# Burning rocks

by Neil Burrows

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.

While fires, ignited by lightning or people, have been a feature of landscapes in the South West for tens of thousands of years, 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 Mt Cooke fire provided an opportunity to improve our knowledge.

Mt Cooke and other monadnocks in the Monadnocks Conservation Park rise spectacularly from jarrah and marri forests and associated woodlands,

*Previous page*
**Main** Extreme heat generated by the Mt Cooke wildfire cracked granite rocks and caused substantial environmental damage. Embedded in forests of long unburnt vegetation, rock outcrops are funeral pyres rather than fire refuges. **Inset** *Melaleuca parviceps*, one of many plants that regenerated and flowered within two years of the Mt Cooke wildfire.
*Photos – Neil Burrows*

**Above left** Before the January 2003 wildfire the Mt Cooke summit was a diverse mosaic of forest, woodlands, heathlands, moss swards and herbfields.
*Photo – Brett Dennis/Lochman Transparencies*

**Left** The Mt Cooke summit soon after one of the most severe wildfires in the northern jarrah forest in recent times.
*Photo – Neil Burrows*

**Above left** Crevices amongst rock sheets can provide protection from fire for plants and animals. However, there are no safe places in large-scale, high-intensity wildfires.

**Top** Before the wildfire, shallow soils and rock surfaces on Mt Cooke were covered with moss, lichen and pincushion plants. Many of these communities were destroyed by the fire and will take decades to recover.

**Above** A thicket of mouse-ears (*Calothamnus rupestris*) killed by wildfire but regenerating prolifically from seed. This species may take four to five years to flower and set seed and eight to 10 years to replenish its seed bank following the wildfire.

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 and 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 constricta*) 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 *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 depend on 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 referred to as '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 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 30,000 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,

**Top left** This grasstree (*Xanthorrhoea preissii*), which is about 200 years old, was one of many that were killed and carbonised by the wildfire, an indication that it was one of the most intense fires these plants have experienced.

**Centre left** Stands of Darling Range ghost gums on Mt Cooke following the fire.

**Left** Post-fire proliferation of daisies (*Hyalosperma cotula)* and pink sunray everlastings (*Rhodanthe manglesii*) frame the Bibbulmun Track boardwalk on Mt Cooke.
*Photos – Neil Burrows*

**Above** Like grasstrees, kingias (*Kingia australis*) are among the first plants to resprout and flower following fire. Kingias flowered within a few weeks of fire, while most other plants had flowered within two years.

**Above right** The flowering spikes of a grasstree.
*Photos – Neil Burrows*

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* spp.)—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*), and kingias and grasstrees (*Kingia australis* and *Xanthorrhoea preissii*) 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.

The winter rains also exposed a sinister consequence of high-intensity wildfires—soil erosion. Without the protection of vegetation, living or dead, sheet and gully erosion on the steep slopes of Mt Cooke resulted in tonnes of topsoil being washed into creeks and streams, which were choked by silt, ash and charcoal. Topsoil is vital to ecosystem health in any circumstance, but it is a particularly critical element on monadnocks. The soil on monadnocks such as Mt Cooke

## 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 a measure of the destructive power of a bushfire. It is related to the size of the flames and is largely dependent upon the amount of live and dead vegetation (fuel) consumed by the fire. It can be calculated knowing the amount of fuel consumed, 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 100 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 2500 kilowatts per metre.

**Above** The overstorey trees took the brunt of the intense heat generated by the wildfire. Many large, old trees were killed outright while younger trees were able to resprout from stem epicormic shoots protected beneath thick bark or from rootstocks buried beneath the soil. *Photo – Neil Burrows*

is 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.

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. Much of Mt Cooke is dominated by dense thickets of so-called 'fire weeds' such as the native prickly moses (*Acacia pulchella*). 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 on Mt Cooke 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 (*Calothamnus 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. Of concern is the lack of regeneration of the pincushion meadows and moss swards that were destroyed by the fire. These communities are important in their own right, but also protect the soil and provide specialised habitat for other life forms.

### 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 considerably 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 were killed outright, and about 5.5 million trees were killed back to ground level, from which they have resprouted. In the

**Top** Species such as *Thysanotus sparteus*, and many orchid species, resprout annually from underground rhizomes, bulbs or tubers so appear to be unaffected by summer wildfires.

**Above** Many plants that grow on rock outcrops, such as rock minniritchie (*Acacia ephedroides*), are readily killed by fire and regenerate from seed stored in the soil. Rock outcrop plants are often slow to mature, taking four to five years to reach flowering age and eight to 10 years to replenish the seed bank.

**Above right** CALM researchers Ray Cranfield and Bruce Ward assess the recovery of vegetation on the summit of Mt Cooke as part of a post-wildfire monitoring program.
*Photos – Neil Burrows*

most intense parts of the fire, on and around Mt Cooke, up to 50 per cent of the large, old trees—some estimated to be more than 200 years old—were killed, suggesting that this may have been the most intense fire these trees had 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 forests to regrowth forests. The forests will take many decades—perhaps centuries for some species—to recover to their pre-fire state.

## 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 200 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 reaccumulate to high levels over large areas is likely to result in another catastrophic fire within 15 to 20 years, possibly causing irreversible changes to these ecosystems. Burning monadnocks too frequently may also be damaging, but infrequent, low intensity patchy fires are necessary to promote and protect biodiversity. The introduction of regular, low-intensity prescribed fires (mosaic burning) to the surrounding more flammable and fire-resilient landscape, applied under mild conditions to avoid burning less flammable fire sensitive monadnock communities, is essential to protect monadnocks from lethal wildfires and to allow them to function as 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.

Neil Burrows is Director of the Department of Conservation and Land Management's Science Division. He can be contacted on (08) 9334 0463 or by email (neilb@calm.wa.gov.au).

Volume 20 Number 4 WINTER 2005

# contents



## Regulars



*Publishing credits*
**Executive editor** Caris Bailey.
**Editors** Carolyn Thomson-Dans, Rhianna Mooney.
**Contributing editor** David Gough.
**Scientific/technical advice** Kevin Kenneally, Paul Jones, Chris Simpson, Keith Morris, Kevin Bancroft.
**Design and production** Maria Duthie, Natalie Jolakoski, Tiffany Taylor, Gooitzen van der Meer.
**Illustration** Gooitzen van der Meer.
**Cartography** Promaco Geodraft.
**Marketing** Estelle de San Miguel
*Phone* (08) 9334 0296 *Fax* (08) 9334 0432.
**Subscription enquiries**
*Phone* (08) 9334 0481 or (08) 9334 0437.
**Prepress and printing** Lamb Print, Western Australia.
© ISSN 0815-4465



Please do not send unsolicited material, but feel free to contact the editors.

Visit NatureBase at www.naturebase.net

Published by the Department of Conservation and Land Management, 17 Dick Perry Avenue, Kensington, Western Australia.