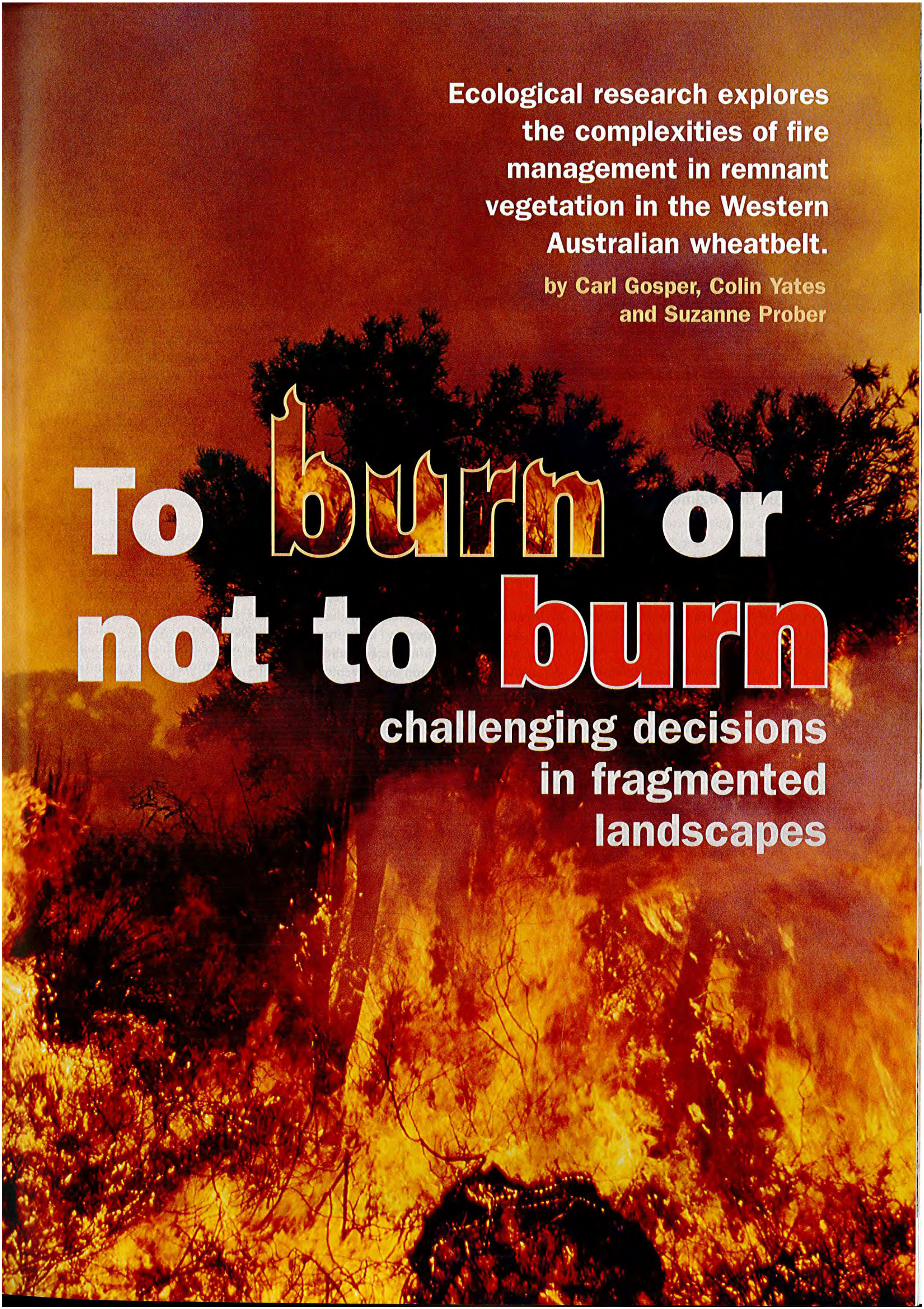


Ecological research explores the complexities of fire management in remnant vegetation in the Western Australian wheatbelt.

by Carl Gosper, Colin Yates and Suzanne Prober

To burn or not to burn

challenging decisions in fragmented landscapes

South-west Western Australia is regarded as one of the world's biodiversity hot spots due to the richness of flora and the degree of threat it faces. In common with other Mediterranean-climate regions, fire has been an important feature of south-west WA for millennia. Together with soils and landforms, it has played a key role in shaping the composition and structure of vegetation communities.

Since European settlement, however, native vegetation has been removed over large portions of this landscape, especially across the WA wheatbelt. One of the many consequences of this fragmentation of native vegetation has been a disruption to the ways fires occur.

Changed fire regimes

Recent analysis of satellite imagery shows that fires have become less frequent in vegetation remnants in the wheatbelt than in comparable continously vegetated landscapes. It has also shown that, within the wheatbelt, the smaller the patch of vegetation, the less frequent the fires.

What might the consequences of this be for biodiversity? It is known that in fire-prone landscapes generally, including south-west WA, many plant species germinate predominantly in the first few years following fire, while others have limited longevity and decline in vegetation that has experienced a long time since fire. On the other hand, some fauna species require habitat features that only develop in long-unburnt vegetation, and many plants require a minimum fire-free period to accumulate a large enough seed bank to replace themselves.

These differing responses to fire suggest that a single fire regime applied widely across space and time—as is the present trend for many wheatbelt reserves—is unlikely to support existing levels of biodiversity. They also suggest that varying fire frequency, intensity, season and extent within ecologically defined bounds may promote diversity (see 'Fire for life', *LANDSCOPE*, Special Fire Edition Volume 2 2005).

Managing fire in south-west WA's wheatbelt nature reserves to achieve conservation objectives—such as the maintenance of biodiversity and diverse ecosystem structures, states and habitats—must take into account the context of the reserves themselves. Introduction of fire in some circumstances could make remnant native vegetation more vulnerable to invasion by weeds, which are abundant in the surrounding agricultural landscape. As fire temporarily removes vegetation cover, it may consequently raise watertables and exacerbate the impacts of secondary salinity. Moreover, because many nature reserves are isolated and poorly connected, species that rely on dispersal from unburnt populations to recolonise areas after fire may be unable to do so.

This creates a conundrum for conservation managers. Various questions arise: should fire be excluded and suppressed in wheatbelt nature reserves because of the potential threat of weeds, particularly alien invasive grasses, even if excessively long periods without fire result in the loss of biodiversity? And, if fire is introduced, how long should it be before an area is burnt again?

Study region and ecosystems

A project jointly funded by the Department of Environment and Conservation's (DEC's) *Saving our Species* initiative and CSIRO Ecosystem Sciences is providing information for managers that will help them assess the risks and benefits of particular fire

Previous page
Main Fires generate new life.
Photo – Len Stewart/Lochman Transparencies

Above Verticordias are among the biodiverse flora species of the wheatbelt.
Photo – Jiri Lochman

Below left Banksia after burning.
Photo – Dennis Sarson/Lochman Transparencies

regimes in wheatbelt nature reserves. The research team has been studying how two plant communities that are widespread in the south-eastern wheatbelt—mallee and mallee-heath—respond to the length of time since fire and how fire affects weed invasion. The mallee community is dominated by species that sprout after fire, with the canopy comprised mainly of mallee (*Eucalyptus* spp.) over an understorey with a significant component of broombush (*Melaleuca hamata*). The mallee-heath community is dominated by obligate seeders (species that are killed by complete canopy scorch and must regenerate from seed after fire), with sparse emergent mallee tallerack (*E. pleurocarpa*).

The study area was centred on Lake Magenta and Dunn Rock nature reserves and adjoining unallocated Crown lands south of Newdegate. These comprise some of the largest areas of native vegetation remaining in the wheatbelt. The fire history of the area was described using remotely sensed satellite imagery (courtesy of DEC's Fire Management Services) and historical maps. The vegetation ages in the study sites ranged from two years since a fire to no fires having been recorded, which means that the last fire occurred before the 1960s.

Changes in vegetation with time since fire

Information on how vegetation communities change with the passage of time since the last fire is crucial when deciding on the appropriate intervals between fires for biodiversity conservation. Fires initiate vegetation redevelopment, but the path this redevelopment takes over long time periods is poorly known.

The results of this study indicated that species diversity in the mallee-heath community was highest immediately after fire and declined as the vegetation aged. What's more, the composition of species differed in the recently burnt vegetation (less than 10 years post-fire) compared with the less recently burnt vegetation.

The occurrence of a suite of species known as 'post-fire ephemerals' is likely to have contributed substantially to these results. These species—which include a variety of forbs (such as *Goodenia* spp.) and short-lived shrubs (such as *Gyrostemon* spp.)—typically occur as above-ground plants only in the immediate few years after fire, quickly maturing and setting seed, then dying and existing only as soil-stored seed until the next fire.

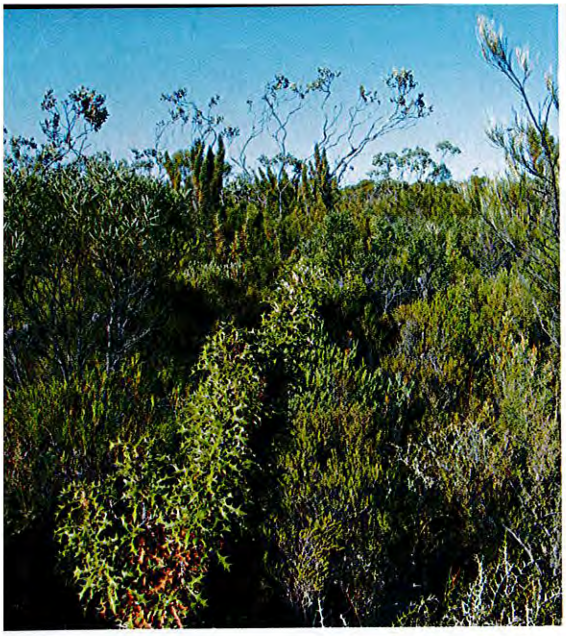
Structurally, the mallee-heath community stagnated when long-unburnt. By about 40 years after a fire, the height of each layer of vegetation and litter cover had peaked, and then either remained stable or decreased as the vegetation aged, while the amount of bare ground and standing dead vegetation increased. Mallee-heath thus appears susceptible to biodiversity and structural decline with unusually long intervals between fires.

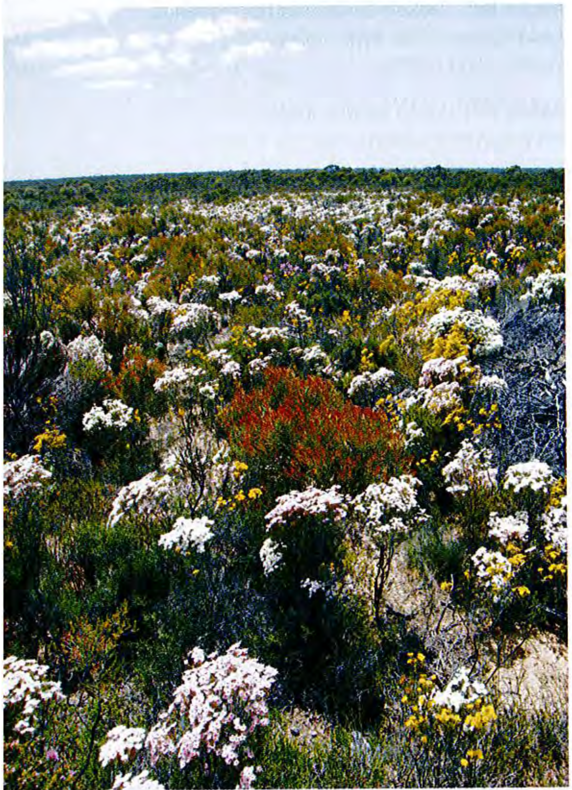
In contrast, the mallee community showed little change in diversity and composition with time since fire: instead, variations in soil properties and regional patterns of species distribution appeared to have a larger bearing on species composition. What's more, the mallee community continued to increase in stature 50 years after the fire and beyond. It was not maintained

Above Mallee woodland after burning.
Photo – Carl Gosper/DEC

Above left Banksia fruits that have opened and released their seeds after fire.
Photo – Jiri Lochman

Below left *Hakea pandanicarpa*.
Photo – Marie Lochman





by fire and appeared resilient to long intervals without fire. Long intervals between fires are also likely to be significant in providing habitat features of importance to mallee fauna and in enhancing carbon accumulation.

Seed bank accumulation and mortality

An alternative way to determine appropriate periods between fires for plant communities is to sample fruit production and mortality in a range of species likely to be susceptible to variation in times between fires. A minimum acceptable interval between fires can be defined as the period since fire that is required for slowly maturing obligate seeding species to accumulate a seed bank of sufficient size for population replacement. A maximum acceptable interval between fires would be the period of time since fire when levels of mortality increase, or seed bank sizes decline such that the potential for population replacement or persistence after fire is reduced.

Fruit crop size and mortality were measured in a range of obligate seeder and sprouter species in which the seed is stored in the canopy, known as 'serotinous' species, from the families Proteaceae and Myrtaceae. Serotinous species were used because fruit crop size is readily measurable and because, unlike species with soil-stored seed banks, serotinous seed banks typically only survive as long as the parent plant survives and are exhausted after each fire.

Top left Long-unburnt mallee heath.

Left Wildflowers in the wheatbelt.
Photos – Carl Gosper/DEC

Below Bushfire in mallee heath.
Photo – Len Stewart/Lochman Transparencies

Patterns of seed bank accumulation over time were broadly similar in both mallee and mallee-heath communities. Many serotinous obligate seeders had not accumulated a substantial seed bank until about 25 years after fire. The slowest maturing species, *Hakea pandanicarpa* subsp. *crassifolia*, did not accumulate a substantial seed bank until about 30 years after fire. This indicates that fire intervals of less than 20 years risk the loss or decline in abundance of a range of serotinous obligate seeding plants, and that intervals extending beyond 30 years are necessary for substantial seed bank accumulation in particularly slowly maturing species. In long-unburnt vegetation (more than about 50 years), several obligate seeding species exhibited a decline in total seed bank size relative to vegetation of an intermediate age.

Mortality rates were generally low, but several species showed a change in mortality rate with time since fire. Of these, each of the obligate seeders had increased mortality with greater intervals since the last fire. In the species with the greatest mortality, (*Hakea pandanicarpa* and *Petrophile glauca*), 80 to 90 per cent of individuals had died at some long-unburnt (more than 50 years) sites. Mortality rates among sprouters were generally lower, and showed a variety of relationships with time since fire.

Due to both higher adult plant mortality and a decline in the size of the seed bank on surviving individuals, declines in the abundance of several obligate seeding species after the occurrence of the next fire is likely at some long-unburnt mallee-heath sites. This suggests that some plant species require fire for population maintenance, and that fire should be viewed as important for biodiversity

conservation in mallee-heath. The uncertainty of the actual age of these long-unburnt sites (known to be more than 50 years, but could be much older) means that defining specific upper bounds of periods between fires is not possible at this stage, only that an upper bound does appear to exist.

Weed invasion

Vegetation remnants are vulnerable to weed invasion due to the combination of changed disturbance regimes (such as fire, grazing and human visitation), altered environments at the edges of the patches of vegetation and high weed seed input from nearby weed populations. Fire potentially facilitates weed invasion by stimulating the germination of dormant weed seed, increasing resource availability and reducing competition. A field experiment in mallee vegetation examined weed abundance and growth in relation to fire, weed seed availability from post-fire seeding with bearded oat (*Avena barbata*) and the position of the mallee vegetation in relation to remnant edges (adjoining paddocks or within reserve interiors).

It was found that the location of vegetation in the landscape had a much greater impact on weed performance than fire: only at paddock edges did weeds grow well, and they did so irrespective of whether the site had been burnt or not. Bearded oat abundance was also related to seed availability, as there were always more plants where seed was added. The study found that higher weed growth at edges is likely to be underpinned by enhanced soil nutrient levels as a result of neighbouring agricultural activities. Soil at the edge of paddocks had higher levels of nitrogen, phosphorus, ammonium, potassium and organic carbon than reserve interiors, irrespective of fire.

The study also showed that fire did not exacerbate weed invasions in intact mallee, and consequently is a viable way of maintaining biodiversity in mallee remnant interiors. However, as weed growth was high at paddock edges with or without fire, it may be appropriate for land managers to take a precautionary approach and seek to avoid fire on paddock edges if resources are not available for post-fire weed control.

Management implications

Mallee and mallee-heath occur in a mosaic across a landscape subject to occasional extreme bushfires and with few topographic barriers to fire spread. While this shared exposure to fire may suggest that these communities may respond similarly to fire, this was not found to be the case. Mallee-heath needed fire to maintain diversity and structure, while mallee did not.

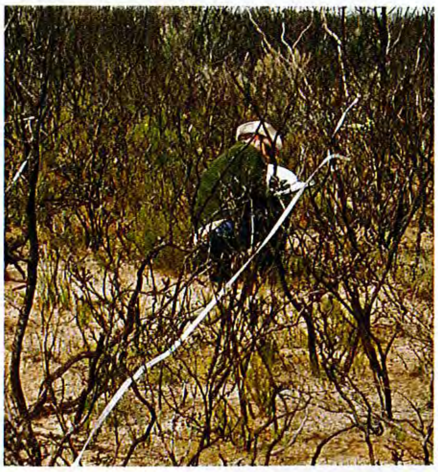
For both communities in the Newdegate area it was found that periods between fire of less than about 20 years will reduce the potential for population replacement of some serotinous obligate seeders. Maximum desirable intervals between fires exist for mallee-heath, and are greater than 50 years. As the average period between fires in small wheatbelt remnants is currently more than 100 years, active fire introduction may be appropriate to rejuvenate aging mallee-heath stands. Mallee showed a lower requirement for fire to maintain structure and diversity when long-unburnt. Consequently, active introduction of fire in mallee communities in remnants should be a much lower priority than for mallee-heath.

While fire management in remnant vegetation in the WA wheatbelt remains a complex task, this research should help land managers make better-informed decisions.

Above right Agricultural paddocks adjoining nature reserves are a source of weed seeds and soil nutrients.
Photo – Georg Wiehl/CSIRO

Below right New banksia growth after burning.
Photo – Jiri Lochman

Below Sampling vegetation in burnt areas.
Photo – Georg Wiehl/CSIRO



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The stratification of survey sites was partly based on the remote sensing data derived from research by Dr Li Shu in digital image processing and remote sensing at DEC's Fire Management Services, Regional Services Division. Georg Wiehl, Blair Parsons and Steve Zabar contributed greatly during fieldwork.

Volume 26 Number 2 SUMMER 2010-11

contents

Regulars

Publishing credits

Executive editor Madeleine Clews.

Editors Joanna Moore, Samille Mitchell.

Scientific/technical advice Kevin Thiele, Paul Jones, Keith Morris, Michael Rule.

Design and production Tiffany Taylor, Lauren Tyrrell, Peter Nicolas, Gooitzen van der Meer.

Illustration Gooitzen van der Meer.

Cartography Promaco Geodraft.

Marketing Estelle de San Miguel.
Phone (08) 9334 0296 or *fax* (08) 9334 0432.

Subscription enquiries
Phone (08) 9219 8000.

Prepress and printing GEON, Western Australia.

ISSN 0815-4465

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

Published by the Department of Environment and Conservation (DEC), 17 Dick Perry Avenue, Kensington, Western Australia.

Visit DEC online at www.dec.wa.gov.au to search the *LANDSCOPE* catalogue.

Department of
Environment and Conservation

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