Mt Cooke Wildfire

January 2003

Report on Monitoring Sites

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Mt Cooke Spring 2002- 3 months before the wildfire

Mt Cooke Wildfire January 2003:
Monitoring Impacts and Recovery

On a warm, dry day in January 2003 a lightning strike sparked a wildfire at Mt Cooke. It burnt through more than 18,000 hectares over three days, making it one of the largest wildfires ever recorded in the northern jarrah forest.

Fires ignited by lightning or people, have been a feature of landscapes in the South West for tens of thousands of years. However, the Mt Cooke wildfire was unusual and significant because of its large size, high intensity and immediate physical impact on ecosystems.

Refuges and refugees

The Mt Cooke fire burnt in an unpopulated area. While there was no loss of human life and only minor property damage, including the destruction of a number of high-voltage power poles and a Bibbulmun Track campsite, the fire was an extreme event of biological significance, presenting an opportunity to improve our understanding of how natural ecosystems are affected by fire and how they recover. These rare events also provide valuable lessons for fire and conservation managers.

Mt Cooke—named after Western Australia’s first Government Astronomer, Ernest Cooke—is a prominent and ancient granite outcrop, or monadnock, within the Monadnocks Conservation Park, some 75 kilometres south-east of Perth. Monadnocks are the remains of an ancient land surface that was thought to have been stripped away some time between the middle Jurassic and the Eocene, 150 million to 60 million years ago.

Granite outcrops of varying sizes are quite numerous throughout the northern jarrah forests, though they form a relatively small proportion of the landscape. They are ecologically significant because of their distinctive assemblages of plants, animals and other life forms in relation to their surrounding environment. They also provide refuge for relicts of ancient eras. Many species are only associated with granite outcrops. These distinctive assemblages rely on the particular conditions of soil, moisture, shelter and biological isolation that granite rocks provide. We have a poor understanding of the ways in which these ecosystems respond to fire, and the Mount Cooke fire provided an opportunity to improve our knowledge.

Mount Cooke and other monadnocks in the Monadnocks Conservation Park rise spectacularly from jarrah and marri forests and associated woodlands, heaths and wetlands. Before the wildfire, the surrounding jarrah forests had not been burnt for 15 to 20 years. This was a deliberate management strategy to protect the fire sensitive monadnocks, but it meant that the forests had reached their maximum fuel loads. Fuel formed from live and dead vegetation—especially dead leaves and twigs on the forest floor, flammable bark on the trees and understorey shrubs—accumulates quickly in the first few years after fire, then slows until, after about 16 years, the rate of accession is similar to the rate of decomposition.

Large sheets of moss, lichen-covered granite and rock piles decorate the summit of Mt Cooke. The diverse vegetation on the summit varies in composition and structure over short distances, due to variations in soil depth and structure and local water flow patterns. It changes from pincushion (*Borya nitida*) meadows, moss swards, herbfields, heaths, woodlands and eucalypt forests within tens of metres. Magnificent stands of Darling Range ghost gum (*Eucalyptus laeliae*) occupy the summit and slopes. Many plants such as minniritchi (*Acacia ephedroides*), an attractive wattle with bark resembling dried carrot peel, are restricted to granite outcrops in this region. This species, like many others growing amongst the rock piles, is readily killed by fire. However, these fire sensitive species also need fire, rarely regenerating in its absence. After a fire, they regenerate prolifically from seed stored in the soil or in woody capsules on the plant.

Granite rocks are often called 'fire refuges' because the rock sheets and piles form natural barriers to fire, and because much of the vegetation is sparse, elevated and discontinuous. However, fires do occur on monadnocks. Before this wildfire, patches of forest and heath vegetation on the summit were quite old. Ring counting of fire-killed *Calothamnus* stems revealed that the most gnarled, ancient-looking stems were about 45 to 50 years old, with nearby patches 20 to 25 years and 25 to 35 years old. Such a range of post-fire ages and associated vegetation structures and habitat types on the summit was probably the result of previous low-intensity, patchy fires on and around Mt Cooke over the past 50 years or so.

Reconstructing fire history by examining the stems of ancient grasstrees (see 'Believing the balga', *LANDSCOPE*, Autumn 1999), David Ward and Gerard Van Didden found that the landscape around the monadnocks was burnt much more frequently before European settlement than in recent decades. Before 1829, burning by Aboriginal people and lightning probably ensured that low-intensity fires burned much of the landscape on a regular basis. Under this regime, most fires were probably small, of low intensity and patchy, and monadnocks would have provided a refuge for fire-sensitive species.

The fire and its aftermath

Driven by north-west winds, and burning in long unburnt, heavy and dry forest fuels, the fire developed quickly, burning fiercely up the slopes and along the spine of Mt Cooke and southwards for another 25 kilometres or so. With its front generating intensities of 10,000 to 20,000 kilowatts per metre—and flames around 10 to 20 metres high—this wildfire was impossible to stop at its peak, only being brought under control when weather conditions abated and the fire ran into forests carrying low fuel as a result of an earlier prescribed burn.

So ferocious was the fire that there were no unburnt pockets or refuges over the entire 18,000-hectare burnt area, not even on the monadnocks. Long-unburnt forests, woodlands and wetlands with heavy fuel loads were the hardest hit. They were totally defoliated, as decades of solar energy stored in live and dead plant material was released in seconds. The material violently combusted, leaving a landscape of charred, black, smouldering, leafless tree boles. Virtually all humus and woody debris on the forest floor were consumed, ashbeds the only sign of their previous existence. With the exception of the stems of trees and larger shrubs, all live vegetation was incinerated, including leaves, twigs and small stems.

The stands of Darling Range ghost gums, heathlands, herbfields, pincushion meadows and moss swards on Mt Cooke's summit were completely defoliated by the flames, or severely scorched and charred by hot gases and radiation. There were no unburnt patches on Mt Cooke, laying to rest the notion that rock outcrops provided refuges from fire. The heat was so intense that granite rocks cracked and flaked under the extreme temperatures. Aluminium tags marking the Bibbulmun Track, which crosses Mt Cooke, melted; aluminium melts at about 620° centigrade.

Discarded glass bottles had melted, indicating that temperatures in at least some patches had exceeded 1000° centigrade. Many grasstrees (*Xanthorrhoea* sp.)—which are known for their fire resilience—literally had the resin boiled out of them, were carbonised and looked like molten wax candles. Many were killed. Animals didn't escape the flames either, with charred remains of lizards, kangaroos, quenda (bandicoots) and even birds visible in the ash.

Fire intensities were significantly lower in forests that had been prescribed burnt, to reduce the fuel load, in the previous five years. Although scorched, few trees were defoliated, unlike the forests that had not been burnt for more than 10 years.

Out of the ashes

Within weeks, the first green sprouts emerged amongst the black, with zamia palms (*Macrozamia reidlei*), grasstrees and kingias (*Kingia australis*) leading the way. Many kingias resprouted and flowered within four weeks, and dispersed seed within six weeks. In the following weeks and months, other plant species resprouted, either from epicormic buds buried under bark, or from below ground organs such as lignotubers, bulbs, corms and rhizomes. Other plants regenerated prolifically from seed, either stored in the soil or in woody capsules on the plant. Heat, smoke and other products from the fire stimulated a massive, synchronised release of seeds and triggered germination of dozens of species. The fire provided ideal conditions for seedling survival and growth. In spring, after the first winter rains, there were prolific seedlings of a great diversity of trees, woody shrubs and herbs.

Of concern is the lack of any sign of regeneration of the once extensive pincushion meadows, most of which were destroyed by the fire. While some plants survived, most were killed, probably by radiated and convected heat associated with this intense fire rather than by flaming combustion. Other organisms, especially relict invertebrates that probably depend on these meadows, have also been impacted. These meadows play a vital role in conserving the thin mantle of soil, much of which has consequently been eroded by water since the fire. Extensive areas of moss swards growing on rock surfaces, and associated organsisms, have also been killed by the fire. These could take decades to recover.

The winter rains also exposed another sinister consequence of high-intensity wildfires—soil erosion. Without the protection of vegetation, erosion on the steep slopes of Mt Cooke has resulted in tonnes of soil being washed into creeks and streams. Soil is vital to ecosystem health in any circumstance, but it is particularly critical on monadnocks, forming a thin, life-supporting mantle that overlays the rock. Apart from organisms such as lichens and mosses that are able to colonise the rocks, most other forms of life on monadnocks depend on the soil mantle, the depth of which varies from a few centimetres, which supports pincushion meadows and herbfields, to a metre or so, where woody shrubs and trees grow. The depth and type of soil determines the patterns of vegetation, and associated life, on the monadnocks. Because soils on rock outcrops are shallow and high in the landscape, they are particularly vulnerable to erosion, with irreversible consequences for biodiversity.

By two years after the fire, the understorey vegetation had regenerated spectacularly, except on patches where water erosion had removed the topsoil, or where the fire was so intense that it sterilised the topsoil, destroying the plant propagules. More than 75 species had flowered on and around Mt Cooke within a year after the fire. By two years, more than 120 species had flowered. The wildflower display in the second spring after the wildfire was stunning, and included a great diversity and abundance of orchids and everlastings. A number of fire-sensitive and keystone species—including mouse-ears (*Calothmnus rupestris*), *Acacia ephedroides* and *Thryptomene* sp.—that were killed by the fire have regenerated prolifically from seed. These may take four to five years to reach flowering age and set seed.

Another feature of the early post-fire environment is the great diversity of plant species. Up to 32 species have been recorded in a square metre, a result of the coexistence of longer-lived species and fire-stimulated, short-lived species.

Trees trashed

While the understorey shrubs and herbs are regenerating vigorously, it is a different story for the trees. More than 85 per cent of the heat energy of a bushfire is dissipated upwards, so for plants in a fire-prone environment it is best that their propagules are close to or in the soil, which is a good insulator and which receives less heat during a bushfire. However, many trees and tall shrubs such as eucalypts, banksias, hakeas and sheoaks rely on epicormic buds beneath their bark, or on seeds protected in woody capsules. This strategy works in most fire circumstances because in less intense fires the buds are not killed. However, as revealed by the Mt Cooke wildfire, it can fail under extreme fire intensities, resulting in plant death or incineration of the capsules and seeds.

Trees were severely impacted by the intense fire. It is most unusual for mature, fire-resilient forest trees to be killed by fire. However, over the 18,000 hectares burnt by the Mt Cooke wildfire, an estimated 1.6 million jarrah, marri, wandoo and Darling Range ghost gum trees killed outright, and about 5.5 million trees were killed back to ground level, from which they have resprouted. In the most intense parts of the fire, on and around Mt Cooke, up to 50 per cent of the large old-growth trees—some estimated to be more than 300 years old—were killed, suggesting this may have been the most intense fire these trees have experienced.

Mortality was lower amongst the small young trees, which were able to resprout vigorously from below ground lignotubers. By killing most trees back to ground level, the wildfire significantly changed the structure of forests over much of the 18,000 hectares affected by the fire, converting patches of mature and old-growth forests to regrowth forests. Parts of the forest will take many decades—perhaps centuries for some species—to recover to their pre-fire state.

There are also indications that this wildfire may have activated the jarrah dieback disease, possibly due to changes in soil moisture and temperature conditions resulting from complete defoliation of the forest. This requires further investigation.

Learning from catastrophes

This fire was one of the most severe wildfires in the northern jarrah forest. Fires of this scale and intensity are environmentally damaging, pose a serious threat to life and property, are very dangerous to suppress and are probably unprecedented over the last 300 years. Before the wildfire, there were at least three post-fire habitat stages on Mt Cooke's summit, reflecting the patchiness of past fires. This wildfire has drastically simplified the mosaic of vegetation, and habitat ages and structures, over a large area. Some impacts, such as loss of topsoil through erosion, are practically irreversible.

Surrounded by heavy, long-unburnt forest fuels, monadnocks cannot function as fire refuges, but are funeral pyres waiting to be ignited. Allowing fuels in the surrounding landscape to accumulate to high levels over large areas will result in another catastrophic fire within 15 to 20 years, causing irreversible changes to these ecosystems. The introduction of regular, low-intensity prescribed fires (mosaic patch-burning) to the surrounding fire-resilient landscape is essential to protect monadnock communities from lethal wildfires and to allow them to function as fire refuges. Such a fire regime will also provide habitat diversity at appropriate scales and will reduce the size, intensity, damage potential and suppression difficulty of wildfires.

FIRE SEVERITY AND INTENSITY

The severity of a bushfire can be characterised according to its immediate impact on the ecosystem, and in terms of the size of the area affected. The most obvious and immediate impact is the extent to which the vegetation has been consumed or scorched by the fire, which results in immediate habitat damage or destruction. Other measures of the severity of a bushfire are the level of death and injury to plants, animals and other living organisms, and the extent of soil exposure, erosion, heating and subsequent chemical and structural alteration. The severity of a bushfire will strongly influence how ecosystems regenerate and recover from a bushfire (see 'Fire for life', *LANDSCOPE*, Winter 2003).

Fire intensity—or the rate of heat energy release—is related to the size of the flames. It can be calculated knowing the amount of fuel (live and dead vegetation) consumed in the flames, the calorific value of the fuel and the rate of fuel consumption, or rate of spread of the flames. Fire intensity—expressed in kilowatts per metre of fire line—is usually calculated for the front of the fire, which is the most intense part.

Depending on the amount and type of fuel, fuel dryness, the weather and the terrain, forest fires can vary enormously in intensity, from about 200 kilowatts per metre to 100,000 kilowatts per metre, the latter approaching the intensity of Ash Wednesday fires and the 2003 Canberra fires. A forest fire is virtually unstoppable when its intensity exceeds about 2000 kilowatts per metre.

SUMMARY OF SOME FIRE IMPACTS

- Severe acute impacts on the vegetation – virtual total defoliation on and around Mt. Cook, removal of fuel and woody debris down to mineral earth.
- Landscape burnout was virtually complete.
- No unburnt patches or pockets remain on the monadnock itself (no refuges).
- Vegetation that did not burn was killed by radiated or convected heat, including moss swards, Borya meadows and 'Babylonian" gardens.
- Observed dead animals including mammals, birds and reptiles.
- Heat-caused exfoliation, flaking and cracking of granite rocks.
- Patches of soil sterilization – vascular plant propagules killed - absence of regeneration except moss swards.
- Understorey is recovering vigorously from seedlings and resprouts.
- Dense regeneration of herbs and other fire ephemerals.
- More than 100 understorey species flowered within 24 months of fire. Some keystone and fire sensitive species including *Acacia ephadroides, Calothamnus rupestris,* some Grevilleas and Hakeas have regenerated prolifically from seed but will probably take 3-5 years to reach flowering age.
- Large areas of moss swards on granite rocks and rock sheets killed, no signs of recolonisation. This will probably take decades? Commensurate impact on other forms of life (mainly inverts.) that depend upon moss swards.

- Large areas of Borya meadows (resurrection plant) killed; little sign of regeneration, which is worrying. Borya meadows grow on shallow soils overlaying rock, Destruction of Borya cover has resulted in significant erosion of thin soil mantle – change could be irreversible, or at best, decades to recovery. Commensurate impact on organisms that depend on Borya meadows, probably invertebrates with Gondwanaland links? This suggests that fires of this intensity are unusual, perhaps unprecedented?
- Rock lichens killed but some show remarkable resilience to heat.
- Overstorey most severely impacted as this is where most of the fire's heat was dissipated. Estimated several million trees (jarrah, marri, Darling Range ghost gum, wandoo) killed outright or killed back to ground level over the fire area. In most intense parts of the fire, long term structural changes to overtsorey. Commensurate with habitat changes.
- ~250 year old jarrah trees killed suggesting that this was the most intense fire experienced during their lifetime.
- Survivors regenerating vigourously from basal sprouts or epicormics.
- Dense seedling regeneration – all tree species.
- There has been significant localised soil erosion and transport of silt, ash, charcoal and plant propagules.
- Some indications that *Phytophthora* has been activated by the fire on some sites at the base of Mt Cooke e.g., ~9.5 km along Millars Log Rd from intersection with Albany hwy - several large patches where trees, which survived the fire by resprouting, are now dying some 2 years after the fire- symptoms consistent with dieback. Possible that complete defoliation over large area has affected surface hydrology on some sites – making soils wetter for longer due to loss of transpiring surface – needs further investigation.

Prior to January 2003 wildfire, and based on dendrochronological analysis, at least three fire ages or seral stages existed on the summit and upper slopes of Mt Cooke:

- o 20-25 years since last fire
- o 35-40 years since last fire
- o 45-50 years since last fire

Now there is one seral stage, so habitat diversity has been simplified over a large area.

Summary

- The <u>scale</u> and the <u>intensity</u> of the fire are of most concern to biodiversity values and ecosystem processes. Biological indicators suggest that fire on this scale and of this intensity is exceptional or possibly unprecedented.
- Heavy fuel loads in long unburnt forests surrounding Mt Cooke resulted in a large fire, extreme fire intensity and complete burnout on Mt Cooke and other granite outcrops.
- Surrounded by heavy, long unburnt forest fuels, monadnocks are not fire refuges, but funeral pyres.
- Prior to the wildfire, there existed at least 3 seral (post-fire) stages on Mt Cooke summit reflecting patchiness of past fires.
- The mosaic of vegetation/habitat ages and structures has been drastically simplified by the wildfire.
- Numerous overstorey trees and cryptogams have been killed or severely damaged over a large area and will take decades to recover. Some communities, such as Borya meadows, may never fully recover if soil is eroded.
- Impacts on fauna, including relictual invertebrates, are unknown.

FIRE MANAGEMENT IMPLICATIONS

- If monadnocks (and other ecosystems) are to be protected from such severe events, then the surrounding (flammable) landscape must be managed proactively with fire.
- Regular introduction of low intensity prescribed fire into the surrounding landscape is essential to ensure habitat diversity and provide some protection to monadnock communities from lethal high intensity summer wildfires.
- Long periods of fire exclusion in the surrounding landscape will ensure complete incineration of monadnock communities, high mortality of fauna and flora, substantial soil erosion, possibly irreversible changes to some rock-specific communities on shallow soils and damage to infrastructure.

LOCATION OF MONITORING SITES

I established most of the monitoring sites on and around Mt Cooke a few days after the fire and have been visiting them regularly to observe and record. I am particularly interested in recording the post-fire regeneration strategies of plant species and how long it takes various species to reach reproductive maturity, or flowering and seeding. I happened to be walking the Bib. Track over Mt Cooke in spring 2002, so have some before and after fire photo points. A selection of photo periods is shown below.

Photo Point 1: Looking up gully on west side of Mt Cooke at back of pines. Marked with star pickets 32^{o} 25.212 116^{o} 18.136.

Photo Point 2: Photo point on summit. Off Bib. Track looking south. Marked with short star picket 32^{o} 25.023 116^{o} 18.544. Northern end of Mt Cooke summit.

Photo Point 3: Approx. 120m N of Photo Point 2 off Bib. Track. Looking North. Marked with short star picket 32^{o} 245.980 116^{o} 18.531.

Photo Point 4: Approx 300m N of Photo Point 3, north end of Mt Cooke off Bib. Track. This is the most northerly of the Photo Points on Mt Cooke. Photo taken from rock cairn looking north with grass tree with bib track sign in middle of shot. 32^{o} 24.822 116^{o} 18.464.

Photo Point 5: South end of Mt Cooke ~200 m south of the end of the board walk. Looking south-west. Marked with short star picket 32^{o} 25.440 116^{o} 18.730.

Photo Point 6: ~300 m North of Photo Point 5 off Bib Track. Photo taken from a sheet of granite near a small rock cairn. Looking to the south. This is also location of **Vegetation Transect 3** 32^{o} 25.249 116^{o} 18.633.

Photo Point 7: Northern end of Millars Log Rod ~5.8 km from intersection of Albany Hwy and Millars Log Rd. West side of road in small swamp. Marked with star picket 32^{o} 21.804 116^{o} 18.361.

Photo Point 8:~9.8 Km from intersection of Albany Hwy & Millars Log Rd and 150m SE of the Power Lines. In jarrah forest and west side of rd. Marked with star picket 32^{o} 23. 553 116^{o} 19.452.

Photo Point 9: South along Power Line ~1.0 km from intersection with Millars Log Rd. In a wandoo gully between power poles 151 & 152. Marked with star picket

Photo Point 10: South along power line some 1.9 km from intersection with Millars Log Rd. Opposite pole 157. In a wandoo patch. Marked with steel picket 32^o 24.578 116^o 19.373

Photo Point 11: On summit of Mt Cooke, north end ~ 100m south of PPt 4. Taken off large rock sheet on Bib Track looking south 32^o 24.894 116^o 18.494.

Photo Point 12: On summit of Mt Cooke, off Bib track with big rock on RHS and grass tree in middle. Looking across forest to NE. 32^o 25.072 116^o 18.563.

Photo Point 13: On summit, off Bib Track near top of Board Walk. Photo of big rock (Cave Rock) on RHS. Looking N. 32^o 25.353 116^o 18.696.

Photo Point 14: On summit, off Bib Track. Opposite Photo Point 3. From rock sheet looking south. 32^o 24.973 116^o 18.534.

Photo Point 15: On summit off Bib Track looking south across valley to south end. Marked with small yellow peg.

Photo point 16: Near Photo Point 1:

VEGETATION MONITORING SITES (1mx1m quads)

Six vegetation monitoring transects were established – 2 in forest on the slopes of Mt Cooke, 4 and on the summit. On each transect there are 10 1x1m permanently marked quadrats (droppers). Species and numbers of individual plants are assessed each spring (commenced spring 2003) with the help of Ray Cranfield and Bruce Ward. Specimens are vouchered with Perth Herbarium.

Transect 1: On Bib. Track north of intersection with power lines – ~150 m along Bib track towards Mt Cooke. Transect is on the RHS going uphill. Sample line is 50 m long with droppers every 5 m, so 10 1m x 1 m quads per transect. 32^o 25.794' 116^o 19.226'

Transect 2: Approx 150 m north of T1, about 30 m south of granite outcrop on Bib Track. In Jarrah forest. 50 m long with droppers every 5 m. 1mx 1m marked with wire pins (same above). 32^o 25.749' 116^o 19.116'. Transect bearing 58 degrees.

Transect 3: At Photo Point 6. 32^o 25.249 116^o 18.633

Transect 4: At Photo Point 2: 32^o 25.023 116^o 18.544

Transect 5: At Photo Point 3: 32^o 245.980 116^o 18.531.

Transect 6: Also at Photo Point 3, opposite side: 32^o 245.980 116^o 18.531.

OVERSTOREY IMPACTS

One-off initial assessment of impact on overstorey trees was completed in December 2003 almost 12 months after the fire. Belt transects were used to score mortality and survival of tree species in heavy fuel, high intensity areas where forest was defoliated and in lighter fuel, moderate intensity areas where trees were mostly fully scorched.

PHOTO POINT 1

January 2003

January 2004

April 2005

PHOTO POINT 2

January 2003

January 2004

April 2005

PHOTO POINT 3

January 2003

January 2004

April 2005

PHOTO POINT 4

January 2003

January 2004

April 2005

PHOTO POINT 5

January 2003

January 2004

April 2005

PHOTO POINT 6

January 2003

January 2004

April 2005

PHOTO POINT 7

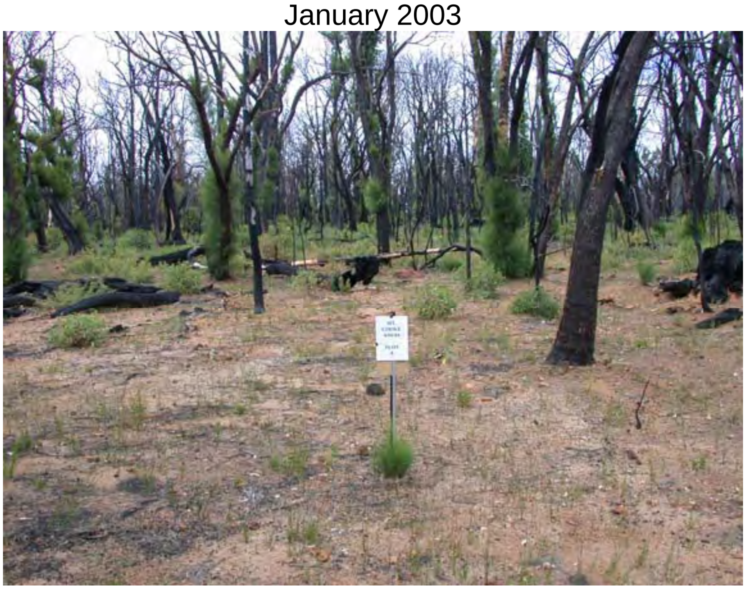
January 2003

January 2004

April 2005

PHOTO POINT 8

January 2003

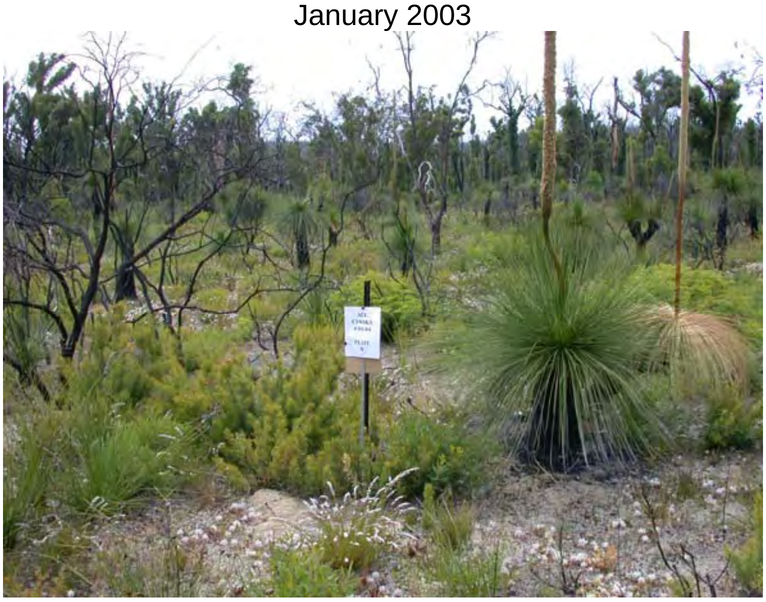


January 2004

April 2004

PHOTO POINT 9

January 2003



January 2004

April 2005

PHOTO POINT 10

January 2003

January 2004

April 2004

PHOTO POINT 11

October 2002

May 2003

January 2004

April 2005

PHOTO POINT 12

October 2002

May 2003

January 2004

April 2005

PHOTO POINT 13

October 2002

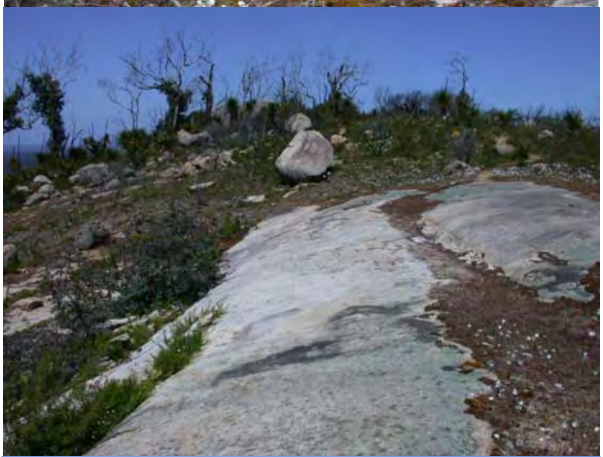
May 2003

January 2004

April 2005

PHOTO POINT 14

October 2002



May 2003

January 2004

April 2005

PHOTO POINT 15

October 2004

May 2003

January 2004

April 2005

PHOTO POINT 16

January 2003

January 2004

April 2005

Other impacts of interest

Damaged Borya meadow and associated soil erosion. Before the fire, soil mantles such as this were virtually covered by Borya, providing specialized habitat and protecting soils from erosion. Some plants survived the fire, but no sign of regeneration yet. April 2005

The pale/white coloured areas of bare, fresh rock surface were where previously covered by moss swards. Large areas of moss on rock surfaces have been destroyed. Brown patch top left is severe soil erosion. April 2005

High mortality rate of overstorey trees and some grass trees. Smaller, younger trees have resprouted either from lignotuber or epicormic shoots, but many older trees, especially of wandoo and Darling Range ghost gum, have been killed. October 2004

Indications of re-activation of jarrah dieback disease on some sites - possibly in response to changes in soil moisture and temperature regimes following defoliation of the forest by wildfire. Grass trees appear unaffected. Millars Log Rd April 2005