gerardiana	P.GER	Chilgoza pine	SFWD
Pinus glabra	P.GLA	Spruce pine	SFWD
Pinus greggii	P.GRG	Gregg's pine	SFWD
Pinus halepensis	P.HAL	Aleppo pine	SFWD
Pinus hartwegii	P.HTW	Hartweg pine	SFWD
Pinus jeffreyi	P.JEF	Jeffrey pine	SFWD
Pinus lambertiana	P.LAM	Sugar pine	SFWD
Pinus leiophylla	P.LEI	Smooth-leaved pine	SFWD
Pinus leucodermis	P.LEU	Bosnian pine	SFWD
Pinus massoniana	P.MAS	Chinese red pine	SFWD
Pinus michoacana	P.MIC	Michoacan pine	SFWD

Species	Code	Common Name	Class[1]
Pinus montezumae	P.MZA	Montezuma pine	SFWD
Pinus monticola	P.MON	Western white pine	SFWD
Pinus mugo	P.MUG	Mountain pine	SFWD
Pinus muricata	P.MUR	Bishop pine	SFWD
Pinus nigra	P.NIG	European black pine, Austrian pine	SFWD
Pinus oocarpa	P.OOC	Ocote pine	SFWD
Pinus patula	P.PTA	Patula pine	SFWD
Pinus pinaster	P.PIN	Maritime pine	SFWD
Pinus ponderosa	P.PON	Ponderosa pine	SFWD
Pinus pringlei	P.PRL	Pringle pine	SFWD
Pinus pseudostrobus	P.PSU	False weymouth pine	SFWD
Pinus radiata	P.RAD	Radiata pine, monterey pine	SFWD
Pinus resinosa	P.RSN	Red pine	SFWD
Pinus rigida	P.RGA	Pitch pine	SFWD
Pinus rigitaeda	P.RIG	Hybrid of P. rigida & P. Taeda	SFWD
Pinus roxburghii	P.ROX	Chir pine, imodi pine, long-leaved pine	SFWD
Pinus rudis	P.RDS	Mexican mountain pine	SFWD
Pinus sabiniana	P.SAB	Digger pine, gray pine	SFWD
Pinus serotina	P.SET	Pond pine	SFWD
Pinus strobus	P.STB	Strobus pine	SFWD
Pinus sylvestris	P.SYL	Scot's pine	SFWD
Pinus tabulaeformis	P.TABU	Chinese red pine	SFWD
Pinus taeda	P.TAE	Loblolly pine	SFWD
Pinus taiwanensis	P.TIW	Formosa pine	SFWD
Pinus tenuifolia	P.TNU	Pino, ocote	SFWD
Pinus teocote	P.TEO	Aztec pine	SFWD
Pinus thunbergiana	P.THA	Japanese black pine	SFWD
Pinus thunbergii	P.THN	Japanese black pine	SFWD
Pinus torreyana	P.TOR	Torrey pine	SFWD
Pinus virginiana	P.VIR	Virginia pine	SFWD
Pinus wallichiana	P.WAL	Bhutan pine	SFWD
Pinus yunnanensis	P.YUN	Yunnan pine	SFWD
Poplar	POSPP	Poplar	HDWD
Populus alba	POALB	White poplar	HDWD
*Populus '*Androscroggin*'*	POAND	Androscroggin	HDWD
Populus angulata	POANG		HDWD
Populus canadensis	POCAN	Carolina poplar	HDWD
Populus deltoides	PODEL	American black popler	HDWD
Populus euramericana	POEUR	Imperial poplar	HDWD
Populus 'Frye'	POFRY		HDWD
Populus nigra	PONIG	Black poplar	HDWD
Populus 'Rumforde'	PORUM		HDWD
Populus spp	POSPP	Poplar	HDWD
Populus tremula	POTRE	European aspen	HDWD
Populus yunnanensis	POYUN	Yunnan poplar	HDWD
Pseudotsuga flahaulti	PSFLI		SFWD
Pseudotsuga macrocarpa	PSMCR	Bigcone douglas fir	SFWD
Pseudotsuga macrolepis	PSMLP		SFWD
Pseudotsuga menziesii	PSMEN	Douglas fir	SFWD
Quercus alba	QUALB	White oak	HDWD
Quercus bicolor	QUBIC	Swamp white oak	HDWD
Quercus cerris	QUCER	Turkey oak	HDWD
Quercus garrayana	QUGAY	Oregon oak	HDWD
Quercus lobata	QULOB	Valley oak	HDWD
Quercus palustris	QUPAL	Pin oak	HDWD
Quercus petraea	QUPET	Sessile oak	HDWD
Quercus robur	QUROB	Pedunculate oak	HDWD
Salix alba	SXALB	White willow	HDWD
Salix discolor	SXDIS	Pussy willow	HDWD

Species	Code	Common Name	Class[1]
Salix spp	SASPP	Willow	HDWD
Sciadopitys verticillata	SCIAVE	Japanese umbrella pine	SFWD
Sequoia sempervirens	SQSEM	Coast redwood	SFWD
Sequoiadendron giganteum	SDGIG	Sierra redwood	SFWD
Taxodium distichum	TADIS	Bald cypress	SFWD
Taxodium mucronatum	TAMUC	Montezuma cypress	SFWD
Tetraclinis articulata	TEART	Sandarack	SFWD
Thuja occidentalis	THOCC	Northern white cedar	SFWD
Thuja orientalis	THOLS	Dwarf thuja	SFWD
Thuja plicata	THPLI	Western red ceda	SFWD
Tilia intermedia	TIINT	Common lime	HDWD
Tilia parvifolia	TIPAR	Small-leaved lime	HDWD
Tilia sylvestris	TISYL	Lime	HDWD
Tsuga canadensis	TGCAN	Common hemlock	SFWD
Ulmus spp	ULSPP	Elm	HDWD
Widdringtonia juniperoides	WDJUN	Clanwilliam cedar, Cape cedar	SFWD
Widdringtonia schwarzii	WDSCZ	Willowmore cedar	SFWD
Widdringtonia whytei	WDWHY	Mlanje cedar	SFWD

Appendix 3: Other Interesting ACT plantings

A number of other plantings of historical interest have been established in the ACT.

Figure A3.1: Other ACT Plantings

Glenloch Cork Oak Plantation[2]

The plantation consists of about 10 ha of Quercus suber planted in 1923 near the Glenloch Interchange, as part of Burley Griffin's vision for a self-sustaining city. The cork has proved to be of high quality and of commercial value and there have been a number of harvests.

Quercus suber is native to south western Europe and northern Africa.

The site is listed on ACT's Heritage Register.

Figure A3.2 Glenloch Cork Oak plantation

Pialligo Redwoods

About 120,000 mixed Sequoiadendron gigantea and Sequioa sempervirens seedlings were planted at Pialligo near the south eastern boundary of Canberra airport by Weston in 1918, again at Burley Griffin's request, despite advice that the Canberra climate is too dry for these species. S. gigantea was reported as growing better than S. sempervirens in 1967 and appeared to have had more tolerance to the drought of 1965 -1966 (FTB File note, 1967) .

A number of trees were removed to enable the airport to be extended. The remaining trees are exhibiting signs of stress and mortality is occurring, with only the hardiest surviving where moisture is sufficient.

[2] See http://www.tams.act.gov.au/live/heritage/heritage_assets/duntroon_wollshed

Figure A3.3 Pialligo Redwoods

Westbourne Woods

This arboretum (and adjacent Yarralumla seedling nursery) was established by Weston at Yarralumla mainly between 1914 and 1918. It occupies about 120 ha and contains one of the largest collections of conifers in Australia with over 150 species of conifers, hardwoods and eucalypts. Many of the trees planted in Canberra were selected on the basis of their growth in Westbourne Woods, notably the cedars fronting Old Parliament House which were transplanted by Weston from the Woods in 1926 (Rout and Eldridge, 1983).

The arboretum has a long history of association with the AFS, which occupied land which formed part of the arboretum, and it has been used as a teaching aid in courses in forest botany, dendrology and mensuration since 1927.

The mid 1940s saw the arboretum struggle with drought and lack of maintenance, with many of the groups of trees planted by Weston in need of thinning.

In 1945 Max Jacobs promoted the idea of turning the arboretum into a golf course so that funds to water and maintain the trees would be available. Work by the Department of Parks and Gardens to construct the fairways commenced in 1949 during Pryor's tenure as Director, and in 1960 most of the area was leased to the Royal Canberra Golf Club when its course was flooded by the formation of Lake Burley Griffin.

Public walks in the arboretum began in 1981 and are currently conducted once a month by the Friends of the ACT Arboreta.

Westbourne Woods – Royal Canberra Golf Course, original plantings
(Photo: J. Shirley, 2008)

Canberra International Arboretum

This arboretum is in its very early stages of development. It is planned to plant about 100 "forests" of predominantly rare and endangered species from around the world. Planting commenced n 2007.

Site of Canberra International Arboretum Source
http://www.cmd.act.gov.au/arboretum/images/arb_byshot04.jpg

CIT Department of Horticulture Arboretum

This arboretum is located in Weston suburb. It is about 2.5 ha in area and was planted by Canberra's Parks and Gardens section in 1978 as a proving ground for species to be used in landscaping the city. It was transferred to Canberra Institute of Technology's ("CIT") Horticulture Department in the late 1980s.

The arboretum is noteworthy for its extensive collection of hardwoods, some of which are quite rare.

Figure A3.4: CIT's Department of Horticulture arboretum layout

Table A3.1: Some interesting trees in CIT's Weston Campus arboretum

Tulip tree (*Liriodendron tulipifera* ; L. chinense)	White cedar or bead tree (*Melia azedarach*)
Red horse chestnut *(*Aesculus x carnea)	Small-leaved lime (*Tilia cordata*)
Golden rain tree (*Koelreuteria paniculata*)	Tupelo (*Nyssa sylvatica*)
Medlar (*Mespilus germanica*)	Ironwood (*Parrotia persica*)
Black walnut (*Juglans nigra*)	Common hornbeam (*Carpinus betulus*)
Chinese pistachio (*Pistacia chinensis; P. atlantica)*	American elm (*Ulmus americana*)
Pepper tree (*Schinus molle*)	Ginkgo (*Ginkgo biloba*)
Amur cork tree (*Phellodendron amurense*)	Dawn redwood (*Metasequoia glyptostroboides*)
Indian ban tee (*Catalpa bignoniodes; C.ovata*)	Pecan (*Carya illinoinensis*)
Chinese cedar/toon (*Cedrela sinensis*)	Beech (*Fagus sylvatica*)

Lindsay Pryor National Arboretum

This arboretum was gazetted 1 August 2001, the centenary year of Australian Federation, as a place of:

"…recreation, scientific research and public education and of the great importance of trees and forests to Australia in the centuries ahead",
to commemorate Pryor's contribution to the city.

The site was originally part of Walter Burley Griffin's proposal for a large continental arboretum, which did not proceed.

Between about 1952 and 1957 Pryor planted the area with mixed indigenous, deciduous and coniferous trees of fifty different species. The impetus for the planting was provided by the then Governor General, Sir William Slim, who was keen to improve the view from Government House which lies just across the lake to the south.

Pinus canariensis, Pryors Arboretum
(Photo: J. Shirley)

Arboretum Plaque
(Photo: J. Shirley)

Weston *Eucalyptus* Arboretum

This arboretum is located near Unwin Place in the suburb of Weston. The gross area is about 10 ha. Approximately 100 species of eucalyptus were planted here in 1980. The arboretum was laid out in eight parallel blocks running the length of the arboretum in a north-south direction. Seed was probably obtained from CSIRO Forest Research's Australian Tree Seed Centre but the seed identification numbers are unknown (FACTA, 2007).

An irrigation system was installed to water the seedlings, but has since fallen into disrepair.

An assessment by FACTA (unpublished) in 1992 indicated that about 93 species had survived. The 2003 bushfire damaged or killed many trees, and subsequent natural regeneration makes identification of some of the original plantings quite difficult.

In 2007 there were about 67 plots with one or more of the original trees surviving. Table A3.2 summarises the survival of the various species.

Table A3.2: Survival of Weston Eucalypts

Best Survival	Moderate Survival	Poor Survival*	Failed
E. argophloia	*E. agglomerata*	*E. apiculata (3)*	*E. acaciiformis*
E. banksii	*E. amplifolia*	*E. aromophloia (3)*	*E. amygdalina*
E. bauerana	*E. angophoroides*	*E. bauerlenii (4)*	*E. andrewsii*
E. bosistoana	*E. bancrofti*	*E. beyeri (4)*	*E. barberi*
E. bridgesiana	*E. baueriana*	*E. cannoni (3)*	*E. camphora*
E. caliginosa	*E. blaxlandii*	*E. chapmaniana (4)*	*E. debeuzevillei*
E. dawsonii	*E. benthamii*	*E. cordata (?) (4)*	*E. decorticans*
E. dwyeri	*E. dealbata*	*E. haemastoma (4)*	*E. dendromorpha*
E. globoidea	*E. dumosa*	*E. microtheca (4)*	*E. exserta*
E. longifolia	*E. fasiculosa*	*E. oleosa (2)*	*E. fraxinoides*
E. mckieana	*E. fibrosa ssp. nubila*	*E. pryoriana (2)*	*E. gunnii*
E. malacoxylon	*E. froggattii*	*E. squamosa (1)*	*E. kybeanensis*
E. moluccana	*E. michaeliana*	*E. viminalis (3)*	*E. oreades*
E. morrisbyi	*E. nigra (= E. eugenioides)*	*E. archeri (?) (1)*	*E. radiata*
E. orgadophila	*E. neglecta*	*E. badjensis (2)*	*E. rummeryi*
E. panda spp. illaquens	*E. oblonga*	*E. behriana (2)*	*E. sieberi*
E. parramattensis	*E. viminalis*	*E. botryoides(4)*	*E. stenostoma*
E. pilligaensis		*E. cephalocarpa (1)*	*E. sturgissiana*
E. polybractea		*E. consideniana (?) (1)*	*E. tenuiramis*
E. populnea		*E. gracilis (3)*	*E. triflora*
E. pulverulenta		*E. ligustrina (1)*	*E.olsenii*
E. rudderi		*E. notabilis (3)*	
E. tereticornis		*E. porosa (1)*	
E woollsiana		*E. siderophloia (4)*	
		E. transcontinentalis (2)	
		E. youmanii (4).	
		E. archeri (?) (1)	

* Number in brackets is the number of trees surviving

Figure A3.5: Weston eucalyptus arboretum, c 2006

Four species (*E. argophloia, E. benthamii, E. cannoni and E. mckieana*) growing in the arboretum have very restricted natural distributions and are classified as ‘vulnerable’ under the Environment Protection and Conservation Act (Department of Environment and Water Resources.

Weston eucalyptus arboretum. (Photo: J. Shirley, 2008)