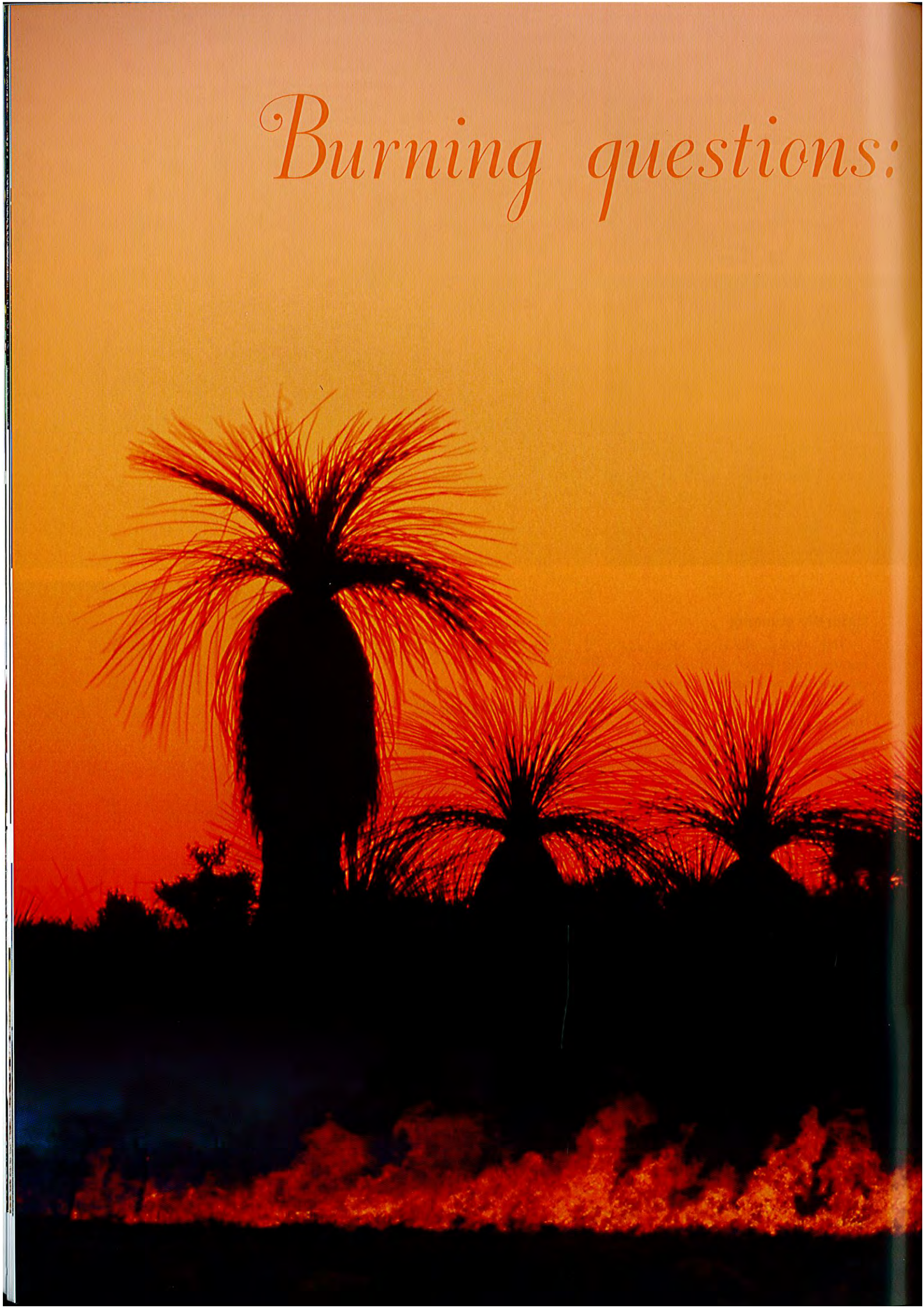
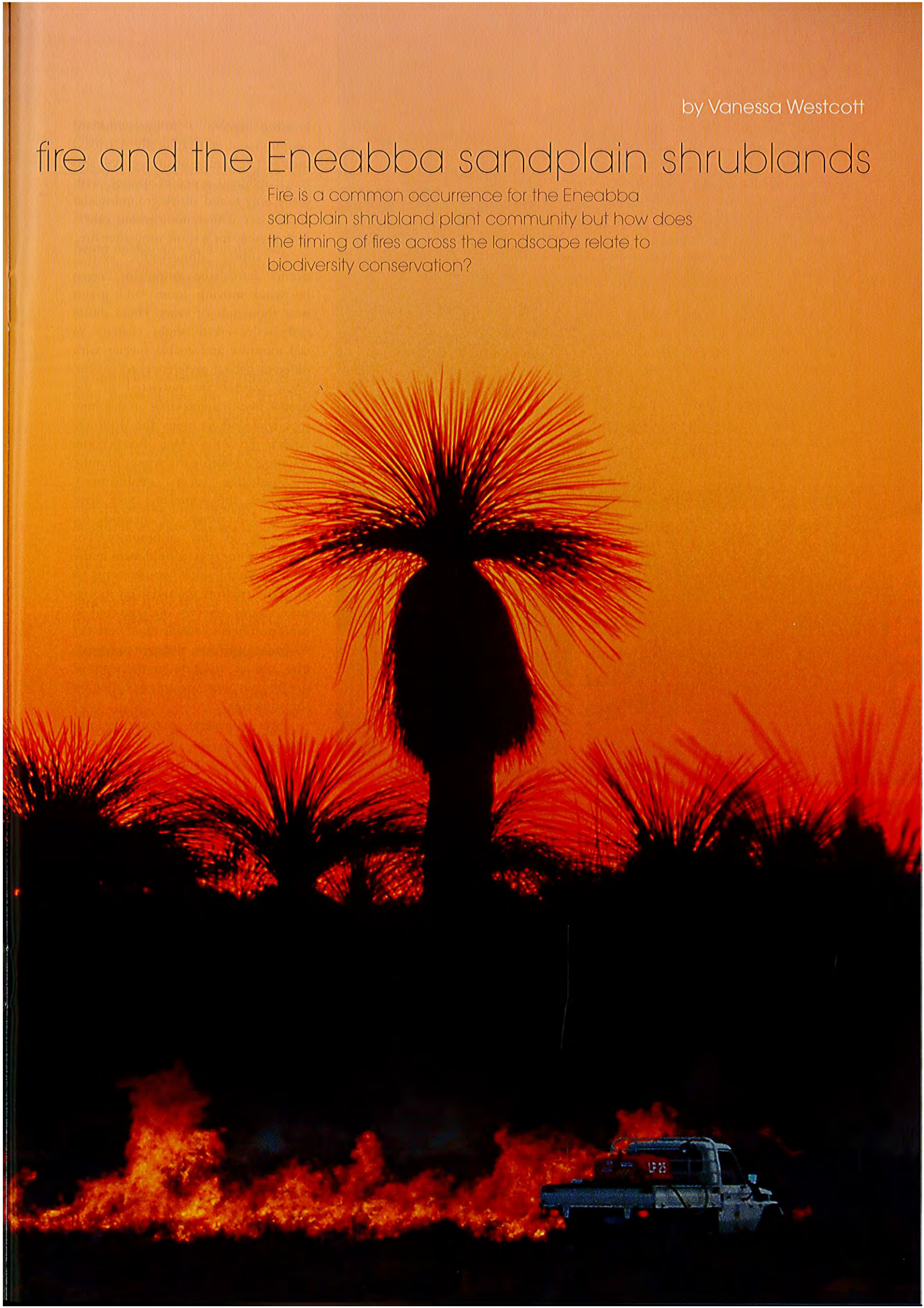
Burning questions:



by Vanessa Westcott

fire and the Eneabba sandplain shrublands

Fire is a common occurrence for the Eneabba sandplain shrubland plant community but how does the timing of fires across the landscape relate to biodiversity conservation?



The Eneabba sandplain shrublands are located 270 kilometres north of Perth, nestled between limestone shrublands running along the coastline and lateritic shrublands further inland. The soils are white sands with extremely low nutrients and it is amazing to think any plants can survive there at all. Yet out of these difficult foundations arise some of the most diverse, endemic-rich shrublands in the south-west of Western Australia. Here are banksias, hakeas, feather-flowers, sundews, orchids and more—and many species are found nowhere else. Fire is an important regenerative agent in this community, providing ongoing opportunities for species to coexist.

The various needs of many species

A botanist attempting to catalogue the vegetation on the Eneabba sandplain must certainly be prepared for a challenge. The continual turnover of species from one place to the next is astounding, with each new survey location having a unique mix of common and geographically restricted species. The timing of surveys will also reveal different types of species, with many only found above ground in the cooler wet winter months and others only present for a short time after fire.

A subtle dune-swale system occurs across the sandplain, driven by wind moving loose sand grains over thousands of years. These dunes and swales create slight changes in soil moisture and enable species with different habitat preferences to coexist. Some species are restricted to the deeper, free-draining sands on the dune tops while others prefer the shallower sands in the swales which often become waterlogged during the winter months.

Gradually, over evolutionary timescales, the sandplain's taxa have finetuned a variety of methods for persisting in the community. For example, some species hold seeds in the canopy within thick woody fruits to protect them from fire and many species store energy reserves underground in roots or tubers to enable rapid post-fire re-sprouting. These different strategies give rise to variation in the optimal fire frequency for species coexisting on the sandplain.

Fire managers working in this diverse system face the difficult task of balancing the needs of species with a range of habitat and fire regime preferences, while ensuring fuel loads remain manageable and assets protected. Fire scar mapping of the

Previous page
Main Grass trees at sunset.
Photo – Sallyanne Cousans
Inset Carrying out prescribed burning.

Above far left The delicate blue-green foliage of the small endemic banksia *Banksia tortifolia*.

Above left A striking endemic feather-flower, *Verticordia aurea*.

Left *Dosera erythrorhiza*.
Photos – Vanessa Westcott

Right Experimental burn of a study site.
Photo – Vanessa Westcott

Below Vanessa Westcott carrying out her PhD research in South Eneabba Nature Reserve.
Photo – Jane Mansergh/DEC

Below right Study site in unallocated crown land west of the Brand Highway.
Photo – Vanessa Westcott

sandplain has identified that the average time between fires for the Eneabba sandplain (referred to as the fire-return interval or inter-fire interval) is about 22 years. However, further information was required by managers attempting to formulate an ecologically sensitive prescribed burning strategy for the sandplain. In particular, managers were unsure of the answer to a key question: what is the minimum fire-return interval for the Eneabba sandplain shrublands if the maintenance of plant species diversity is to be achieved?

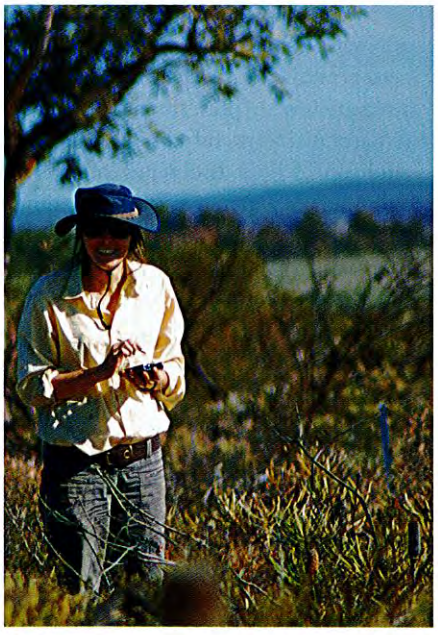
Science meets management

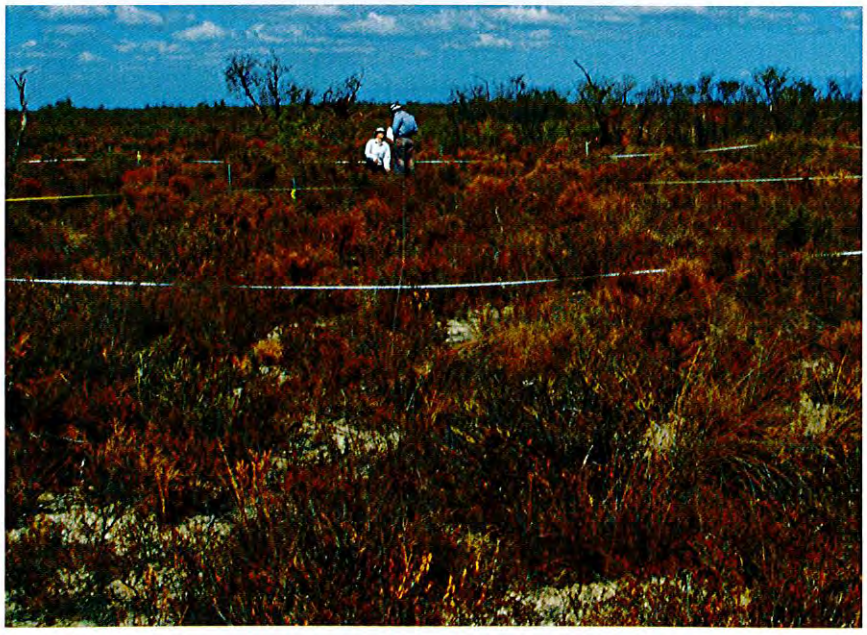
In order to address this question for the sandplain, a collaborative PhD project was devised between the Department of Environment and Conservation's (DEC's) Midwest Region office and Moora District office, and the universities of Melbourne, Murdoch and Curtin. The aim of the project was to better understand the ecological response of the sandplain community to short inter-fire intervals, to ensure prescribed burning procedures are consistent with the aim of conservation of biodiversity.

Research approach

The overall approach of the project was to closely monitor the Eneabba sandplain vegetation before, during and after a series of experimental fires. Between 2006 and 2010, 18 study sites were established across the sandplain, in both dunes and swales, all of which had been burnt relatively recently (four to 16 years since the last fire). Information was gathered within a series of quadrats at each site including the species present, their density, size and whether they were flowering or fruiting.

DEC staff then burnt the sites under autumn prescribed burning conditions which created a short inter-fire interval at each site. After the fires, the quadrats were revisited to capture the regeneration at each site. Statistical analyses of pre-fire and post-fire data were undertaken to identify changes in the community as a consequence of





Top The number of cones on a Hooker's banksia can reveal how long it has been since the plant has been burnt.
Photo – Rob Neave/Sallyanne Cousans Photography

Above Seedlings germinating after a fire.
Photo – Vanessa Westcott

the short inter-fire intervals. A number of key findings were made which have direct relevance to land managers and help to define a minimum inter-fire interval length for the Eneabba sandplain.

Fuel accumulation

The relationship between the size of plants and their fuel load (biomass) was determined for a variety of common sandplain species by harvesting plants of increasing size and comparing their dimensions (height and width) with their weight. This information was then used to estimate the total fuel load of the study sites where the dimensions of all plants had been measured. Leaf litter loads were also estimated and included in the total fuel calculations for each site.

This fuel analysis revealed that the Eneabba sandplain shrublands are able to regenerate rapidly after fire and this is likely due to the high proportion of species that are not killed by the fire but are able to resprout using energy stored below the ground. This rapid fuel accumulation meant that the experimental fires burnt successfully through vegetation that was last burnt as recently as five years ago.

A neat relationship was identified during this fuel analysis—the height of the tallest shrubs at a site is strongly correlated to total fuel loads. This means that a fire manager going to a location on the Eneabba sandplain can measure the height of the tallest shrubs and then use a simple graph to estimate total fuel loads. This increases the accuracy of fuel load estimation and enables better predictions regarding the risks associated with prescribed burns. This is particularly useful on the Eneabba sandplain where the types of species and their regenerative capacity differ between the dunes and swales, making fuel age too simple a measure for accurate fuel load estimation.

These methods could be applied in other diverse shrublands where estimating fuel is difficult because of the lack of a dominant species or where topographic variation is important in driving biomass loads.

Storing seeds in the canopy

For species that hold their seeds in the canopy and are killed by fire,

their long-term persistence is directly related to the amount of time between fires. After fire, seeds that have been released from the canopy germinate, the seedlings grow, the plants mature and begin to flower, the accumulation of seed in the canopy then commences and, eventually, sufficient seed storage for adequate post-fire recruitment is achieved. This all takes time.

These fire-sensitive species require enough time between fires to complete these milestones; otherwise, they may decline and even become locally extinct. Understanding the time it takes these species to store adequate volumes of seed is useful in determining how often is 'too often' in terms of repeated fires in the community.

Hooker's banksia (*Banksia hookeriana*) is a prominent endemic of the Eneabba sandplain. It is a large single-stemmed shrub reaching up to two metres tall which produces orange flowers and has serrated bright green foliage. This species is restricted to the dune tops of the sandplain and is killed by fire. By counting the number of cones on plants at sites with increasing fuel age it was possible to determine the timing of important early life-history stages of the species.

It takes four to five years after fire for the species to start seed production, with no cones observed on plants until four years from the last fire. Rapid and continuous cone production then starts and increasingly large numbers of seeds are added to the canopy every year, particularly from about 10 years onwards. This is likely to continue beyond the range of fuel ages examined in this study. Understanding these timelines reveals the vulnerability of the species to extremely short inter-fire intervals.

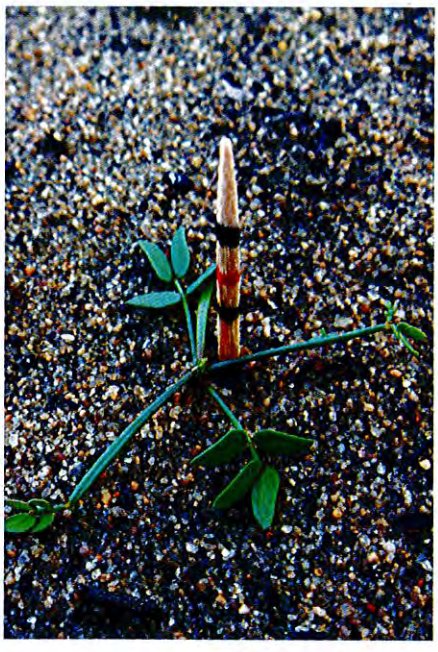
Community stability and the soil seed bank

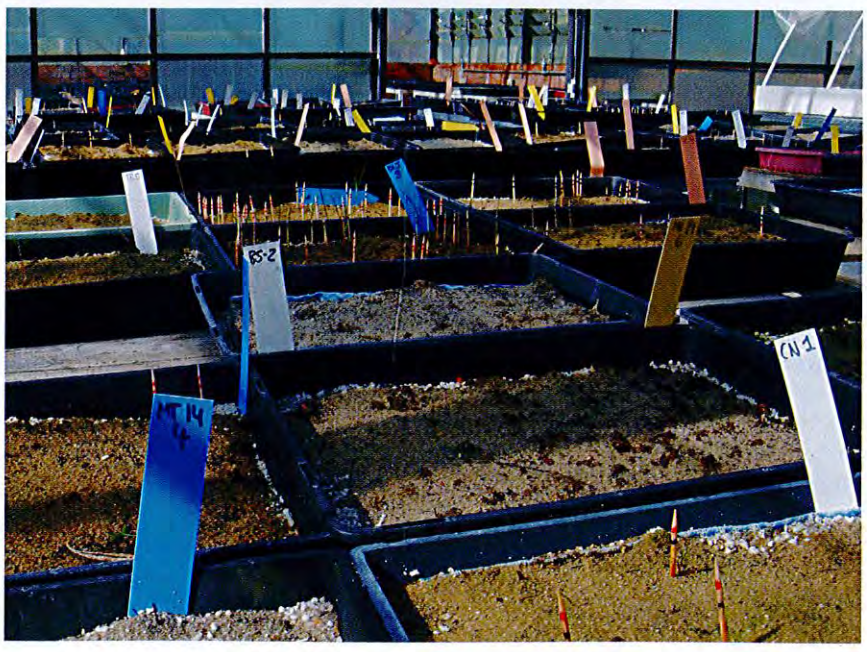
An alternative to storing seeds in the canopy is allowing them to drop to the ground and form part of the soil seed bank. In fact, the majority of species on the Eneabba sandplain store their seeds in the soil. Smoke and

Right Study site south of Yardanogo Nature Reserve after a fire.

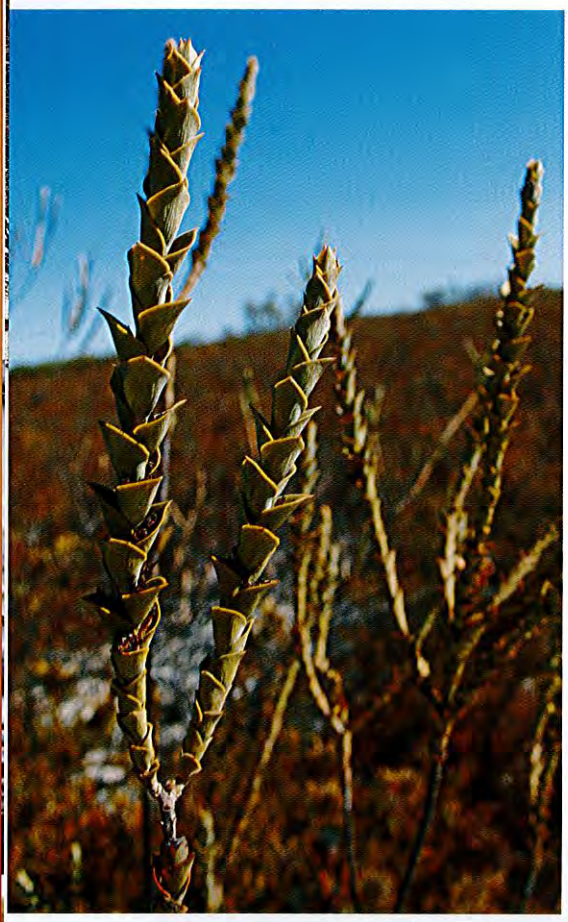
Below An *Acacia* sp. seedling.

Below right Germinating seedlings.
Photos – Vanessa Westcott





heat from fires penetrates the soil and breaks seed dormancy, and the seeds then germinate in the nutrient-rich post-fire environment where there is minimal competition for light and space. It is a clever approach to living in such harsh conditions.



A comparison between the species above ground at the study sites and those represented in the soil seed bank was undertaken by collecting soil samples and germinating the seeds in the soil in a glasshouse. The results showed that as time since the last fire increases, species present above ground were more likely to be represented in the soil seed bank. This is because the above ground plants present at the sites had more and more time to produce seeds. This outcome suggests better community stability (that is, minimal changes to community composition) is more likely to be achieved as inter-fire interval increases, at least over the range of intervals examined in this study.

The harsh summer months

The south-west's Mediterranean climate means that very little rain falls during the summer months. This makes conditions difficult for post-fire seedling growth. After the fires occurred at the study sites, seedlings in the quadrats were identified and counted at six months (spring) and again at 12 months (the following autumn). Analysis of this information revealed that the magnitude of seedling deaths during this period was strongly linked to the amount of post-fire rainfall.

This illustrates that even if the plants are given time to accumulate seeds between fires, they are still vulnerable to declines in numbers and even local extinction if the post-fire conditions are unfavourable. For this reason, a greater amount of time to accumulate even more seeds between fires is recommended given the unpredictability of the post-fire conditions. With climate change experts predicting that hotter and drier conditions are likely for the Eneabba sandplain shrublands, a precautionary approach to minimum fire intervals is recommended.

Management implications

With this science up their sleeves, fire managers can now better tailor their prescribed burning program to ensure it is based on a sound ecological understanding of the Eneabba sandplain shrublands. This research has shown that even though fires may

Left *Leucopogon obtectus*, a threatened species restricted to the sandplain.

Below Eneabba sandplain.
Photos – Vanessa Westcott

Below right Sundews (*Drosera* sp.), found at Beekeepers Nature Reserve, catch and digest insects caught in the sticky glands on their leaves.
Photo – Ann Storrie

Above Hakea.
Photo – Vanessa Westcott

Right Sunset on the Eneabba sandplain.
Photo – Marie Lochman

spread through vegetation five years old, prescribed burning at such short intervals is inappropriate with a real risk of local extinction for vulnerable species and a reduction in community stability.

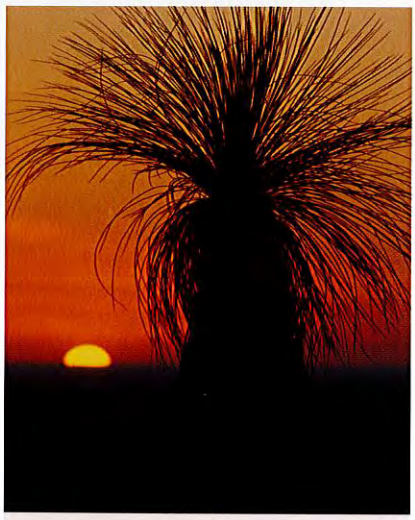
Based on a variety of data analyses at the species and community levels, inter-fire intervals of 13 to 15 years were identified as the minimum fire-return interval consistent with the protection of plant species diversity. This amount of time will limit the number of species that are not able to produce adequate volumes of seed for self-replacement (whether stored in the canopy or soil) and takes into consideration the increasingly unfavourable post-fire weather conditions likely to occur as a consequence of climate change.

This result should be incorporated into a landscape-scale fuel age and fire frequency mosaic approach which is widely accepted as optimal for biodiversity conservation. Fire mosaics maximise the opportunities for species with different fire regime preferences to coexist. This research has been able to identify a lower limit on the range of inter-fire intervals that should be incorporated into such an approach. At the other extreme, beyond the scope of this study, there is also likely to be an upper limit, with long intervals also likely to be unfavourable as seeds in the seed bank lose viability and older plants become more susceptible to drought and disease.

It is important to acknowledge that this outcome is specific to the ecology of the Eneabba sandplain shrublands. This project was later extended onto the adjacent limestone shrublands and considerable differences in the mix of species, variation in strategies, fuel accumulation rates and minimum fire-return intervals are becoming apparent as analysis comparing the two communities continues.

Come and visit

The shrublands of the Eneabba sandplain are worth a visit. Nature reserves, including South Eneabba, Beekeepers and Yardanogo, each harbour a unique mix of species that is best seen in late winter and spring with each new month revealing a different flush of colour emerging from the bleached white sands.



Vanessa Westcott recently completed her PhD at the University of Melbourne and is currently working as a botanist at Biosis Research in Melbourne. She can be contacted by email (vanessacwestcott@hotmail.com).

The author would like to thank the following people for their involvement in the project: Neal Enright, Byron Lamont, Ben Miller, Joe Fontaine and Ian Thomas for academic support; Dave Atkins, Anthony Desmond, Vince Hilder, Sam Hurd and the Department of Environment and Conservation Moora District fire crew for assistance with the experimental fires; and Karina Knight, Mike Hislop, Skye Coffey, Juliet Wege and Russell Barrett for plant specimen identification and lodgement at the Western Australian Herbarium.

Volume 27 Number 4 WINTER 2012

contents

Regulars

Publishing credits
Executive editor Madeleine Clews.
Editors Rhianna King, Joanna Moore.
Scientific/technical advice Lachie McCaw, Keith Morris, Kevin Thiele.
Design and production Natalie Jolakoski, Gooitzen van der Meer, Sonja Schott, Tiffany Taylor, Lynne Whittle.
Illustration Gooitzen van der Meer.
Cartography Promaco Geodraft.
Marketing Cathy Birch.
Phone (08) 9334 0296 or *fax* (08) 9334 0432.
Subscription enquiries *Phone* (08) 9219 8000.
Prepress and printing GEON, Western Australia.

© Government of Western Australia
May 2012

All material copyright. No part of the contents of the publication may be reproduced without the consent of the publishers.

Maps should be used as a guide only and not for navigational purposes.

ISSN 0815-4465

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

Published by the Department of Environment and Conservation, 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