Criterion 3

Maintenance of ecosystem health and vitality

This criterion contains two indicators. The first considers the scale and impact of agents and processes affecting forest health and vitality, including pests, diseases, salinisation, soil acidification and climate change. The second assesses the area of forest burnt by planned and unplanned fire.

Key findings

Threatening processes

- Drought affected large areas of Australia during the reporting period, with significant impacts on forest health in several regions. Drought contributed to a series of intense wildfires that affected large areas of forest in southeastern Australia.
- Predicted changes in climate, including increased temperatures and lower moisture availability, could make forests more susceptible to pests, diseases, fire and other pressures.
- Damage to forest ecosystems from most native insect pests and pathogens is usually widespread and of low severity. Occasional outbreaks and epidemics occur and the resultant damage can adversely affect commercial values, particularly in plantations.
- Several exotic organisms that pose a threat to Australian forests have moved closer to Australia's shores, increasing the importance of effective quarantine.

Fire

- The estimated area of forest burnt in the period from 2001 to 2006 was 24.7 million hectares; an estimated 20.0 million hectares was burnt in unplanned fires and 4.7 million hectares was burnt in planned fires.
- Fire is an important forest management tool in Australia because many forested ecosystems are ecologically adapted to fire and require it for regeneration.
- There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for planned fires to shift and narrow in southeastern Australia.

Fire in a pine plantation near a log dump, Tumut, New South Wales, December 2006.

Indicator 3.1a

Scale and impact of agents and processes affecting forest health and vitality

Rationale

This indicator identifies the scale and impact on forest health of a variety of processes and agents, both natural and human-induced. Through the regular collection of this information, significant changes to the health and vitality of forest ecosystems can be monitored and measured.

Key points

- Drought affected large areas of Australia during the reporting period, with significant impacts on forest health in several regions. Drought contributed to a series of intense wildfires that affected large areas of forest in southeastern Australia.
- Predicted major changes in climate, including increased temperatures and lower moisture availability, could make forests more susceptible to pests, diseases, fire and other pressures. The productive capacity of the principal timber production forests (both native and plantation) could decline in the medium term.
- Several exotic organisms that pose a threat to Australian forests have moved closer to Australia's shores, increasing the importance of effective quarantine. The European house borer, which infests seasoned coniferous timber and can cause structural damage to houses, has been detected in Perth and steps have been taken to control its spread.
- Damage to forest ecosystems from most native insect pests and pathogens is usually widespread and of low severity. Occasional outbreaks and epidemics occur and the resultant damage can adversely affect commercial values, particularly in plantations.
- Chemical pest and disease control methods used in forest plantations are highly regulated, and the quantity of pesticides used is estimated to be less than 1% of the total Australian market.

This indicator addresses the factors affecting the health and vitality of Australia's native forests and plantations and considers the impacts of vertebrates, invertebrates, pathogens, weeds, drought, soil acidification, climate change and other potentially damaging agents. The active management of these agents in forests is directed principally towards protecting commercial values in multiple-use public and private native and planted forests and, in all forests, biodiversity and other forest values. Many pests and diseases, particularly native ones, show cyclical patterns of impact and are generally of minor concern.

Limiting the introduction of new exotic pests and pathogens is the goal of biosecurity and quarantine measures. Specific plans have been prepared for several threats, including fire ants, guava rust and pine pitch canker (Case study 23 refers to red fire ants).

As with most agricultural enterprises, plantation forestry uses pesticides for crop protection and to improve production under the same system of regulation that applies to all other Australian chemical pesticide users. In 2003–04, the Australian forestry plantation sector was estimated to constitute less than 1% of the total Australian chemical pesticide market, including household and agricultural use.

Where chemicals are used to control pests and diseases, only authorised chemical ingredients are used and manufacturers' instructions on mixing and application are required to be strictly followed. Chemicals are applied using both ground-based and airborne application systems. To minimise spray drift, strict guidelines determine when spraying can be carried out. Forest management agencies are working continuously towards minimising chemical use and finding more targeted and environmentally benign active ingredients or non-chemical methods of control.

River regulation, extreme climatic events, salinisation, soil acidification and climate change also affect Australia's forests and are sometimes precursors to poor forest health.

Vertebrates

Animals can damage forests, for example by browsing and ringbarking juvenile and mature vegetation, contributing to soil erosion, competing for food and habitat, and predating on native fauna. Table D1 in Appendix D lists, by jurisdiction and tenure, the vertebrate animals that have destructive impacts in Australian forests and estimates the severity of those impacts.

Native species

Kangaroos, wallabies and possums can have an adverse impact in multiple-use public forests in most states and territories, particularly by grazing on seedlings in the early stages of forest regeneration and planting. In South Australia, the impact of kangaroos has increased compared to the SOFR 2003 reporting period, the impact of wallabies has declined and the impact of possums has remained the same.

Exotic species

At least 80 introduced animal species have established wild populations in mainland Australia. Some of those species, such as rabbits, foxes, pigs and cats, have become major pests in forests and the environment generally.[1] Foxes have a high adverse impact in forests in all mainland states and territories except the Northern Territory, while cats are also a significant problem in many jurisdictions. Pigs continue to have an adverse impact in Western Australia. Cane toads continue to be a problem in Queensland and have moved westwards into the Northern Territory and southwards into northern New South Wales. Exotic birds are a problem in the Australian Capital Territory and Queensland.

Invertebrates

Australia's native forests and eucalypt plantations are regularly browsed by a wide range of native insects, including leaf-chewing chrysomelid beetles, scarab beetles, sawflies, leaf skeletoniser moth larvae, and sapsucking psyllids. Infestations are sometimes severe and repeated, but control programs have generally been conducted only in plantations where attacks may result in reduced growth and poor form. Eucalypts are generally resilient and able to rejuvenate their foliage once infestation subsides, often as a result of native predator activity. Many outbreaks are also cyclical. Table D2 in Appendix D lists, by jurisdiction and tenure, the invertebrate animals that have destructive impacts in Australian forests and estimates the severity of those impacts.

Species of the chrysomelids *Paropsis* and *Paropsisterna* (formerly *Chrysophtharta*) cause damage in eucalypt forests and plantations Australia-wide. Their prevalence appears to have increased since SOFR 2003 in South Australia, Victoria and Western Australia, probably at least partly due to the growth in the total area of eucalypt plantations. Integrated pest management programs have been developed to minimise the effects of these pests.

Autumn gum moths (*Mnesampela privata*) are present in most states and territories and cause widespread damage to juvenile or young adult eucalypt foliage: young larvae skeletonise the leaf and older larvae eat the whole leaf, rapidly defoliating trees. Since SOFR 2003, autumn gum moths have become more of a problem in Victoria and South Australia. Broad-spectrum insecticides are sometimes used to control this insect in young plantations, but also reduce populations of beneficial predator insects.

The gumleaf skeletoniser (*Uraba lugens*) causes widespread and severe defoliation of natural eucalypt stands across a range of climatic and vegetation types, but generally few trees die as a result. Regional outbreaks tend to occur on a 5–10-year cycle. In plantations, impacts are not usually severe and control measures are generally unnecessary. The episodic impact of this insect increased in Western Australia in the SOFR 2008 reporting period compared to SOFR 2003.

Wingless grasshoppers can cause total defoliation in young eucalypt plantations, particularly during periods of drought, and have been significant pests in several states; recent prolonged drought led to an upsurge in severity in Western Australia and South Australia. The Australian plague locust had a widespread and severe impact in New South Wales during the SOFR 2008 reporting period.

Pests of exotic pine plantations that can reduce commercial productivity include the pine-killing wood wasp (*Sirex noctilio*), the Monterey pine aphid (*Essigella californica*), and the five-spined bark beetle (*Ips grandicollis*). *Sirex* usually attacks stressed trees, and numbers high enough to cause significant damage generally do not develop in vigorous, healthy stands. In the past, however, serious *Sirex* outbreaks have killed several million trees in *Pinus radiata* plantations in several states. The National Sirex Control Strategy encourages an integrated pest management approach that aims to keep *Sirex* wasp populations low by maintaining and releasing virulent strains of the nematode *Beddingia siricidicola*, as well as a range of parasitoid wasps, as biological controls, and by encouraging optimal

Common brushtail possum (*Trichosurus vulpecula*).

1 Hart and Bomford (2006).

plantation thinning practices and site selection to minimise the occurrence of stressed trees in areas at risk. Since it first entered Tasmania in the 1950s, *Sirex* has spread slowly through Victoria, South Australia, New South Wales and the Australian Capital Territory but has not yet been observed in Western Australia, Queensland or the Northern Territory. The extent and severity of *Sirex* attacks increased in New South Wales and Victoria during the SOFR 2008 reporting period compared to SOFR 2003. Regular trapping and surveillance programs monitor *Sirex* levels, and controls are implemented to avoid major outbreaks. Only a small number of individual, already suppressed trees are killed by *Sirex* under the optimal control practices in place in major plantations. Under the recent drought conditions, the incidence of *Sirex* and *Ips*-related tree deaths began to increase in southeastern Australia.

The Monterey pine aphid, which infests a range of pine species, was first observed in Australia in 1998 but was probably already in the country for some time by then. It has since been detected in most pine-growing areas in all states, but the biggest impacts have been in Victoria and New South Wales. In Victoria, the aphid is now widespread and having an adverse impact. Aphid levels are regularly monitored in most states using standard foliage-beating methods during surveys.

The five-spined bark beetle is the most serious pest among several exotic pine bark beetles that have been introduced accidentally from the northern hemisphere; it is able to infest all plantation pine species grown in Australia. The beetle has been present in Australia for at least 60 years and occurs in all mainland states and the Australian Capital Territory but is absent from Tasmania and the Northern Territory. Pheromone traps are used in some states to monitor beetle presence and numbers. Population levels build primarily on fresh logging debris or in damaged (e.g. after fire) or severely stressed standing trees. High beetle numbers, particularly in trees in overstocked stands during periods of drought, can result in tree death. The beetle also acts as a vector for blue stain fungi such as *Ophiostoma ips*. A range of parasitoids has been introduced into Australia to limit beetle numbers. Western Australia reports that the severity of *Ips* infestation has increased since SOFR 2003.

Australian sawfly (*Perga* sp.) larvae.

The European house borer (*Hylotrupes bajulus*) was first detected in Western Australia in 2004. This insect is a destructive pest of seasoned coniferous timber, including pine and oregon, and can cause major structural damage to buildings. Several measures are being taken to contain and, if possible, eventually eradicate this pest. For example, regulations were introduced in Western Australia in 2006 to control the movement of seasoned pine. Surveys are conducted regularly to detect new infestations, ways to better detect the pest are being developed, infested materials are removed and destroyed, and a communication program is under way to inform the general public and the building industry about the pest.

Fire ants (*Solenopsis invicta*) are another serious potential pest in Australia. Since they were first detected in Queensland in 2001, a major program has successfully controlled their spread (Case study 23).

Weeds

Species such as blackberry (*Rubus fruticosus*, *Rubus* spp.), lantana (*Lantana camara*) and brome grasses (*Bromus* spp.) compete with native flora and can become locally dominant, reducing biodiversity and other values; they can also interfere with commercial forest plantations impacting on access as well as tree growth and product yield. Table D3 in Appendix D lists, by jurisdiction and tenure, the exotic plants that are regarded as weeds in Australian forests and estimates the severity of their impact. Several exotic plants common in Australian forests are included in the Weeds of National Significance Program under the National Weeds Strategy.

Blackberries occur in all Australian states and the Australian Capital Territory and are the single most widespread pest plant threat across southern and eastern Australia, mainly in regions with an annual rainfall of more than 750 millimetres. The area of forest affected by this weed is not known nationally. Blackberry in forests is mostly controlled by herbicides.

Lantana is a shade-tolerant invasive pest plant which develops dense shrubby thickets that can overwhelm native species. It affects over 4 million hectares of land, predominantly in coastal forests extending from far north Queensland to southern New South Wales but also, to a lesser extent, in parts of the Northern Territory, Western Australia and Victoria. The weed is gradually spreading inland, and its impact in both multiple-use native forests and nature conservation reserves in New South Wales is now particularly severe. Whole ecosystems and many species are affected and some are threatened by this species. It causes major reductions in invertebrate and avian biodiversity and, among other things, can lead to a reduction in the recruitment of native plant species. Integrated pest management measures include the use of biological control agents such as introduced sap-sucking insects and a fungal leaf rust.

The invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) and boneseed (*C. monilifera* subsp. *monilifera*) is listed as a key threatening process in New South Wales. Bitou bush primarily invades dune vegetation systems and is found along more than 80% of the state's coastline. However, it also encroaches on coastal forest and woodland communities on the sand-dune fringes, where it affects numerous threatened species, plant communities and native animal habitats. Biological methods have proved to be of limited value in controlling the infestation of the bush, which has no known effective predators. A management regime being tested in southern New South Wales includes a spray–burn–spray cycle. In Queensland, the only significant occurrence of bitou bush is in areas in the southeast; control programs generally consist of removal by hand. The closely related boneseed is more widespread across different environments; it is found in southern New South Wales, Victoria, Tasmania and southeastern South Australia. Boneseed is an invader of a range of forest types and is spread by seed. Biological controls have so far been unsuccessful in Australia, and eradication efforts tend to involve uprooting and burning.

Willows (*Salix* spp.) have invaded many forested parts of southern Australia, mainly along watercourses; the Australian Capital Territory, New South Wales, Tasmania and Victoria are the jurisdictions most affected. Guidelines for the identification and eradication of particular willow species from inappropriate environments have been prepared in a range of jurisdictions and programs are under way. Camphor laurel (*Cinnamomum camphora*), which was introduced to Australia in 1822 as an ornamental tree, is especially invasive of moist stream banks and disturbed rainforest in eastern Australia, reducing light penetration and crowding out native species.

Measuring the effects of pest plants on forest productivity and biodiversity on a regional, state or national scale is still problematic. Coordinating data collection across jurisdictions and forest types, and separating forest and non-forest data remain major challenges.

Pathogens

With the exception of the soilborne and waterborne root-rotting pathogen *Phytophthora cinnamomi*, which is widely considered to be introduced, native forests and plantations of native tree species are affected significantly only by indigenous plant pathogens, whereas the most damaging agents in exotic plantations are usually exotic (Table D4 in Appendix D). *P. cinnamomi* and a number of other *Phytophthora* species affect and kill a wide range of plant species in all states and territories, predominantly in regions with more than 600 millimetres of annual rainfall. The pathogens' most significant impacts are on the biodiversity of flora and fauna, but quantitative nationwide data are limited in their capacity to distinguish the area and impacts in forests from those in non-forest vegetation types, such as heathlands. As many as 2,000 of the estimated 9,000 native plant species in southwestern Western Australia

Michael F. Ryan

Myrtle wilt (*Chalara australis*) is a fatal disease of myrtle beech (*Nothofagus cunninghamii*).

are susceptible to *P. cinnamomi*. *Phytophthora* is listed as a 'key threatening process' in the *Environment Protection and Biodiversity Conservation Act 1999*, and a national threat abatement plan for the pathogen was released in 2001. *P. cinnamomi* spread is controlled with hygiene protocols to limit the movement of soil and water and the use of management zones for the protection of threatened flora. Forestry, national park and local agencies in many jurisdictions have implemented plans to restrict pathogen spread. In Western Australia, intensive monitoring is undertaken to identify the distribution of the disease in commercial forests and conservation areas and to help in the designation of 'disease risk areas' in which special measures apply to minimise the risk of infection.

A wide range of chronic or episodic crown dieback syndromes, often causing significant tree mortality and associated impacts on ecosystems, occur to some degree in native forests in all states and territories. They are usually caused by combinations of factors such as climatic stress, poor management practices, severe insect attacks, and an imbalance in insect predator levels. Pathogenic fungi are not usually the primary causal agents, but canker-causing fungi, including *Cryphonectria eucalypti* (formerly *Endothia gyrosa*) in Western Australia and New South Wales, and *Botryosphaeria* species in New South Wales, often have a secondary role.

The identification of syndromes and their causal agents is often problematic and, because a wide range of land tenures is also involved, there are impediments to the effective delineation of the areas affected. For example, Mundulla yellows is a progressive and complex dieback condition that is often fatal in eucalypts and also affects a range of other tree species. It is characterised by distinctive intervein yellowing of foliage, and occurs most commonly along road verges and in paddock environments, as well as in some urban plantings. It is especially common in the southeast of South Australia, but similar symptoms are recognised to varying extents in most states and territories. Attempts to find a causal biotic agent have failed; recent work suggests that the symptoms of Mundulla yellows are actually the symptoms of a lime-induced chlorosis.[2]

Defoliating diseases have become more prevalent as the native hardwood plantations have expanded. Outbreaks tend to be cyclical in response to such factors as local climatic conditions, age and the genetic composition of plantations. While few fungal leaf diseases of eucalypts are economically damaging in commercial or environmental plantations, significant exceptions include several species of the native genus *Mycosphaerella*, the most serious being *M. cryptica* and *M. nubilosa* in young blue gum (*Eucalyptus globulus*) and shining gum (*E. nitens*) plantations in southern Australia, *Cylindrocladium quinqueseptatum* in young eucalypt plantations in northern Queensland, and *Quambalaria pitereka* in young spotted gum (*Corymbia* spp.) plantations in humid areas of New South Wales and Queensland. Such diseases are less debilitating in natural forests, where inoculum levels are usually low. Control measures in plantations include selecting genotypes for their genetic resistance to these foliar pathogens.

Root and butt rots caused by *Armillaria* species, most significantly *A. luteobubalina*, in eucalypt forest in southern Australia and southwestern Western Australia cause small patch deaths of a range of plant species. Similarly, *Rigidoporus vinctus* and *Phellinus noxius* kill a low but increasing number of trees in Queensland, including young hoop pine (*Araucaria cunninghamii*), rainforest species, eucalypts and *Acacia* species, especially in regrowth forests or second-rotation plantations. However, the distribution of these pathogens is usually localised and limited control measures are being implemented.

Various species of native gall or phyllode rust fungi (*Racospermyces* and *Uromycladium*) affect *Acacia* species across a wide range of land tenures and forest ecosystems, sometimes with severe defoliation and effects on form as well as tree death. The effects in natural stands are usually ephemeral; on the other hand, impacts in plantations such as those of *A. mangium* in northern Australia have led to investigations into disease resistance.

In areas where climatic, topographic and stand conditions are suitable, the exotic needle-cast fungus *Dothistroma septospora* can cause severe needle loss in radiata pine (*Pinus radiata*) plantations up to 15 years of age and can have a significant impact on tree growth. First recorded in Australia in 1975, the fungus is most prevalent in the Walcha district of New South Wales and small areas of southeastern Queensland, but is sometimes also significant in parts of Tasmania. Stand thinning is used as an ameliorative measure, but aerial spraying with low concentrations of fungicide is also occasionally carried out. The disease has not been observed in South Australia and has had little impact in Western Australia. The incidence of needle blight has been relatively low for the past decade because of drought conditions over much of the radiata pine estate. Disease-resistant stock is being used to reduce disease impacts in highly prone locations in northern New South Wales. In most jurisdictions, the fungus *Diplodia pinea* (formerly *Sphaeropsis sapinea*) is associated with dying crowns and occasionally significant mortality in radiata pine, usually on drought-prone sites. Needle-cast associated with the fungus *Cyclaneusma minus* also occurs in pine-growing regions, including in New South Wales and South Australia.

River regulation

River regulation – controlling or modifying the natural flow of a river or stream – is a widespread practice in Australia, most commonly through the use of dams. It occurs for a number of reasons, including to store water for irrigation, hydropower generation and urban and rural water supply, and to divert water to other catchments. Regulation can have long-term ecological impacts on wetlands; for example, it affects normally periodically inundated forest lands such those populated by river red gum (*Eucalyptus camaldulensis*). The health of large stands of *E. camaldulensis* in the Deniliquin region has been affected by significant moisture deficits caused by a combination of drought and water regulation.

Salinisation

Dryland salinity is a widespread and growing problem in Australia. It affects biodiversity, agricultural and forest productivity, and regional and urban infrastructure such as water supply, roads and buildings.

Dryland salinisation occurs predominantly on cleared agricultural land and also affects adjacent forests. A contributing factor is the widespread clearing in the past of deep-rooted native tree species, which has caused watertables to rise, thereby mobilising salt in the soil. Increased concentrations of salt and the waterlogging of soils adversely affect plant growth and survival and can affect animal populations. Biodiversity is under threat in some areas as a result of salinisation, but catchments that are still largely forested are probably at less risk.

Salinity monitoring programs exist in most states. Rehabilitation and salinity management are often a joint effort between government and communities and may involve various strategies such as tree planting, the regeneration and maintenance of native vegetation, and strategic water usage and redirection, including pumping.

Soil acidification

In natural ecosystems, the acidification of soils is a gradual process. Australia's soils are old and highly weathered and can be naturally quite acidic, both at the surface and deep in the profile; surface and subsoil acidity occurs in all Australian states and territories and affects an area up to nine times that affected by dryland salinity. The largest areas of acid soils are in New South Wales, Western Australia, Victoria and Queensland.[3]

2 Parsons and Uren (2007).

3 NLWRA (2000).

Cyclone damage, Northern Territory.

Accelerated soil acidification is a serious soil degradation problem. When soils and sediments containing iron sulfides are drained or disturbed, sulfuric acid is formed. The rate of soil acidification increases when land is developed for agriculture or forestry because such development involves both disturbance and changes to the nitrogen and carbon cycles. The impact of forest plantations on soil acidity has yet to be examined in detail.

The National Strategy for the Management of Coastal Acid Sulfate Soils, which was released in 2000, involves risk mapping; avoiding disturbance of coastal acid sulfate soils; educating stakeholders in the agricultural sectors; policy; planning and development strategies; mitigating impacts when disturbance is unavoidable; and remediation in the form of acid neutralisation, the revegetation of acid scald areas and the modification of drains and floodgates.

Generally, there are insufficient monitoring sites or measurements in soil profiles within forested lands to obtain baselines or trends in soil acidity in forests.

Climatic events and climate change

Drought

Australia is the driest inhabited continent on Earth and has a highly variable rainfall regime. Drought occurs in a cyclical pattern and can extend over several years. In economic terms, it is probably the most costly of all the country's climatic phenomena: it not only causes production losses in native and exotic timber plantations, but often contributes to the severity of fires, dust storms and general land degradation. Additionally, drought-stressed flora are more susceptible to disease and to infestations of insects such as stem borers, and face increased browsing pressure when food sources for fauna become scarce in affected regions. Significant areas of Australia were in severe drought from 2003 to the end of the SOFR 2008 reporting period.

For example, much of the Murray–Darling Basin, the coastal zone of southwestern Western Australia, southern New South Wales, most of Victoria and parts of South Australia experienced serious rainfall deficiencies over a three-year period from January 2004 to December 2006, with some areas receiving the lowest rainfall on record during that period. The drought contributed to the severity of several major fires in eastern Australia (Indicator 3.1b). In addition, stress caused by rainfall deficits has been shown to contribute to tree death in eucalypt savanna in central Queensland,[4] although the scale of drought-related tree death is not known at the national level. Drought also affects the water yield of forests (Indicator 4.1d).

Wind and storm damage

There are no formal means of collecting information on wind damage to forests across Australia, although damage in forest plantations is monitored through systematic forest health surveys. In addition to catastrophic incidents of wind damage caused by cyclones, thunderstorms, winter gales and tornados, the young growing shoots of trees can be blown out, resulting in bud loss, flattened crowns, forks and multiple leaders. This is particularly prevalent at higher altitudes and in exposed areas in winter when there is a combination of snow loading and strong winds.

Climate change

Australia has widely varied climates and ecosystems, including deserts, rangelands, rainforests, coral reefs and alpine areas. The nature of predicted climate change in Australia is complex when spatial and inter-annual variability are taken into account.[5] The climate is strongly influenced by the surrounding oceans: the El Niño – La Niña – Southern Oscillation phenomena produce a sequence of floods and prolonged droughts, especially in eastern Australia. Floods and droughts do not necessarily alternate, and each can occur during longer episodes of the other. The continent is vulnerable to a possible change towards a more El Niño-like state, which is one of the scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC).[6]

Increases in the frequency and severity of tropical cyclones, mid-latitude storms, heavy rain events and droughts are predicted under several climate change scenarios. The IPCC estimates that annual average temperatures in Australia will increase by 1°C by 2030 compared to 1990 and by up to 5°C by 2070, with associated increases in potential evaporation and heatwaves and fewer frosts.

Annual rainfall in the country's southwest could change by between –20% and +5% by 2030 and by between –60% and +10% by 2070; in southeastern Australia, rainfall is projected to change by between –10% and +5% by 2030 and by between –35% and +10% by 2070. In northern Australia and parts of eastern Australia, average rainfall could increase or decrease, depending on locality. When changes in rainfall are combined with increases in potential evaporation due to temperature rises, a general decrease in

4 Fensham and Fairfax (2007).
5 CSIRO and Bureau of Meteorology (2007).
6 CSIRO and Bureau of Meteorology (2007).

Table 42: Definitions of the four main health surveillance and monitoring activities carried out by forest managers in Australia

Activity	Definition
Forest health surveillance	Damage-focused and optimised to detect and then quantify damage (rate incidence and severity in delineated area). Introduced to Australia in 1996–97.
Health/condition monitoring	Tree/forest-focused and optimised to describe the condition of trees and detect change.
Pest population monitoring	Pest-focused and optimised to measure populations of the target pest.
Ad hoc detection	Damage-focused and designed to incur the least cost (for detection). The term 'guided ad hoc detection' is used if forest workers receive training to focus attention on specific pest and disease issues.

Source: Wardlaw et al (2007)

Table 43: Status of health surveillance and monitoring in Australian forests, by jurisdiction

State	Softwood plantations	Hardwood plantations	Multiple-use public native forests	Public nature conservation reserves
Qld	FHS, PM	Ad hoc	Ad hoc	
NSW	FHS, PM	FHS, Ad hoc	FHS, Ad hoc	HM, PM, Ad hoc
Vic.	HM, PM	HM, PM, Ad hoc	HM	
Tas.	FHS, PM	FHS, PM, Ad hoc	Ad hoc	
SA	PM	PM, Ad hoc	Not applicable	
WA	PM	PM, Ad hoc	PM, HM	

Ad hoc = ad hoc detection; FHS = Forest health surveillance; HM = health and condition monitoring; PM = pest population monitoring; (See Table 42 for an explanation of these categories.)

Source: T Wardlaw, pers comm, 2007

available soil moisture is projected across Australia, with droughts likely to become more severe. There is some evidence to suggest that the observed warming trend in Australia has already contributed to an increased severity of drought through higher evaporation and water demand.

Climate change of the magnitude described here could have a profound effect on forests and forest production in Australia. Native forests in many locations are expected to experience more stress due to increased temperatures and lower moisture availability; such forests are likely to become more susceptible to pests, diseases, fire and other pressures.[7] The productive capacity of the principal forest areas (both native and plantation) may decline in the medium term, requiring a restructuring and adjustment of the industry and possibly its geographical relocation.

Forest health surveillance

In many jurisdictions, forest health surveillance is carried out regularly to identify the severity and extent of problems mainly in planted forests where pests, diseases, vertebrates, nutrients and weeds limit growth or affect tree survival. Table 42 lists the four main health surveillance and monitoring activities carried out by forest managers in Australia; Table 43 gives the status of those activities for the main forest types, by jurisdiction. Surveillance is carried out in plantations and multiple-use public forests in three states: Queensland, New South Wales (see Case study 22) and Tasmania. Less intensive monitoring is conducted in South Australia, Victoria and Western Australia. The main monitoring of forest health in public nature conservation reserves in New South Wales is conducted as part of three-yearly 'state of the parks' surveys and on a case-by-case basis. The area of pine plantation subject to forest health surveillance is stable but that of eucalypt plantation has fallen; there has been little uptake by the private sector except in Tasmania. Although forest managers now have a clearer understanding of the purpose of forest health surveillance and its costs are well known, the benefits have not been quantified.[8]

ForestCheck plot, Western Australia.

7 Chakraborty (2005), Garrett et al (2006).
8 Wardlaw et al (2007).

Cane toads (*Bufo marinus*) have expanded their range from Queensland westwards into the Northern Territory and southwards into northern New South Wales.

Outcomes of surveillance

One aim of pest and disease surveillance is to identify resistant/susceptible genotypes. Blue gum provenances with relatively high resistance to damage from autumn gum moths are planted in some regions.

Surveillance indicates that infestations of Christmas beetle (*Anoplognathus* spp.) occur at the interface of forest and cleared land, particularly in river red gum communities in Victoria, but also in blue gum and flooded gum plantations in eastern Australia.

The use of DNA 'fingerprinting' has enabled the detection of a wide range of blackberry genotypes across Australia and will help in the use of biocontrols as part of integrated reduction and control programs. Observations of the Monterey pine aphid suggest that there are differences in genetic predisposition to infestation by the aphid among individual trees.

References and further reading

Chakraborty (2005), CSIRO and Bureau of Meteorology (2007), Fensham and Fairfax (2007), Garrett et al (2006), Hart and Bomford (2006), NLWRA (2000), Parsons and Uren (2007), Wardlaw et al (2007) (list at the end of the report).

Web resources

Case study 24: Guava rust

Case study 25: Pine pitch canker

Case study 22: Forest health surveillance by Forests NSW

Forests NSW regularly carries out forest health surveillance in its plantation forests. Softwood plantations in all regions were surveyed in June–September 2005. Sixty state forests or plantations were surveyed by helicopter, with the majority receiving follow-up ground surveys. The data collected can be used to predict pre-harvested wood volumes in affected stands, adjust management regimes for 'unhealthy' stands (e.g. bringing thinning forward in drought-affected stands), apply fertilisers or weed control to improve the establishment, growth and survival of young trees, control-spray for *Dothistroma*, and increase trap-tree plots in *Sirex*-infested areas.

Routine forest health surveys of hardwood plantations were conducted in the summer and autumn of 2006. Over 110 plantations were surveyed from the ground, some twice, as part of the monitoring program for the psyllid insect *Creiis* sp. Over 50 plantations were surveyed by helicopter in May 2006 and again in July. Such surveys identify important pests and diseases that may be limiting the growth and establishment of eucalypt plantations and that may need further research, as well as certain sites and areas that may have increased health problems. Continued forest health surveys are essential to increase knowledge of known pests and diseases and factors influencing damaging outbreaks of these problems, as well as to increase the ability to detect new diseases and pests (including exotic species).

Source: Forests NSW

Assessing forest health, Badja State Forest, New South Wales.

Case study 23: Red fire ants

The fire ant (*Solenopsis invicta*) was first discovered in southeastern Queensland in 2001 but had clearly entered the country some years earlier. Queensland's Department of Primary Industries and Fisheries found colonies over almost 30,000 hectares of land – and spreading fast.

The fire ant is considered by some ecologists to be the greatest ecological threat to Australia since the introduction of the rabbit and potentially worse than the cane toad. The World Conservation Union lists it among the world's top 100 pest species.

Fire ants have a coppery brown head and body and a darker abdomen. A distinguishing feature of the ant is size variation: a single nest will contain ants ranging in length from 2 millimetres to 6 millimetres. Nests form dome-shaped mounds, up to 40 centimetres high, or occur next to or under objects on the ground, such as rocks, logs and timber. The tops of the nests have no obvious entry or exit holes.

Fire ants pose such a serious threat to the Australian economy and environment and to people's lifestyles that they have been declared a notifiable pest under Queensland's *Plant Protection Act 1989*. A cost–benefit analysis estimated that the ant would cost the Australian economy $8.9 billion over 30 years.

To combat the threat, the $175 million National Fire Ant Eradication Program, funded by all states and the Australian Government, was launched in September 2001. As fire ants have been found almost entirely around the Greater Brisbane area (with a small outbreak near Gladstone), the Queensland Department of Primary Industries and Fisheries has primary responsibility for the program. In other states, high-risk areas such as ports and airports are under active surveillance. The program is the largest of its type ever mounted in Australia and at its peak in the mid 2000s employed close to 650 staff.

The first three years of the program were spent finding the ants and stopping their spread – that is, treating known infestations, detecting new or previously unknown infestations, and minimising the risk of spread to new areas. A massive baiting and surveillance program began with 400 ant-control officers spreading bait on 100,000 properties in Brisbane. The hormone bait targeted the queen, the only ant in the colony that can reproduce.

A recent survey found that 99.5% of all known previously infested properties are now fire ant free. In 2001 it was estimated that there were 65,000 colonies; in 2006 only about 100 colonies were found. Treatment has ceased in some areas but continues in others. All properties in the fire ant infested area are surveyed several times a year. The target area has been reduced to 14,000 hectares.

The final two years of the program will be spent monitoring the treated areas and eradicating small infestations, but total eradication may be some way off.

Source: www2.dpi.qld.gov.au/fireants (accessed July 2007)

Indicator 3.1b

Area of forest burnt by planned and unplanned fire

Rationale

This indicator provides an understanding of the impact of fire on forests through the reporting of planned and unplanned fire. Fire is an important part of many forest ecosystems in Australia and may have either positive or negative impacts on forest health and vitality.

Key points

- In the period from 2001 to 2006, the estimated total area of forest burnt was 24.7 million hectares. This estimate was determined using a combination of data on fire extent derived from satellite imagery (for the Northern Territory, Queensland and northern Western Australia) and data supplied by state agencies in New South Wales, South Australia, Tasmania, Victoria and Western Australia.
- Of the total area affected by fire, an estimated 19.5 million hectares was in northern Australia and 5.2 million hectares was in southern Australia.
- From 2000 to 2006, unplanned fires burnt an estimated 20.0 million hectares and planned fires burnt 4.7 million hectares of forest.
- Fire is an important forest management tool in Australia because many forested ecosystems are ecologically adapted to fire and require it for regeneration.
- There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for planned fires to shift and narrow in southeastern Australia.

This indicator reports on the area of planned and unplanned fires in forested landscapes. Unplanned fire is defined as fire started naturally (such as by lightning), accidentally or deliberately (such as by arson) that is not in accordance with planned fire management prescriptions; the terms 'unplanned fire', 'bushfire' and 'wildfire' are used interchangeably here. Planned fire is fire started in accordance with a fire management plan or some other type of planned burning program or bushfire-response procedure, such as fuel reduction (prescribed) burning.

Tools for capturing information on fire management and reporting are increasingly available in some jurisdictions to assist fire management. However, there is currently no nationally coordinated approach to the systematic mapping and reporting of the extent, seasonality and intensity of fires and of whether they are planned or unplanned. To support the reporting of this indicator, a nationwide analysis of fire using satellite imagery has been compiled for the first time; it has been used here to estimate fire occurrence in forests in northern Australia, complementing data provided by some states for forests in southern Australia.

Aftermath of a mega-fire, Namadgi National Park, Australian Capital Territory.

Fire as a factor in Australian forests

Fire has been an important factor in Australian ecosystems for millions of years. Many of our plants and animals have evolved to survive fire events, and most Australian ecosystems have developed highly specialised relationships with fire.

The extent and intensity of forest fires vary with latitude and seasonal rainfall. In northern Australia, low-intensity fires may burn over large areas. In the southeastern and southwestern corners of Australia, hot, dry and windy conditions in summer mean that bushfires are often intense and difficult to control. Such fires (sometimes called 'mega-fires') can result in the loss of human life and destroy community assets such as buildings, fences, bridges and power lines; water supplies and standing timber can also be affected. Increased summer temperatures and declining rainfall – such as have been observed during the recent drought – exacerbate the risk of fire and increase the challenges associated with fire management. Fire is rare in the tropical rainforests of northern Australia and in the temperate rainforests, mixed rainforests and wet sclerophyll forests in parts of Tasmania and Victoria, but even those forests can dry out during prolonged droughts and will then burn if ignited.

Impacts on ecological values

The long-term effects of fire on landscapes and biodiversity rarely arise from a single fire, but vary according to the sequence of fire events; this is often called the 'fire regime'. Fire regimes are determined by three factors: intensity (how severe fires are), frequency (how often fires occur) and season (the times of the year in which fires occur).

Plant communities vary in their response to the period of time between fires, as do individual species and plants. Some, such as mountain ash (*Eucalyptus regnans*), may not survive if fires are too frequent because trees are unable to reach maturity and produce sufficient seed before the next fire. Infrequent fires may displace plants that require fire to assist their regeneration, such as most heath species.

Regeneration post-2003 fires, Swifts Creek, Victoria.

However, mega-fires can have a dramatic ecological impact, including the replacement of a multi-aged forest structure with even-aged regeneration, the loss of species that prefer frequently or mildly burnt forest, and the degradation of soils and waterways.

The structure and composition of the savanna forests of the Northern Territory, northwestern Queensland and Western Australia's Kimberley region appear to be the result of a very frequent fire regime, especially where the understorey is dominated by native cane grass *(Zygochloa* sp.). Variations in fire frequency and season in these forests are associated with shifts in structure and the composition of the forest understorey.

There are still many gaps in the understanding of forest fire ecology, partly because of the complexity of the interactions between fire regimes and forest types and the long timeframe over which ecological changes can occur. Most is known about the impacts of fairly frequent (<10-year interval), low-intensity fires in southern eucalypt forests; least is known about the long-term impacts of infrequent, very high intensity fires.

Fire management

Australian bushfire scientists and anthropologists generally agree that, before European settlement, Indigenous people carried out frequent, regular and wide-scale burning, especially in the drier forest types. The net result was a mosaic of burnt and unburnt vegetation patches that limited the extent and intensity of fire under severe weather conditions. European settlers, particularly in southern Australia, attempted to deal with the fire threat with a policy of fire exclusion, under which bushfires were identified rapidly and suppressed where feasible. In some forest areas, that policy was accompanied by strategic burning to reduce accumulated forest fuels in narrow strips adjacent to railway lines, roads, farms and settlements.

A fire-exclusion policy remains in some agricultural districts in southern Australia where the main assets are crops, pasture and domestic stock. In general, however, it has proved unsuccessful in forests. This is partly because ignition (by lightning or humans) is inevitable and partly because bushfires in long-unburnt forests are often impossible to control, even under relatively mild weather conditions and with a large and expert firefighting force.

The lack of success of a fire-exclusion policy led Australian forest managers to adopt prescribed burning as a means of systematically reducing forest fuels in zones across the forest. Many studies in temperate Australia and elsewhere illustrate the effectiveness, within limitations, of prescribed burning in reducing fuel loads, ameliorating subsequent bushfire behaviour and assisting management operations. Other studies have led to modifications in burning practices to maximise their value to biodiversity or to protect particular species or forest types, and to ensure that smoke from prescribed burning does not cause haze in urban areas. While the application of prescribed burning is increasingly sophisticated, it has also become more costly, and the opportunities for prescribed burns may in future be reduced due to increased climate variability (especially in Western Australia, Victoria and New South Wales). On its own, prescribed burning does not constitute a fire management system; it is only effective as part of a holistic approach that also includes fire prevention and suppression; education and training; research; and law enforcement.

In the tropical savanna, open forests with a grassy understorey are part of a patchy landscape mosaic that may include other vegetation types, such as rainforest. Fuel loads from the grassy understorey build up during the dry season, increasing the risk of high-intensity fires late in the season. Up to 50% of some northern Australian landscapes may be burnt in a single year; most areas burn at least once every three years. If fire is suppressed, reduced fire frequency can lead to increased tree and shrub invasion and thickening, which may adversely affect biodiversity and habitat values and reduce pastoral productivity. The management of fire in tropical savannas is a trade-off between the tree–grass balance and grazing values, and Indigenous land managers are being encouraged to employ traditional early wet season burning techniques that result in reduced fire intensity.

Fire management has been the subject of intense scrutiny in recent years following several severe, large-scale bushfires in southern Australia. Major public inquiries were conducted into fires that occurred in Sydney in 2001; in New South Wales, Victoria and the Australian Capital Territory in 2002–03; and in Victoria in 2006. The severity of the 2002–03 fire season prompted an inquiry into bushfire mitigation and management by the Council of Australian Governments. Among other things, that inquiry recommended the adoption of a bushfire risk management framework and a national program of fire regime mapping.

There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for prescribed burning to shift and narrow in southeastern Australia.[9] Continued scrutiny of fire management regimes can be expected, given the increasing number of people living in bushfire-prone areas and the possible effects of climate change on bushfire occurrence and severity. The continued development of sustainable fire management strategies is therefore both critical and challenging.

Fire and the urban population

Nearly 75% of Australians live in or within 50 kilometres of a coastal city. In recent years there has been an increase in the number of people living at the urban–forest interface, often in areas prone to unplanned forest fire. Therefore, the management of fire in these zones both for biodiversity and for the protection of built assets has become a major challenge for Australian forest and fire managers, particularly on the east coast. Many jurisdictions now require that the risk of bushfire be considered in urban planning and in the design of houses and other buildings.

Reporting on fire impacts

A number of innovative programs are now in place to carry out fire mapping and to monitor fire regimes more closely. For example, the Victorian Department of Sustainability and Environment has established IFIS (the Integrated Fire Information System), and the Western Australian Department of Environment and Conservation records planned and unplanned fires in its centralised FIRE SYSTEM database. Forests NSW recently upgraded its wildfires database to a centralised system for rapid input and access to data and for better integration with the fire reporting systems of other agencies.

Fire in Australia's forests, 2001 to 2006

In Australia's northern forests, several satellite-based platforms can be used to derive meaningful wildfire datasets, including Advanced Very High Resolution Radiometer, Moderate-resolution Imaging Spectroradiometer (MODIS) and Landsat.[10] Such datasets are useful for detecting fires in more open forests, such as tropical savannas, but are less effective in closed forests, such as many forests in the southern mesic rainfall zone (Figure 45). In Australia's southern forests, particularly those managed for timber production, state agencies use a combination of ground-based approaches and high-resolution aerial photography to estimate the extent and distribution of wildfire.

In this analysis, data on the extent and seasonality of fire in Australia's southern forests were supplied by state agencies, while the extent of fire in Australia's northern forests was determined for the period from February 2000 to December 2006 with the aid of MODIS satellite imagery.[11]

Synthesis of southern and northern fire estimates

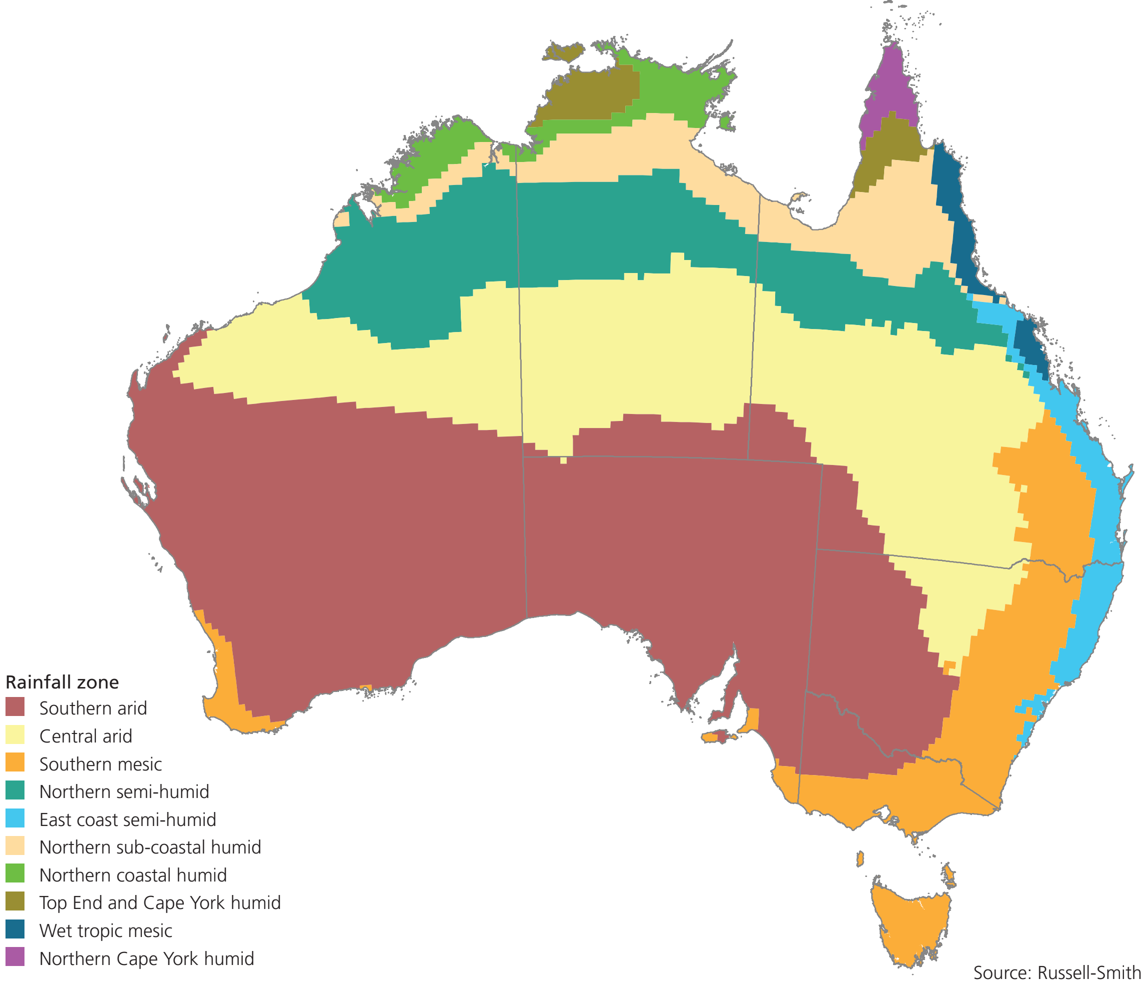
Table 44 shows the estimated total extent of planned and unplanned fire by jurisdiction, derived using the two methodologies. The reported data for the extent of fire in the southern forests (i.e. in New South Wales, South Australia, Tasmania, Victoria and southwestern Western Australia) were combined with estimates of fire-affected areas derived from MODIS for Australia's northern forests (i.e. the Northern Territory, Queensland and northern Western Australia) to generate the total area of Australian forests burnt between 2001–02 and 2005–06. Although the reporting of fire events in the popular media focuses mainly on southern Australia, where fires are particularly damaging to human life and infrastructure, most forest fires occur in northern Australia.

9 Hennessy et al (2005).

10 Russell-Smith et al (2007).

11 The relatively low resolution of 1 kilometre used in this analysis means that small, low-intensity fires are not easily detected, particularly when obscured by cloud cover or forest canopy. Such limitations may result in a significant underestimation of the extent of both planned and unplanned fires. The methodology and its advantages and disadvantages are described in Thackway et al (in press).

Figure 45: Rainfall classification showing 10 geographical regions that vary markedly in seasonal rainfall distribution over four nominal seasons



The differences between the two methodologies for detecting and reporting the extent of forest fire highlight the need for a nationally coordinated fire reporting program that extends across all land tenures and takes into account the difficulty in using remote sensing to detect planned fires in the southern mesic rainfall zone.[12]

Planned and unplanned fires in southern forests

New South Wales, South Australia, Tasmania, Victoria and Western Australia provided data on the extent of planned and unplanned fire. Some reported fire on land that might include non-forested areas and some only on public land tenures (multiple-use public forest and/or public nature conservation reserves). According to these state-reported data, up to 5.2 million hectares of native and non-native forests was burnt by planned and unplanned fire in the southern mesic rainfall zone in New South Wales, South Australia, Tasmania, Victoria and southwestern Western Australia in the period from 2001–02 to 2005–06; more than 2.7 million hectares of this was burnt during the severe fire season of 2002–03 (Case study 26). Of the total, unplanned fires burnt about 3.6 million hectares and planned fires about 1.6 million hectares.

Planned and unplanned fires in northern forests

Data on the extent of forest in Australia and the occurrence of fire (as identified in MODIS satellite imagery) from 2000 to 2006 were used to classify fires into 10 rainfall zones (Figure 45) and four nominal seasons: January–March (summer), April–June (autumn), July–September (winter), and October–December (spring). For each rainfall zone, fires were classified as planned or unplanned according to season (Table 45). In northern Australia (zones 4, 6, 7, 8, 9 and 10), fires that occurred during autumn (i.e. the early dry season) were considered planned, while fires that occurred during spring (the late dry season) were considered unplanned (since it was unlikely that forest managers would deliberately light fires when they would be at their most

12 Walsh et al (2007).

Table 44: Total area burnt by planned and unplanned fire, 2001–02 to 2005–06, by jurisdiction (hectares)

	2001–02	2002–03	2003–04	2004–05	2005–06	Totals 2001–06
NSW[a]						
Planned	51,039	73,904	134,794	70,173	56,411	386,321
Unplanned	679,755	1,167,835	76,705	24,130	44,222	1,992,647
NT						
Planned	915,165	282,893	225,680	647,665	157,571	2,228,974
Unplanned	2,157,920	1,459,565	1,075,819	2,714,257	886,696	8,294,257
Qld						
Planned	168,800	186,346	97,419	160,002	94,213	706,780
Unplanned	2,189,488	1,319,413	948,369	1,240,991	1,144,032	6,842,293
SA[b]						
Planned	129	103	141	103	77	553
Unplanned	11	146	6	24	13	200
Tas.						
Planned[c]	17,900	16,700	15,300	16,000	13,000	78,900
Unplanned	378	32,468	60,203	11,472	787	105,308
Vic[d]						
Planned	52,669	30,178	101,193	97,509	51,898	333,447
Unplanned	38,448	1,141,828	12,167	19,157	103,975	1,315,575
WA[e]						
Planned	53,403	68,000	30,520	73,150	20,300	245,373
Unplanned	196,031	364,288	160,405	348,521	136,372	1,205,617
WA[f]						
Planned	87,330	130,780	171,930	186,380	182,400	758,820
Unplanned	17,640	131,680	22,190	50,630	22,560	244,700
Totals						
Planned	1,346,435	788,904	776,977	1,250,982	575,870	4,739,168
Unplanned	5,279,671	5,617,223	2,355,864	4,409,182	2,338,657	20,000,597
All reported fires	6,626,106	6,406,127	3,132,841	5,660,164	2,914,527	24,739,765

a Data supplied by Forests NSW and the Department of Environment and Climate Change (NSW) for multiple-use and nature conservation reserve tenures only and may include non-forest areas.

b Data for ForestrySA plantations in multiple-use public forests and public nature conservation reserves only.

c Planned fires on Forestry Tasmania land only.

d Data supplied by the Department of Sustainability and Environment (Vic.). Data are for public land tenures only.

e All regions except the southwest.

f Southwest forest region only.

Note: Unshaded cells show estimates supplied by state agencies for southern forests and shaded cells show estimates derived from MODIS imagery for northern forests. Totals may not tally due to rounding.

intense). According to the analysis, 3.2 million hectares of forest in northern Australia (the Northern Territory, Queensland and northern Western Australia) was subject to planned fires in the period from 2001 to 2006 and 16.3 million hectares to unplanned fires.

Native forest (*Hakea* sp.) in the foreground is adapted to fire with seedpods opening after being scorched.

Table 45: Proportion of forest area burnt in planned and unplanned fires in each rainfall zone, 2000 to 2006, based on MODIS data (%)

Rainfall zone	Proportion of forest burnt – unplanned	Proportion of forest burnt – planned	Unplanned fires as proportion of total area burnt	Planned fires as proportion of total area burnt
Southern arid (1)	2.9	0.1	97.9	2.1
Central arid (2)	8.0	2.3	77.4	22.6
Southern mesic (3)	10.1	1.6	86.0	14.0
Northern semi-humid (4)[a]	17.5	14.6	54.6	45.4
East coast semi-humid (5)	6.7	3.5	65.5	34.5
Northern subcoastal humid (6)[a]	31.8	4.1	88.5	11.5
Northern coastal humid (7)[a]	51.7	6.3	89.2	10.8
Top End and Cape York humid (8)[a]	44.8	11.5	79.5	20.5
Wet tropic mesic (9)[a]	17.5	0.7	96.3	3.7
Northern Cape York humid (10)[a]	48.0	0.8	98.3	1.7
Total (Australia)	17.8	3.8	82.3	17.7

a Denotes rainfall zones defined as wet–dry tropics. Other rainfall zones are considered to be temperate rainfall zones.

The proportion of forest area burnt was higher in the wet–dry tropical rainfall zones than in the temperate rainfall zones (Table 45). The northern semi-humid (4) and east coast semi-humid (5) rainfall zones had the highest proportions of planned fires as a proportion of total area burnt (45.4% and 34.5%, respectively). Table 45 also shows that most of the area burnt (82.3%) was burnt as a result of unplanned fire.

Mega-fires

Table 46 lists the main mega-fire events over the period from 1993–94 to 2006–07. The 2002–03 fire season in southern Australia was particularly bad, largely because it was in a period of severe drought. In New South Wales, 1.46 million hectares of both forest and non-forest landscapes was burnt over 151 consecutive days between September 2002 and February 2003; in Victoria, 1.1 million hectares of forest was burnt (Case study 26), including about 20,000 hectares of production alpine ash forest.[13] In the Australian Capital Territory, a severe fire in January 2003 burnt 157,000 hectares, including 11,000 hectares of pine plantation; 500 homes were destroyed and 4 people were killed.

Case study 27 describes the timber salvage operation undertaken after a large area of pine plantation was burnt near Tumut, New South Wales, in 2006.

Table 46: Mega-fires in southern Australia, 1993 to 2007

Fire season	Location	Area burnt (hectares)[a]
1993–94	Sydney/Blue Mountains/ North coast NSW	800,000+
1995	Southeast Qld	333,000
1997–98	Hunter/Blue Mountains/ Shoalhaven, NSW	500,000+
1997–98	Caledonia River, Gippsland, Vic.	32,000
2001–02	Greater Sydney, NSW	744,000
2002	Stanthorpe/Toowoomba, Qld	40,000
2002–03	Eastern Highlands, Vic.	1.1 million
2002–03	Brindabella Ranges/ Canberra, ACT/NSW	157,000+
2002–03	NSW east coast, including Greater Sydney	1.46 million
2002–03	Arthur–Pieman, Tas.	100,000
2005	Eyre Peninsula, SA	145,000
2006–07	Eastern Highlands, Vic.	1.05 million

a Total area burnt, including vegetation types other than forests.
Source: Bartlett et al (2007)

References and further reading

ABS (2004b), Bartlett et al (2007), Dexter and Hodgson (2005), Ellis et al (2004), Hennessy et al (2005), Russell-Smith et al (2007), Thackway et al (in press), Walsh et al (2007), Wareing and Flinn (2003) (list at the back of the report).

Web resources

Case study 27: Tumut fire salvage operations

13 Dexter and Hodgson (2005).

Case study 26: The 2003 fires in Victoria

Eighty-seven fires were started by lightning in the northeast of Victoria on 8 January 2003. Eight could not be contained, and joined to form what became the largest fire in Victoria since the 1939 'Black Friday' bushfires. Burning for 59 days before being contained, the fires burnt 1.1 million hectares, including 507,000 hectares of multiple-use public forest, 470,000 hectares of national parks and 90,000 hectares of freehold land. Extreme fire activity on several days during the two months the fires were burning contributed significantly to the fire spread. The fires increased from 27,000 hectares on day 8 to 230,000 hectares on day 16 and to 880,000 hectares on day 23.

The fires destroyed 41 homes, 213 structures and thousands of kilometres of fencing and killed over 13,000 head of livestock. Tragically, one firefighter lost her life towards the end of the fires, drowning in a flash flood. The cost of fighting the Victorian bushfires has been estimated at $115 million, while an additional $86 million was spent on post-fire recovery operations. The fires saw unprecedented levels of cooperation between land management and related government agencies and rural fire services, private companies, local government and interstate and overseas-based fire personnel. The high priority accorded to the protection of assets undoubtedly reduced losses of private structures but may have concentrated resources near private property.

About 60% of the Alpine National Park and 81% of the Mount Buffalo National Park were burnt during the fires. Firefighting efforts were in hard-to-access, remote and rugged forest terrain, making the fires very difficult to control and extinguish. The consequences of the fires included reduced water quality and quantity, loss of vegetation (including habitats for flora and fauna), the destruction of commercial timber, and damage to recreation and tourism infrastructure assets, cultural sites and farms adjacent to public land.

According to at least one analysis,[14] the 2003 fires clearly demonstrated the widespread environmental, economic, cultural and social impacts that can result from a failure to control wildfires and showed that some environmental impacts, such as soil erosion, can be long lasting. The analysis concluded that similar bushfire conditions could occur in the following year due to the ongoing drought and that global warming is likely to increase the risk of more frequent and severe bushfires. It also considered that the trend towards the urbanisation of forest areas is occurring without adequate attention to fire risk and that the contraction of the native forest industry is affecting our ability to contain new fire outbreaks.

The rebuilding of local communities and the recovery of natural resources in bushfire-affected areas in the wake of the 2003 fires was a major task. The Victorian Government allocated $70.6 million for a bushfire recovery program for the environment and agriculture, focusing on four areas:

- asset repair or replacement in parks, forests and alpine resorts ($24.9 million)
- the protection and restoration of water catchments and water supply ($23.9 million)
- the restoration of ecological and cultural heritage values ($13.2 million)
- practical assistance to affected farm enterprises ($8.6 million).

This was the biggest bushfire recovery effort ever undertaken in Victoria and was characterised by a collaborative whole-of-government approach. The government agencies involved in coordinating and doing much of the recovery work were the Department of Sustainability and Environment, Parks Victoria and the Department of Primary Industries. Also involved were the North East and East Gippsland catchment management authorities, VicForests, and the managers of the three affected alpine resorts.

Sources: Bartlett et al (2007), Department of Sustainability and Environment (Vic.)

14 Wareing and Flinn (2003).

Log landing during salvage operations in a burnt alpine ash (*Eucalyptus delegatensis*) area following the 2003 fires.

Pulpwood stack, post-fire salvage operation.

Mountain ash (*Eucalyptus regnans*) and grey gum (*Eucalyptus punctata*) open forest, Kingslake, Victoria.