One year after the fire

During the Australian summer of 2019–2020 Wandella Woods Arboretum, the arboretum of past IDS Australian Vice President BRIAN MYERS, was engulfed by flames. A year after the disaster he assesses the remarkable recovery of a large number of the trees throughout 2020.

Figure 1. The main street of Cobargo on New Year's Eve, 2019.

Summary

In the early hours of New Year's Eve 2019 a massive bushfire ravaged the town of Cobargo (Figure 1, above) in south-eastern New South Wales (NSW) and numerous surrounding localities including Wandella. Virtually all trees in Wandella Woods Arboretum owned and managed by IDS members Brian and Shirleyanne Myers were burnt or scorched. This is a report on the extreme climatic conditions that led to the fire, the more benign conditions in the wet year of 2020 that followed, and how the trees in the arboretum have responded one year after the fire. It summarises by what mechanisms different tree species and genera survived. One important lesson learned is to not be too hasty in felling exotic trees after fire damage. Numerous trees that looked totally dead in the first months have new healthy crowns after 12 months.

Climatic conditions before and after the fire.

2019 was the driest year in recorded history for south-eastern NSW. The total rainfall during the nine months April to December was 145 mm, just 16 mm per month, which was 77 % below the 130-year average and 30 % below the previous driest year of 1982 (see Figure 2 on page 118). The low rainfall was exacerbated by above average temperatures. 2019 was the hottest year on record in NSW at 1.95 °C above the long-term average.

In dramatic contrast, we had a very wet winter and spring during the year after the fire. From July to December 2020 the region enjoyed 150 % above average rainfall: 1009 vs 400 mm, under the influence of a strong La Niña event (see Figure 3 on page 119). The result has been growing conditions seldom experienced here and the transformation has been exceptional, particularly in the hardwoods. Many trees that appeared to be dead and and requiring removal in the autumn have recovered, with full healthy crowns.

Wandella Woods Arboretum

Wandella Woods is a 10 ha property in the Wandella Valley near Cobargo, in the Far South Coast region of NSW. The long-term annual rainfall is 930 mm. We started planting native and exotic trees in 2004. In the next 15 years we established over 350 broadleaved trees of 240 species (colloquially referred to as the hardwoods) and 180 conifers of 115 species including 17 Australian native conifer species. Some species were rare, endangered, or extinct in the wild.

About 20 m^3 of woodchip mulch had been applied to the younger and smaller trees between October and December before the fire, ironically to prevent the trees from dying in the drought.

The arboretum comprises 4 ha of native low-land eucalypt forest and 6 ha of planted trees in five sections: hardwoods, conifers, maples, wattles, and a trial of eucalypt species. The effects of the fire and degree of recovery differed dramatically depending on the section, species and genus, tree size and age and whether the trees had been mulched with woodchips.

The number of species of the major genera in the arboretum before the fire is shown in Table 1 (opposite).

The Badja Forest Road fire

The summer of 2019/2020 will always be remembered as 'Australia's Black Summer' when 18 million ha were burned nationally including 20 % of the country's forests—a figure unequalled anywhere in the world.

In NSW alone, more than 5.5 million ha (6.7 % of the area of the State) were burned, 33 people died, more than one billion native birds and animals were killed, and 2,476 homes were destroyed.

Beginning in August, wildfires progressively moved southward in eastern NSW until on 26 December the *Badja Forest Road Fire* began about 50 km north-west of Cobargo. Most of Wadbilliga National Park—comprising thousands of

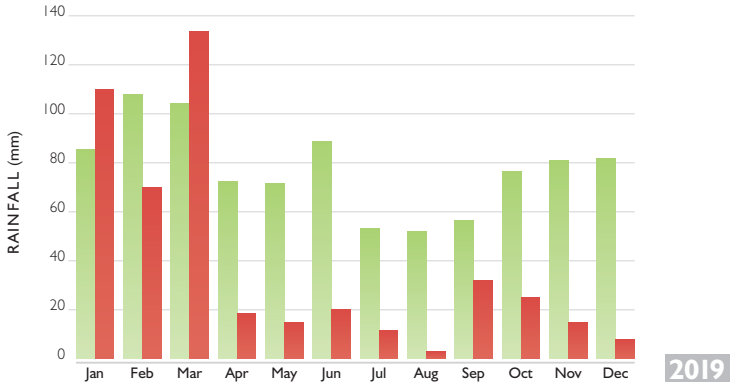

Figure 2. 2019 Monthly rainfall at Wandella (red); 130 year average (green)

Table 1. Major genera and species in the arboretum before the fire.

Genus	Common name	No. of species
Acer	Maple	52
Quercus	Oak	37
Pinus	Pine	30
Cupressus	Cypress	16
Acacia	Wattle	13
Callitris	Cypress pine	10
Betula	Birch	9
Fraxinus	Ash	8
Alnus	Alder	7
Picea	Spruce	7
Thuja/platycladus	Arborvitae	6
Liquidambar	Sweetgum	6

Genus	Common name	No. of species
Podocarpus	Podocarp	6
Cornus	Dogwood	5
Ulmus	Elm	5
Chamaecyparis	False cypress	5
Populus	Poplar	5
Fagus	Beech	4
Catalpa	Catalpa	4
Juniperus	Juniper	4
Araucaria	Araucaria	4
Other hardwoods		89
Other conifers		49

hectares to the north-west of Cobargo—had not undergone a fuel-reduction burn in more than 30 years.

Satellite imagery shows that approximately 160,000 ha of forest and farmland were consumed by this fire in the 24 hours from midday on 30 December. Figure 4 (see page 120) gives some idea of the extent of the fire. The fire burned more than 315,000 ha over 48 days, destroyed more than 400 homes, including many in Wandella and resulted in the deaths of five people.

During the annual Australian IDS meeting in 2009 two *Pinus halepensis*

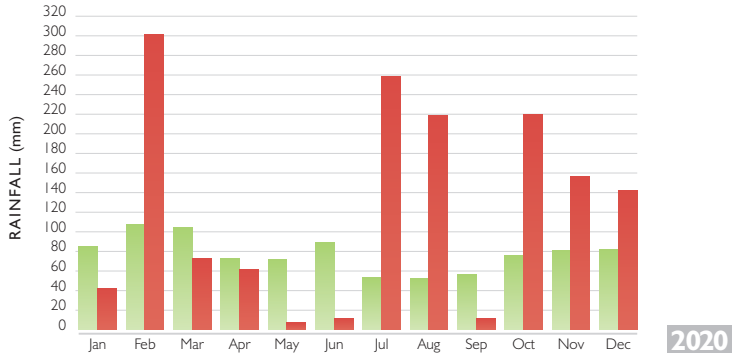

Figure 3. 2020 Monthly rainfall at Wandella (red); 130 year average (green)

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Figure 4. Aerial thermal image of the New Year's Eve fire.

(Aleppo pines) directly descended from seed collected by an Australian soldier in the trenches of Gallipoli, were planted by senior Australian members at the Wandella Hall War Memorial. Sadly, the two ten-year-old trees were killed and Wandella Hall itself was destroyed.

Arboretum damage and recovery

Wandella Woods is in the northern end of Wandella Valley. It is surrounded on three sides by Jeffers Ridge, 500 m ASL and Peak Alone, 900 m ASL. At the peak of the inferno on New Year's Eve, when the entire valley and surrounding ridges were burning, the air temperature in the valley would have been

Figure 5. Severity of fire damage to surrounding eucalypt forests in January 2020.

Figure 6. The hardwoods in January 2020 (**above**, **left**) and January 2021 (**above**, **right**).

extreme enough to scorch and kill all living foliage. As a rule of thumb, leaves exposed to 60 °C for 60 seconds will die. As temperature increases, the time required to kill foliage decreases exponentially. The temperature on that night likely exceeded 100 °C. One eyewitness in Wandella saw the fire front ascend from the valley floor to the top of Peak Alone in 25 seconds. The severity of the crown fire damage to native eucalypt forests on the slopes was extreme as shown in Figure 5. The entire area of the arboretum suffered ground fire, burning what little ground cover and litter there was. Some trees in the arboretum were burnt but the crowns of all trees were totally scorched—even up to 35 m.

The hardwoods

First six months (January–June 2020)

Before the fire, this section contained 350 native and exotic broadleaved trees from one to 15 years of age. Virtually every tree was totally crown-scorched. They shed their foliage and in the first few months they looked dead. But as time passed, more and more individuals began producing epicormic foliage, some on their trunks, and others on the branches. Other individuals produced basal coppice shoots from the trunk or root-shoots near their base. All basal shoots were protected from rabbit and wallaby browsing with wire mesh guards (not that there were many browsing animals left) and most grew encouragingly. In some cases, winter frosts killed the succulent epicormic foliage.

Last six months (July–December 2020)

Rainfall during winter and spring of 2020 was 150 % above average, resulting in excellent growing conditions. The transformation in the hardwoods has

Figure 7. Photos (**above and opposite**) show the full crown regrowth of several hardwood species. **Above left**, *Acer paxii*; **above right**, *Quercus suber*. **Opposite page**, **top left**, *Firmiana simplex*; **top right**, *Acer buergerianum*; **bottom left**, *Parrotia persica* and **bottom right**, *Prunus serotina*.

been exceptional. Many trees that appeared to be dead at the end of winter (September) have produced full healthy crowns. Others that produced healthy new coppice crowns are growing vigorously. The outcome is so much better than it appeared to be during winter. Figure 6 (on page 121) shows a view of the scorched hardwoods in January 2020 with the ground covered with dead leaves and the amazing recovery in the same view one year later.

Of the initial 350 trees in the hardwood section 143 (41 %) have produced a full, or more than 80 % crown regrowth. One hundred and ten trees (32 %) have recovered by producing vigorous basal coppice or root shoots. Fifteen trees (4 %) are alive but have less than 25 % of crown and only 81 trees (23 %) are dead or too severely damaged to be retained. Many of the trees in the 'full crown' category require substantial removal of fire-killed branches but will completely recover while those with only partial crowns may not survive or be kept.

There was a significant difference in survival rates between the major genera. *Quercus* (oak) species survived far better than any other genus with 90 % of trees (32 species) now growing well and only four trees were killed. 59 % of *Acer* (maples) survived (17 species) but 19 trees were killed. This does not include the younger trees burned in the maple section (see page 130). The

recovery of the major genera of hardwoods is shown in Table 2 on page 125.

Examples of full crown recovery of several species are shown in Figure 7 (opposite and above) include *Acer paxii* (evergreen maple), *Quercus suber* (cork oak), *Firmiana simplex* (Chinese parasol tree), *Acer buergerianum* (trident maple), *Parrotia persica* (Persian ironwood) and *Prunus serotina* (black cherry).

Figure 8. Photos (**above and opposite**) show strong coppice regrowth of several species. **Top left**, *Acer rubrum*; **top right**, *Acer capillipes*; **above left**, *Quercus macrocarpa*; **above right**, *Itoa orientalis*. **Opposite page**, **top left**, *Liriodendron chinense* and **top right**, *Castanea sativa*.

Examples of strong coppice regrowth of several species are shown in Figure 8 (opposite and above) include *Acer rubrum* (red maple), *Acer capillipes* (red snakebark maple), *Quercus macrocarpa* (burr oak), the very rare *Itoa orientalis*, *Liriodendron chinense* (Chinese tulip tree), and *Castanea sativa* (Spanish chestnut).

Table 2. Recovery in the hardwoods of the most common genera (*by survival rate*).

Genus	Common name	Number (pre-fire)	Full crown regrowth	Coppice regrowth	Survival rate (%)
Quercus	Oak	62	35	21	90
Liquidambar	Sweetgum	18	15	1	88
Fraxinus	Ash	16	9	5	87
Acer	Maple	51	13	17	59
Betula	Birch	17	2	5	41
Alnus	Alder	8	1	1	25
Cornus	Dogwood	7	1	3	57

The conifers

The conifers were much more severely affected by the fire than were the hardwoods, with greater mortality. Of the original 180 trees before the fire,

about 30 (16 %) have regrown full or substantial crowns after one year. These were primarily in the older section with larger trees between five and 15 years of age. Figure 9 (below and opposite top) is a view of the scorched conifers in January 2020 and the recovery and loss in the same view after one year. The green tinge on the burnt ground in January 2020 was grass sprouting due to scattered showers during the three weeks following the fire.

Table 3. Recovery in the conifers of the most common genera.

Genus	Common name	Number (pre-fire)	Full crown regrowth	Survival rate (%)
Pinus	Pines	43	14	33
Taxodium	Swamp-cypresses	6	6	100
Cupressocyparis	Leyland cypresses	5	4	80
Araucaria	Monkey puzzles	7	3	42
Podocarpus	Podocarps	9	3	33
Cupressus	Cypresses	21	2	9
Juniperus	Junipers	4	1	25
Callitris	Cypress-pines	16	1	6

There was a significant difference in survival rates between the major genera of conifers which is shown in Table 3 (above). The two genera that recovered best were *Taxodium* and *Pinus*. Both *Taxodium* species survived, *Taxodium distichum*

photograph © Bryan Myers

Figure 9. The older conifers in January 2020 (**above**) and in January 2021 (**opposite page**, **top**).

photograph © Bryan Myers

(bald cypress) and *T. mucronatum* (Montezuma-cypress), as did 14 individuals of six pine species. Three podocarps of different species produced healthy epicormic crowns—*Podocarpus elatus* (Illawarra plum, an Australian native), *P. henkelii* (Henkel's yellowwood) and *Afrocarpus falcatus* (Figure 12, page 128, bottom right). Also, two *Araucaria cunninghamii* (hoop-pine) produced healthy epicormic crowns (Figure 10, below). This epicormic foliage in the hoop pines was unexpected. Among the Australian native conifers, three of seven *Araucaria* (21 %) recovered. Surprisingly, the native *Callitris* (Cypress-pines) did very poorly with only one tree surviving. Trees in the cypress family (Cupressaceae) were the worst affected (e.g. cypresses, false-cypresses, cypress-pines, junipers and cedars). No *Abies* (firs) or *Picea* (spruces) survived. Three *Sequoia sempervirens* (coast redwoods) did survive producing copious stem epicormics and basal shoots.

Most conifers that developed 'full 'crowns have required high pruning of fire-killed branches—some up to over half their height. Figure 11 (on page 128) shows two high-pruned *Pinus pinaster* (maritime pine).

Crown recovery happened in two phases. During the first six months

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Figure 10. Epicormic foliage on *Araucaria cunninghamii* (Hoop-pine).

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Figure 11.
High pruning on two *Pinus pinaster* (maritime pine) to remove fire-killed branches.

some trees produced epicormic foliage, and during the wet spring, normal foliage grew from over-wintering buds leading to full crown recovery in some trees. Examples of 'full' crown recovery of several conifer species are shown in Figure 12: *Pinus pinea* (Stone pine), *Afrocarpus falcatus* (Outeniqua yellowwood), *Taxodium mucronatum* (Montezuma cypress), *Cunninghamia lanceolata* (Chinese-fir), *Pinus patula* (Mexican weeping pine), and *Pinus halepensis* (Aleppo pine).

photographs © Bryan Myers

Figure 12. 'Full' crown regrowth of several conifer species. **Opposite page**, **far left**, is *Pinus pinea* and **right**, *Afrocarpus falcatus*. **This page**, **top left**, *Taxodium mucronatum*; **top right**, *Cunninghamia lanceolata*; **above left**, *Pinus patula* and **above right**, *Pinus halepensis*.

The maples

This was the newest section of the arboretum and suffered the worst damage. Before the fire there were 130 trees of 35 *Acer* species from 5 to 10 cm in diameter planted from 2017 to 2019 all of which were deeply mulched for drought protection. They were planted in groups of five to nine trees per species arranged to contrast the visual effect of differing autumn colours. That aim has been set-back by the fire, but it will still happen in due course. The deep wood-chip mulch around each tree burned resulting in the death of

Figure 13, (**below left** and **bottom left**) shows the remains of two burnt maple trees. Figure 14, **below right**, the author (**left**) and Simon Grant (**right**) IDS Australian Vice President with the regrowing *Acer pentaphyllum*.

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125 of the 130 trees (Figure 13, opposite). Five trees of three species survived, fortunately one of which was an *Acer pentaphyllum* (five-leaved maple) that is believed to be extinct in the wild in China (Figure 14, opposite). Six trees of three species have regrown from root suckers. Four were *A. campestre* (field maple), one *A. cappadocicum* 'Aureum' (golden Caucasian maple) and one *Acer pseudoplatanus* 'Atropurpureum' (purple-leaf sycamore maple). We have begun re-establishing the maple section by planting 30 new trees of four species to replace some of those killed and we have several more species in the nursery.

Eucalypt species trial

A trial of farm forestry *Eucalyptus* and *Corymbia* species was planted in 2004 consisting of 20 trees each of five species in replicated plots. Seventy trees remained before the fire. The best performing species at age 15 was *Corymbia maculata* (spotted gum) with a height of 30.2 m and diameter at breast height of 34 cm. Figure 15 (below) shows the recovered champion *C. maculata* in January 2021 (tree on the right).

The crowns of all trees were totally scorched, even up to 30+ m and the foliage was shed. Figure 16 (on page 132) shows the trial with burnt ground in January 2020 and the same view showing crown recovery in January 2021. The two *Corymbia* species have fully recovered. They have produced full crowns with very few stem epicormics and have shed their bark in large thick sheets.

photograph © Bryan Myers

Figure 15. Recovered tree crowns in the species trial in January 2021.

Figure 16. (**above**) the Eucalypt species trial in January 2020 (**left**) and January 2021 (**right**).

Figure 17. (**below**) copious root suckers from Maiden's wattle (**left**) and Tasmanian blackwood (**right**).

The smallest three species: *Eucalyptus tricarpa* (Mugga ironbark), *E. argophloia* (Chinchilla white gum) and *E. cladocalyx* (sugar gum) suffered more severe damage, have produced many stem epicormics and will need to be removed.

The wattles

The acacia (wattles) were planted in 2004. There were initially ten individuals of ten species. Many species are relatively short-lived, and some had died after 16 years. Before the fire there were just 30 trees of four species remaining, all of which were killed by the fire. One of the very interesting and unexpected developments was that after several months many thousands of new individuals grew up from root shoots (not seed germination) of two of the

Figure 18. (**above**, **left**) the 'Wattle Walls of Wandella' in June 2020. Figure 19. (**above**, **right**) shows epicormic stem growth on a *Eucalyptus meulleriana* (Yellow stringybark) after five weeks. **Below**, *Eucalyptus baueriana* (blue box) after ten weeks.

longer-lived species *Acacia maidenii* (Maiden's wattle) and *A. melanoxylon* (Tasmanian blackwood) (Figure 17, opposite). We have slashed the wattle regrowth in bays to produce the 'Wattle Walls of Wandella' (Figure 18, above) which will provide a useful windbreak in the future. The sucker regrowth after one year is up to 2 m tall and some individuals are located up to 30 m away from the dead parent tree.

Native trees and forest

Eucalypts have evolved in Australia in a fire-prone environment and are well adapted to recover from fire. Different eucalypt species respond to fire quite differently. Species with rough bark have epicormic buds (dormant growth buds) deep beneath the bark which are protected from fire. When the tree is burnt and the foliage removed, the epicormic buds are triggered into life and they start to grow. Other eucalypts regenerate

Figure 20. Champion *Eucalyptus baueriana* (blue box) before the fire.

Figure 21. Champion *Eucalyptus baueriana* in January 2020 (**left**) and January 2021 (**right**).

from underground lignotubers which are large root structures from which the tree can sprout new growth. Although the above-ground part of the tree may not survive being burnt, the lignotuber and root-system remains alive.

At Wandella, while the crowns of all the native trees were scorched and shed their foliage in January and February, rough bark species such as *Eucalyptus baueriana* (blue box), *E. muelleriana* (yellow stringybark) and *Angophora floribunda* (rough-barked apple) started producing stem epicormics within a month of the fire (see Figure 19 on page 133). Smooth-barked species such as *E. elata* (river peppermint) only began producing basal shoots from their lignotubers after six to 12 months if at all.

One incredibly sad tree loss was the destruction of a gigantic *Eucalyptus baueriana*. It was arguably the largest tree of the species in Australia with a height of 30 m and a girth of 5.4 m, (Figure 20) but was not listed on the *National Register of Big Trees* because it was not a single stem. It consisted of three stems which had inosculated leaving a channel up the middle, in which native orchids grew. In the fire, the channel acted as a chimney conducting intense flames up inside the tree which virtually exploded in four directions (Figure 21).

Many severely damaged mature trees have shown their resilience after 12 months. Figure 22 (opposite) shows an appropriately named *Angophora floribunda* in full flower in January 2021 against the backdrop of the ravaged slopes of Peak Alone. Our lowland forest that did not suffer crown fire is

Left, Figure 22. *Angophora floribunda* in full flower, January 2021. **Below**, Figure 23 shows dense *Acacia mearnsii* germination under a killed *Eucalyptus elata* (river peppermint) stand.

Figure 24. Barren forest on Jeffers Ridge above the arboretum, January 2021.

recovering with a dense understorey of *Acacia mearnsii* (black wattle) (Figure 23). This is an important stage of recovery as the wattles fix nitrogen and help to regenerate the burnt soil. Various eucalypts in the forests further up the slopes that were destroyed by the crown fire appear to be totally dead and will take many more years to recover (Figure 24).

Conclusion

It has been a relief that so many trees have recovered well one year after the fire. More hardwood trees recovered (nearly 75%) than conifers (only about 15 %). There were large differences between genera. Fire-damaged exotic trees should not be felled too soon post-fire before they have had a year to recover.

The 'Tree of Life' sculpture that survived the fire (Figure 25) is a symbol of the resilience of trees and our optimistic hopes for the future.

Figure 25. The 'Tree of Life' sculpture that survived the fire.