Urban Bushland Council (WA)

Burning our Bushland

Proceedings of a conference about fire and urban bushland

Cockburn Wetlands Education Centre
Bibra Lake, Western Australia
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Edited by
Jillian Harris

Burning our Bushland
Proceedings of a conference about fire and urban bushland

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Cover photograph by Greg Keighery
Burnt *Callitris preissii* woodland, Woodman Point.

URBAN BUSHLAND COUNCIL (WA)

PO Box 326, West Perth WA 6872

To promote the recognition and conservation of urban bushland, our natural heritage.

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Preface

This conference was organised by the Urban Bushland Council, with the assistance of a grant from the Minister for the Environment. The grant enabled us to employ Jillian Harris as conference organiser, and we wish to acknowledge her skills and dedication in providing a stimulating programme and in getting such a wide cross-section of people to attend in pleasant surroundings. Jill was guided by a conference steering group, comprising Kirsten Tullis, Michael MacShane and Mary Gray. Special acknowledgment is made of their vision and direction.

An additional grant from the Gordon Reid Foundation enabled us to compile, print and distribute the proceedings more attractively and more widely, for example to all local government authorities and libraries and relevant state agencies. To both these funding sources, a special thank you form the Urban Bushland Council and from delegates who benefited so much from the conference.

Many of our members contributed in many different ways to make the conference such a success. Some washed the dishes, swept the floor, brought along displays, helped organise the programme, gave talks, asked probing questions, chaired sessions, and made others feel welcome.

A special thank you also to Margo O'Byrne form the Ecoplan programme run by the Department of Environmental Protection, for sponsorship of a number of community delegates. Tony Poynton from the Cockburn Wetlands Education Centre helped ensure the smooth running of proceedings during the two days. Dianne and Bob Tizard did an excellent job of catering which was much appreciated by delegates.

The idea for the conference arose from community concern over the high incidence of fires in urban bushland during the past two summers. Of particular concern was the alarming rate of arson, sensationalised media reporting of fires, certain fire fighting practices, and importantly for the long term, the ecological damage resulting from frequent fires.

Thus the conference had two distinct goals. Firstly, to draw together all sectors interested in the burning of our bushland: community groups, scientists researching various aspects of fire, bushland managers, arson investigators, and fire fighters. Secondly, to reduce the incidence of fires and the ecological damage they cause. The conference provided a forum for a healthy exchange of information and views.

Delegates were challenged at the start of the conference to keep certain questions in mind: What can be done to reduce the incidence of fire in urban bushland? What can you as an individual do? What can the Urban Bushland Council do?

Suggestions from delegates for improvements in fire management were put forward in the final session. In addition, during discussion sessions throughout the conference, many valuable ideas and suggestions were presented and all of these have been summarised in these proceedings by the conference steering group.

As a positive outcome of the conference, the Urban Bushland Council is pursuing key ideas formulated during the two days. A valuable dialogue has been established between UBC member groups and the fire fighting agencies, especially with Richard Robertsen of the WA Fire Brigade. We have been included on a multi-agency committee looking at the implementation of recommendation 23 of the John Day Report ('Report of the Ministerial Working Group investigating the Darling Escarpment Fire Hazard, 24 May 1994).

The Urban Bushland Council hopes that the collective wisdom expressed openly at the conference will enhance the understanding about the ravages of fire and the need for better fire management to protect our priceless urban bushland heritage. We look forward to a marked decline in the incidence of fires next summer.

Mary Gray
President
Urban Bushland Council

Urban bushland and the Urban Bushland Council (WA)

Western Australia's urban bushland has outstanding natural heritage values. These include intrinsic, nature conservation, scientific, educational, social, recreational, economic and aesthetic values. Despite these values urban bushland in Perth and regional centres and towns faces problems such as: rapid urban development causing the loss of large areas of bushland; a lack of awareness of the values of urban bushland; no state-wide co-ordination of management for bushland areas; and degradation as a result of disturbance by frequent fires, weeds, dieback, feral and domestic animals and inappropriate land uses.

In response to continuing threats to urban bushland, with Hepburn Heights being one notable case, over 40 groups represented at a workshop organised by the Conservation Council on 7 November 1992 unanimously called for the establishment of a coalition of community groups to protect urban bushland. A Steering Committee was formed, and the Urban Bushland Council was formally launched in Kings Park on Sunday March 21 1993.

The Urban Bushland Council (WA) is a peak community organisation for urban bushland protection, it is voluntary and non-government. The membership comprises conservation groups committed to urban bushland protection. There are 35 member groups. Individuals can become 'supporters'. Any non-affiliated group or individual involved in urban bushland is welcome to receive the information and support the Council offers. The functions of the Council include local action and networking, policy development, lobbying and raising public awareness of the values and problems facing urban bushland.

The Urban Bushland Council meets on the first Tuesday of every month at 7.30 at the National Trust in Havelock Street, West Perth. Anyone interested is welcome to attend. The Executive Committee meets on the third Tuesday at the same venue.

Official opening

John Day, MLA for Darling Range
Representing the Minister for the Environment, The Hon Peter Foss, MLC

This conference is appropriate and timely given the increasing incidence of unplanned fires in urban surrounding areas and the significant environmental, social and economic impacts that such fires are having.

We only have to think back to last summer, and the hundreds of bush fires that occurred throughout the metropolitan area, to appreciate the strain that was placed on the resources of not only the WA Fire Brigade, Bush Fires Board Brigades and Department of Conservation and Land Management fire fighters, but the many thousands of volunteer fire fighters who give their time to protecting life, property and community assets from the effects of wildfires.

As Member for Darling Range, which obviously includes much of the Hills area, I am well aware of the efforts of the volunteers and acknowledge that without them, this State could not possibly hope to suppress the number of fires without extensive loss of property and human life.

In considering the question of fires and urban bushland, there are a number of significant factors that need to be taken into account.

Firstly, fire is a natural phenomenon in the Western Australian environment. Our plants and animals have evolved alongside fire and many of them depend on it for their survival.

Secondly, our Mediterranean climate, with its long dry summers of six to seven months combined with the natural fast build up of fuel, leaves, twigs and vegetation, creates potentially dangerous situations — every year.

Thirdly, each year there will be some days when wildfires are impossible to control by direct means. Invariably, these days are of very high or extreme fire danger with high temperatures, strong northerly to easterly winds, and fuel — leaves, twigs and vegetation — are at their driest.

Fourthly, of the three factors that make up the fire triangle — heat, oxygen and fuel — there is only one over which fire managers can have control. That is the amount of fuel that builds up on the ground.

Therefore, the management of the fuel level is critical if we are to minimise the number of days each year on which wildfires will be impossible to control.

Reducing fuel loads by low intensity, prescribed burns has proven to be the most effective and efficient way of controlling intense wildfires when they inevitably break out. Nowhere was this more evident than last summer when many large fires on the Darling Scarp and within metropolitan bushland areas were only able to be controlled when they ran into areas in which fuel loads had been reduced from previous prescribed burns.

Over the past 40 years, extensive fire ecology research by CALM, CSIRO and various universities, in a wide range of forest and woodland types, has confirmed that fire is an essential part of the natural environment. Fire, whether it is in the spring, summer or autumn, frequent or infrequent, high or low intensity, will affect the forest ecosystems in complex and subtle ways.

Consequently, while prescribed burning is an essential tool to protect communities and natural values from wildfires, it is one that must be thoroughly planned and carefully applied to ensure that there are no long term, deleterious impacts on the environment, including the air quality and water catchments.

Agencies such as CALM must continue to be thorough in their endeavours to accommodate

these needs and to minimise the impacts of burning on factors such as plant communities, declared rare flora and fauna, habitat, soil erosion, water quality and air quality.

I understand that the result of much of this research is now being used extensively not only by CALM, but also by volunteer brigades. Training programmes through local shires and the Bush Fires Board are placing increasing importance on the environmental consequences of fire, including wildfires and prescribed burns, and these impacts are now being more fully understood by volunteer brigade members.

I strongly support this trend as it will have long term benefits not only for our natural environment, but also for the safety of our communities and the people who live in them.

One of the aspects of prescribed burning on which there has been much research has been the timing of the burn. They need to be carried out under mild weather to achieve their objectives and to minimise the risk of escape. However, stable weather often means smoke may not disperse rapidly and consequently will accumulate over residential areas that may be several kilometres from the site of the burn.

As a result, there are phone calls from irate residents to the Minister's office, to CALM, to the WA Fire Brigade, local shires, the Department of Environmental Protection and the media.

Of course, CALM is not responsible for every particle of smoke. Burns by private land owners, volunteer brigades and property developers also contribute to the problem. However, there is an unfair public perception that if it is smoke, then it belongs to CALM!

CALM has applied a smoke management programme as part of its burning operations for many years. This process is now carried out in association with the Bureau of Meteorology and the Department of Environmental Protection. It is significant that the number of days on which there is a smoke haze over Perth as a result of prescribed burns has fallen from an average of 10 days a year down to four or five.

However, the smoke management programme has also significantly reduced the number of days on which prescribed burns can be carried out. For example, in the northern jarrah forest, burning is restricted to days with south-west winds. This constraint, combined with extremely dry summers over the past two years, has prevented CALM from achieving a very large proportion of the burning programme in the forest areas around Perth. Some of the burns are not only for community and environmental protection, they are necessary to regenerate forest areas. The result has been a big build up of areas carrying high fuel loads and an increased risk of large, uncontrollable and damaging wildfires. It means that smoke will occur with, or without, planned burning. And it needs to be remembered that wildfires can result in loss of lives and cause heartbreak by destroying private assets and natural resources.

The NSW fires in January last year caused such devastation and exposed the public to heavy smoke for days on end. In the main we have been able to avoid such a distressful situation through the judicious application of protection burns in the South-West region.

Perhaps it really boils down to the fact that we, as a community, need to recognise that at times value judgements will have to be made when it comes to protecting life, property and environmental values. Part of that judgement is the undeniable fact that everyone in the community owns the risk and threat of bush fires.

Prescribed burning and its associated smoke management are highly controversial issues. I therefore congratulate the Urban Bushland Council for organising this forum as I am sure it will make a positive contribution towards the wider community's understanding of fire's role in the environment and how it should be managed to sustain and protect our environment and community assets.

I am pleased to declare your conference open.

The bushland community group perspective: Stop burning our bushland.

Compiled by Kirsten Tullis and David Wake, Urban Bushland Council (WA)

Introduction

There are dozens of community or 'Friends' groups in Perth and regional centres that have an active interest in urban bushland. Many regularly visit particular sites to carry out activities such as bush regeneration and education programmes. Members of these groups have become dismayed at the growing number and intensity of fires in urban bushland. The summer past was especially bad. Although there are the normal concerns that people have with bush fire, especially if they live in a vulnerable position where their own life or property might be at risk, this is recognised as a threat to the bush itself, to its very integrity. Our bushland, with its animals and plants, its diversity, structure and feel, is one of the most beautiful expressions of nature's work on earth.

Fire adds to the unprecedented pressures on urban bushland from clearing and a growing human population. Our bushland is adapted to fire, but not to the increased frequency we have seen since European settlement. Fragmentation is another enemy, for it isolates populations of plants and animals and impedes recruitment - when a fire strikes a small reserve it can be devastating.

Eight bushland community groups were surveyed for this paper. The members told us of their bushland areas, their experience and personal feelings regarding the impact of fire, and made suggestions on how to improve protection for bushland from this unwelcome visitor.

Ellis Brook Valley Reserve, Martin

1642 hectares

Margaret Robertson - Friends of Ellis Brook Valley

Situated on the Scarp overlooking the Coastal Plain, Ellis Brook Valley is diverse in landscape and plant and animal species. Unfortunately, its Marri/Wandoo and Jarrah/Banksia woodlands, heathlands, and patches of granite outcrops and shallow soils have been burnt frequently - the edges every two to three years and the main part every 10-15. Arson has been the main cause identified, and the person responsible in January 1992 (where 900 hectares were burnt) was a serious operator - he used time delay devices in ten separate locations. Unfortunately, although known to police, this man was never charged as he was not caught in the act. Just over one year later another devastating fire (of 500 hectares) was started, burning most of what was not burnt the year before.

Margaret describes the initial shock following the big fires as being like losing a friend, and she went through a period of grieving - especially for the native animals injured, killed, displaced or now hungry. Her team's strategy following a fire is to try and assess the damage, recover injured fauna and collect as much native seed as possible for regeneration. They also try to keep out the vehicles of sightseers and vandals. She is concerned that the (now) more open bush is not as well protected against trail bikes, four wheel drives and horses. During the fire fighting, one of the adjacent land holders did immeasurable damage using a bulldozer with a 12 foot wide scraper. Additional pressure from weeds is increasing with each fire, and

fauna is feeling the effect through habitat loss - some have not yet returned. Initiatives in awareness raising is a main defence, and so the Friends have asked locals and frequent users to "keep your eyes open and report anyone acting suspiciously". They have found most people keen to prevent big fires from happening again. Despite the size and importance of the area, the local council has not established a fire management plan - currently the Friends are preparing a draft document for presentation to council. As the City of Gosnells manages the reserve, Margaret says her team is restricted as to what liaison can take place with the local fire authorities.

Perpetrators of arson love to hear the damage reports, and so Margaret believes that less glorification of this crime by the media will go a long way to help our bushland. In addition, she bemoans repeated scenes of fire from helicopters. It may help if the media acknowledged more the efforts and concerns of bushland groups, and it would certainly help if local and state government agencies did so too. The Friends are concerned that there is not enough emphasis on proper management and rehabilitation. Further, by working with and not against community groups, which have much local knowledge, bushland management and conservation in general would progress greatly. Margaret urges that the decades of indoctrination that 'frequent fire is good for the bush' be overcome.

Port Kennedy

1100 hectares
Jeff Anderton, Port Kennedy Land Conservation District Committee

Port Kennedy has been listed on the National Estate for its geomorpholgy and flora, and has been recommended for conservation in the recent publication by Neil Gibson and others entitled *A Floristic Survey of the southern Swan Coastal Plain*. The area is remarkable in habitat for mammals, such as bandicoots, which are among the nine species of endangered fauna living here. It also carries Australia's youngest wetlands, which are evolving as the land grows slowly from the ocean. This wetland succession dates back some 8,000 years.

This year Port Kennedy has had seven fires, all the result of arson. Jeff's team, the local Land Conservation District Committee, is highly efficient and practiced in fire fighting. One of their main priorities is fast response so fires are put out quickly. In summer months they maintain a constant vigil against fire and vandalism. They have a good and continual rapport with the fire authorities.

The Committee has seen the negative impacts of fire - damage to flora and fauna, erosion and degradation. Large fires occurring before the formation of the LCDC burnt up to 50 per cent of the area, although these areas are now regenerating.

The Committee is proving that with a proper fire management plan, vigilance and trained volunteers the impact of fire can be reduced. Jeff believes that public education, improving response and better planning are the keys to a good future for bushland.

Note: Another paper appears in this publication with more details on the activities of the Port Kennedy LCDC.

Brixton Street Wetlands, Kenwick

19 hectares
Regina Drummond and Trevor Drummond, Friends of Brixton Street

Brixton Street Wetlands is regarded as one of the most important natural sites in the Perth Region, and many experts agree it has world significance. This is because it is a naturally rare ecosystem in a sea of cleared land. Much is seasonally inundated, and its claypans have some declared rare flora species. Approximately 370 native plant species occur at Brixton Street.

There have been fairly frequent fires in recent years - due entirely, to the knowledge of Regina and Trevor's group, to arson. These have varied in severity, with last summer

seeing one of the bad ones, in which approximately half of the area was burnt out. Despite the initial intense feelings of anger and concern for the bandicoots and other creatures, the Friends have taken advantage of fire events to some extent by clearing away the rubbish left uncovered. Some of the noticeable negative impacts include increased weed invasion, reduction of mature seeding plants, death of wildlife and deprivation of habitat. Regina and Trevor are concerned that there may be permanent reduction, or even loss, of fauna populations.

The Friends of Brixton Street have had no contact with fire authorities, either before or after the last big fire. One wish they have is for fires to be put out as quickly as possible. To help reduce the fire risk at Brixton Street, the Friends have undertaken some weed control, although there is not a fire management plan to work to. A management plan, however, is being developed with close liaison between community groups and the Department of Conservation and Land Management. Soon, the vesting process will be complete where the land will be transferred to CALM from Homeswest. Homeswest presently maintains the firebreaks.

Regina and Trevor believe more publicity is needed on the harm of fire so people will be more alert to arsonists and hopefully report them to the police. They also urge the media to report less sensationally on fire.

Quinns Rocks area

Natalie Reeves and David Wake, Quinns Rocks Environmental Group

This active environmental group is interested in the remnant bushland in and around the suburb of Quinns Rocks. The remnants vary in size and shape. Some are as small as a hectare, and the larger ones range from thin coastal reserves to wide expanses on the urban fringe where development threatens. Vegetation ranges from coastal and limestone heath, shrublands and woodlands of Banksia, Tuart and Jarrah.

Some urban bushland areas around Quinns Rocks suffer from *ad hoc* prescribed burning, and others - especially the larger fringing areas - from occasional arson or carelessness. Often, cases arise when burning off by developers goes astray. For instance, in the summer of '93/'94 hundreds of hectares of Neerabup National Park were incinerated when contractors (working for a land developer) were clearing and burning of remnant vegetation nearby. Residents claim recent fires at Burns Beach, had a similar cause. This area, which burnt right up to Mindarie Tip, was in excellent condition and had been long unburnt. It will soon be subject to an application for urban development.

As well as the unprecedented loss of bushland to urbanisation the Group is very concerned by the effects of frequent fire. They cite added weed invasion, especially in the dunes, whose vegetation regenerates slowly; death of fauna - many of which cannot escape because much of the bush is isolated and without connecting corridors; a reduction of biodiversity; and loss of the beneficial processes of leaf litter decomposition and recycling.

The Group has had limited contact with the local fire authorities but agrees that bush carers and fire fighters need to get together and learn about each other's points of view. They do communicate with the City of Wanneroo regarding prescribed burning policies, but have found them to be unaware of bushland values or uninterested in the Group's concerns. None of the bushland areas have a management plan, though there is a draft one for Kinsale Park. The Group would like to see plans instigated, with community input, and modelled on Kings Park and Botanic Park's plan which recommends against prescribed burning. They would also like to see all developers banned from burning off. The Environmental Protection Authority has published guidelines to minimise burning off practices, yet these are rarely heeded and are not enforceable. Mechanisms to ensure the whole community receives a clear message of the impact of burning and the illegalities of arson are needed. Until we see the end of authorities being permitted to carry out burns, then the general public will maintain the idea that burn offs are good for bushland.

Bungendore Park, Bedfordale

498 hectares
Jeff Lewis, Bungendore Park Management Committee

Situated approximately five kilometres south of Armadale, this popular park has large areas of bushland — predominantly Jarrah/Marri with an area of Wandoo, and some scrub heath surrounding outcrops. The Management Committee has been caring for the park for many years. During that time it has had a close liaison with the local fire authority through the fire suppression programme, during which fuel loads are monitored and controlled burns undertaken. Despite the programme, conditions were ripe one hot and windy day in December '94 for a fire which swept through the park from the south, leaving only 15 per cent unaffected (this portion had some protection from recent control burning). No one can recall when last a fire burnt the whole park. This extremely hot burn decimated all the flora and most of the fauna, and even for those creatures that did survive little food was left. Jeff's group felt anger at the cause, supposedly the burning of a stolen vehicle more than 10 kilomtres away beyond the Wungong Valley, and despair at the loss of flora and fauna. Because of the time of year, the heat and the dry soil, a few trees died soon after regenerating.

One of the longer term effects included closure of the park, which, for some time, will be unusable for educational purposes and wildlife research other than for regeneration studies. The Group has recorded extensive regrowth of a large number of plant species and gradual return of some of the animal and bird species in its post fire monitoring programme. Interestingly, there has been a heightened awareness of the effects of wildfires and increased interest in the park by the public. Unfortunately, it has not been possible to block access totally and protect against the illegal wood cutting, rubbish dumping and other acts of vandalism. Recently the Committee has attended the Armadale Chief Fire Officer's debriefing of events leading up to, and after the fire. A management plan has been contracted out, and is open to community input during the drafting process.

The Group urges such measures as these are necessary: harsher penalties for arsonists; regular patrols by police and shire staff in susceptible areas; and an increased community vigilance.

Armadale Settlers' Common

383 hectares
Brett Tizard, Friends of Armadale Settlers' Common

A large area of urban bushland, Armadale Settlers' Common forms a buffer between the urban and rural zone. It is on the Scarp and is typical Jarrah forest with some Wandoo. This year there has been an obscene amount of arson on the Common, with five major fires - one every month from November to March. Over the March long weekend alone, there were ten separate fires. These were all due to arson, and lit in such a way that it was difficult for the fire brigade to deal with them. The arsonist on the days of the March fires used a trail bike and time delay devices.

Brett and his team experienced a mixture of emotions following the fires. A great deal of anger and sorrow, especially after the last deliberate campaign. Much of their hard work in regeneration had disappeared; they lost nearly 3,000 seedlings planted the year before - these didn't grow back although older seedlings planted some five years previously have re-sprouted. They expected a period of despondency to follow, perhaps a permanent one. Brett says that to his pleasant surprise he and his group have become 'all fired up' to do more to improve the Park, and that this impetus arose from the anger not the sorrow. Although they tended to work in the hardest hit areas, which was a little depressing, they watched the slow emergence of the green amongst the black in the areas that were first assailed by fire.

The Friend's have a happy association with the Bedfordale Volunteer Fire Brigade and the City of Armadale's fire crew. With regular dialogue and a willingness to listen to each other's needs and wants, techniques are continually being amended. Occasionally, one brigade member will remind another of the more environmentally friendly methods. Up until eight years ago the Common had a patchy fire history and it tended to be managed strictly for fire control where big areas were burnt in rotation. Now, the aim is for a mosaic pattern of prescribed burning with varying intensity and times of the year. This is done with the bush's health in mind and in keeping with the management plan. For instance, careful planning goes into maintaining the best known fire regime to support the Common's rare orchid.

The Common was shut in March until mid-winter - mainly for safety reasons. The Friends negotiated with the brigade not to push any trees down - the usual response following fire, just in case they fall. Happily, most were still stable and regenerated, so only two were eventually felled, not forty or fifty. The City of Armadale has invested considerable money in much needed state of the art equipment. For instance, high powered cannons are used to extinguish tree top fires - preferable to felling a tree to kill the flames. The fire personnel are now working to reduce the number of trails, and when a new firebreak is cut in the 'heat' of the moment the entrance is concealed so it is not used again by park visitors, and the bush can regrow.

The Friends work to help manage fire impact through weed control, a particular problem here given the proximity to paddocks. They also have an informal bush watch structure, and actively encourage people to use the reserve, so that there are plenty of people to keep a look out.

With their recent experience members of the Friends of Armadale Settlers' Common are greatly concerned by arson, and the fact that it takes only one or two people to wreak such harm. They believe the media sensationalises fire and thus promotes arson activity. Perhaps the extensive reporting of the '93/'94 eastern states' bush fires contributed to the high incidence of urban fires around Perth in summer '94/'95. Also, the Common was reported after one event as having suffered minor property damage - only one shed was affected. Yet eighty or ninety hectares of bushland went up.

Hepburn Conservation Reserve, Padbury

20 hectares
Alan Lloyd, Friends of Hepburn and Pinnaroo Bushland

Made famous in 1992 by the massive community effort to prevent development, Hepburn Heights lost a significant portion of its bushland habitat to housing, including most of its Tuart trees. What remains is the Hepburn Conservation Reserve, which has interim listing on the Register of the National Estate with the Australian Heritage Commission. This reserve, together with bushland in the adjoining Pinnaroo Memorial Park, retains three landforms: older dunes with Banksia and Jarrah/Marri woodland; limestone ridges; and Quindalup dune ridges.

The reserve suffered a major fire in January '93 where about half was burnt. It was caused by arson but made worse by the actions of the fire brigade. Alan watched in dismay and anger as a small vehicle drove up and down the tracks igniting the bush (a process he describes as "forward burning") while four fire units remained sitting on Hepburn Avenue. Alan found the fire personnel unwilling to listen to his concerns, and there has been little or no dialogue since then. The local police have shown little empathy toward the bushland's values. On one occasion a smaller fire was started by two children identified by residents, yet the police did not follow up the complaint as no property was threatened.

Alan's response to the big fire was to write an early morning media release, make follow up calls and arrange an on-site meeting that very day before noon. Seventy-five people and Channel 7 attended. The Friends made it clear to the developer, LandCorp, that just because of the fire it did not now give them an added reason to develop the land. The Friends have since organised a 'Bush Watch' programme.

One of their members takes a walk there every day. The reserve has a management plan, and both the Friends and council undertake weed control. Alan rejects prescribed burning for the reserve, and promotes the idea of a fence and the replacement of all feral animals by native ones, so that weeds and understory are naturally controlled.

Improvements in urban bushland protection could be made by the media gaining a better appreciation of the bush, and helping to educate the public against vandalism, including arson. Alan's experience shows children to be a particular problem with regard to arson. On a positive note, he recognises that education and communication between affected groups is growing all the time.

Yellagonga Regional Park, City of Wanneroo

1400 hectares
Cate Tauss, Friends of Yellagonga Regional Park

Scenic Yellagonga Regional Park is predominantly a lake and wetlands ecosystem, with small amounts of upland Tuart, Jarrah/Marri and Banksia woodlands. Some of its wetlands are seasonal, the rushes and sedges fringed by Freshwater Paperbarks and Flooded Gums. Its remnant bushland and wetlands provide valuable habitat for birds of the bush and water.

Historically, much of the area was farmed, and thus burnt extensively and regularly. Today, fire is still a common occurrence - due to arson, the setting alight of grass and heaped vegetation near new housing developments, and the firing of bush "to reduce fuel load". Spring and summer of '94 was particularly bad for burn offs and bush fire. Arson caused the fire west of Wallubuerup Swamp, and another was due to landowners actually igniting the park adjacent to their property. A third was in some bushland next to a land auction at Kingslake. The dismay at the fires has prompted Cate to ring the City of Wanneroo to register disapproval at what was happening and approach the Environmental Protection Authority. She was disappointed to discover the Lakes Environmental Protection Policy does not have a clause to prevent burning at wetlands like Yellagonga.

The Friends are alarmed at these aspects: the increase in weeds, which not only means more bush regeneration work for members but some weeds increase the fire hazard; greater potential for nutrient run-off into the lakes; loss of native seed germination through fire and competition with weeds; repeated loss of humus, which is habitat for small creatures and also forms microclimates favouring native seed regeneration; a reduction in natural biodiversity; smoke pollution; and habitat destruction, including mature trees. Cate has noticed that some local people are accepting of the situation, in that they add garden rubbish to the waiting piles of native vegetation either cleared by developers or scraped together by managers to 'tidy up'.

Initiatives employed by the Friends to allay the fire situation range from weed control; putting the small fires out when there at the time; keeping watch on the bush in an informal way; reporting fires to the brigade; and complaining to all and sundry. There is no management plan to work to, though the Friends suggest improvements such as appropriately placed firebreaks - not ones that are sited in the species-rich seasonally-damp transition zone of wetlands; better weed control; no harvesting and piling of dead vegetation and trees for lighting; and no prescribed burns unless under exceptional circumstances. The present *ad hoc* situation is not adequate. There is a need for the various formal managers to gain greater expertise and be more co-operative in approach to managing the area and dealing with the Friends. Unfortunately, some local residents and developers see native vegetation as an eyesore or fire threat, so burning off has been used as a quick temporary clean-up measure, especially around the wetlands in the park. At Yellagonga the landscape is also sanitised against trees that might fall, logs in which snakes may or may not live, and the less attractive native coloniser species growing in disturbed sites - the first stage of a natural succession in bushland repair. In all these cases valuable habitat is lost. A bush regeneration approach is needed, not fire. The

Friends would also like to see signs erected and prosecution of perpetrators, including landowners who let fires escape — on purpose or otherwise. They also wish for more public education on the impact of fire and on how to use the park appropriately. It would help to have more random patrols by rangers in susceptible areas and community effort to assist this.

To conclude Cate says "the popular myth amongst many land management agencies is that Australian bush is adapted to fire and needs it often. In my opinion this has contributed directly to the epidemic of arson we are experiencing and it is time that responsibility is taken."

Synthesis and conclusion

Summary of concerns

- Immediate and long term loss of flora, fauna and biodiversity;
- Loss of habitat;
- Loss of food source for animals;
- High frequency of fire;
- Increased weeds, with some weeds increasing the fuel load;
- Loss of seed sources;
- Loss of leaf litter;
- Fire adds to problem of isolation, and impact of land clearing for development;
- Undoing of time and effort in bush regeneration work etc;
- Aftermath is emotionally draining;
- Fire often at hottest and driest time of year, e.g. some later loss of regenerating trees;
- Parks closed to public;
- High incidence of arson, difficulty in detecting the perpetrator and use of time delay devices;
- Sometimes no follow up on interviewing or prosecuting arsonists or people who allow fires to escape - partly because unless caught in the act they cannot be prosecuted;
- Lack of patrols by agencies;
- Problems with sightseers, wood removal, rubbish dumping and vandals after fire;
- Lack of management plans for many reserves;
- Inappropriately placed firebreaks;
- Control burn programmes don't always stop wildfire, e.g. Bungendore;
- Use of fire by land managers to 'clean-up' and to sanitise bush, rather than using bush regeneration techniques;
- Fires escaping from burn offs by developers etc;
- Because land managers use fire such a lot the public thinks it appropriate;
- Smoke pollution;
- Bush burnt is less attractive, and thus encourages developers to move in;
- Additional and often unnecessary damage during fire fighting (parallel or vertical firebreaks and mature trees felled);
- Bush fires not put out quickly or left to burn out;
- Lack of communication with fire authorities, land managers and local and state agencies;
- Lack of appreciation by authorities of community group efforts and expertise;
- Lack of appreciation in elements of the community for bushland values and impacts of fire;
- Media often sensationalises fire;
- Media lacks understanding of community group efforts and bushland values - e.g. makes reports on property damage, not on flora and fauna loss.

Summary of positive aspects

- Renewed impetus to carry on;
- Establishment of bush watch programmes;
- Establishment of management plans with community input;
- Improved liaison with fire and government authorities and a willingness to change practices for the better;
- Sometimes areas previously control burned are better protected from wildfire, e.g. the untouched part of Bungendore;
- Purchase of new effective equipment, e.g. City of Armadale;
- Raising of awareness and interest in the community of fire and bushland values;
- Development of a successful, well trained and quick response team, e.g. Port Kennedy LCDC;
- Natural regeneration following a fire and some return of animals;
- Fire presents the opportunity to remove rubbish;
- Post fire monitoring of bushland recovery.

The similarity and diversity of experience and approach between groups is fascinating. One thing that is common to all is the feelings of anger and despair following a fire - especially if it is the result of arson. This is understandable, for bush carers develop a close relationship with their bushland areas and put much time, money and energy into regeneration, study, clean-ups and interpretive trails and signs. Often, a fire happens at the worst time of the year - when it is hot, dry and food difficult for animals to find. A difference between the community groups, for instance, is that some have formed a good relationship with their local fire authority and council while other groups have achieved little or no rapport. Another, is one or two groups are experiencing the burning off activities of developers in bushland surrounding the newer suburbs.

Also common is the feeling of a need for change. There must be a raising of awareness in the whole community of the value of bushland and the impact of fire, and fire frequency must somehow be reduced. Arson and arsonists must be tackled. It is unlikely that many people are aware that the Bush fires Act provides for a very stiff penalty of up to $250,000 fine and/or a 14 year term of imprisonment. Thus, community awareness, vigilance and response is to be encouraged, so that our bushland gains greater protection.

Fire control must be quick and be done with minimal damage to the environment, using the most up to date equipment (some crews are not well provided for, yet this was not generally raised by the groups), and done in such a way that permits the bush to go through its normal recovery processes. This will happen if better liaison is developed between groups and fire personnel - most groups are not trained in fire fighting and when a fire strikes they have to stand back and trust the actions of volunteer and professional fire fighters. Each side has a different slant on fire. Each should make an effort to understand the other, and inform the other of changes it wishes. Whilst a fire crew may allow a fire to burn so that a return visit is not needed, much against the wishes of the community group, there may have been environmentally friendly fire control methods available which could have helped prevent the fire in the first place. Monitoring after a fire, such as that carried out by Jeff Lewis of Bungendore Park, will assist fire management and understanding. Thus, there is plenty yet for all of us to learn.

There is much to be said about the media. The group members generally agreed the sensationalising of fires makes the situation worse, appealing to the strange psyche of arsonists. Also, how often do we hear "there was no property damage" but no mention of the many hectares of our bushland burnt and animals lost? The media has been helpful in saving bushland areas from time to time, and raising the awareness of bushland values in the community. A down side to this is that often such sites experience a higher incidence of burning.

If and when the entire community understands the issues surrounding bush fire, and supports measures to better protect our natural heritage, it will be possible for all bushland in urban areas to have a close network of carers and fire response people. This is something to strive toward and look forward to.

A fifty year record of fire management in Kings Park bushland.

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As Perth's longest standing bushland reserve, Kings Park has a reasonably complete record of fire management and the effects of fire on bushland [Stoate (1950?), Baird (1977), Wycherley (1983), Recher and Serventy (1991), Kings Park and Botanic Garden (1993), Walton and Kullmann (1994)].

During the fifty years reviewed there have been four fire management regimes:

1. Prescribed block burning 1944-1962
During this period, from November 1944 to June 1962, a total of 796 hectares was prescribe burnt (this excludes wildfires). This was the minimum; some entries indicate there may have been more burnt. A three year controlled burning cycle was introduced in 1947 but was not fully implemented because of wildfires interferring with the programme. A policy was introduced in 1950 to prescribe burn a quarter of the park each year, though this policy was not strictly adhered to as various factors, including involuntary bush fires, upset the programme (Wycherley 1983, Wycherley 1992). Equipment for fighting fires was basic during this period, e.g. only one fire-fighting vehicle.

2. No burning 1963-1973
Due to the large number of fires (in the previous period) and their effect on the bushland the Kings Park Board decided to end prescribed burning (this was surprising in view of the disastrous Dwellingup forest fire of 1961).

3. Buffer strip burning 1974-1984
A total of 146 hectares was strip burnt along the edges of paths and tracks during this period. The intention was to reduce fuel levels in narrow strips, so as to retard the initial spread of fires especially bursting across fire-breaks. In 1974, the number of fire vehicle was increased to four units with the purchase of a new fire truck to add to the old truck and two Landrovers. This enabled the fire fighting crew to respond with a fast attack fighting fires on more than one front.

4. Integrated management 1985-1994
There was no prescribed burning during this period. The smaller fire fighting units were upgraded to Landcruisers in the mid 1980s, enabling a much faster (rapid) response to fires. A successful Veld Grass control programme was introduced reducing the cover of this highly flammable weed by more than 50 per cent in some areas. A programme to reduce woody weeds was introduced in 1993. Internal communications were reviewed and upgraded periodically. Recently communications between Kings Park and Botanic Garden and the Western Australian Fire Brigade (which assists in fighting wildfires) have also occurred. Fire breaks are maintained and new fire fighting techniques and equipment are evaluated. All outside workers receive training in fighting bush fires.

This regime will continue for the next 10 years (Kings Park and Botanic Garden Bushland Management Plan).

Discussion

During the above periods the bushland has endured recurrent arson and wildfire of unknown origin, averaging 10 fires each year (known incendiaries accounting for five fires each year or 48 per cent of all wildfires).

To simplify analysis the regimes have been divided into two periods: block burning 1944-1962 and the remainder 1963-1994 added together.

The total area burnt (prescribed and wildfire) during the block burning period of 18 years amounted to 1046.85 hectares, averaging 58.16 hectares burnt each year. Of this an average of 13.94 hectares each year was burnt by wildfire.

During the following period of 32 years, a total of 605.42 hectares was burnt (prescribed and wildfire) with an average of 33.28 hectares burnt each year. Of this, an average of 14.36 hectares was burnt each year by wildfire.

The above information and attached graphs clearly illustrate that far more bushland was burnt under the prescribed block burning regime and only a slightly greater area was burnt per year in wild fires during the latter 32 year period.

It also illustrates that, despite the differing policies, there is a major wildfire every 10 to 15 years; a risk the community needs to consider, along with the accompanying restoration costs.

Too frequent fires in Kings Park without restoration have led to proliferation of weeds (herbaceous and woody), particularly Veld Grass (Walton and Kullmann 1994 and Stoate 1950?), loss of native flora (Baird 1977) and birdlife (Recher and Serventy 1991), and changes in species composition of the fauna (Barendse et al 1981).

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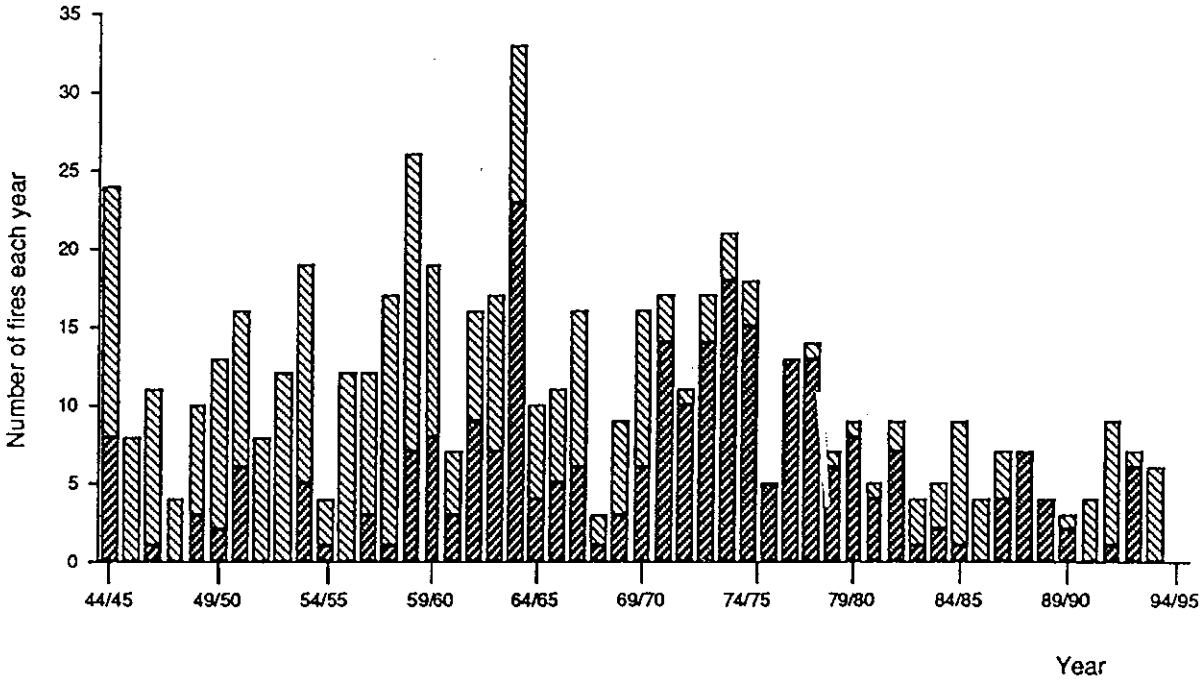
CONTROL OR PRESCRIBED BURNING IN THE BUSHLAND OF KINGS PARK (UP TO 1938 FROM NOTES BY JOHN HEATH, 1938 ONWARD IN BOARD MINUTES AND/OR MONTHLY OR ANNUAL REPORTS, PROBABLY INCOMPLETE)

1932	January	Adoption of Mr Kessell's plan for a 3 years program in which the Park would be divided into 50ac (20ha) sections, some of which would be burnt off at night each autumn.
	May/June	Program of burning off put into effect.
1933	May	Burning off commenced.
	September	Lesser area burnt than required according to plan.
1934	July	Possibly some burning off.
1935		Not clear if any burning off this year.
1936	December	Fire track burnt from Brewery to past Crawley Baths joining May Drive.
1937	December	Clearing and burning off near houses at Crawley.
1938	November	Burning fire hazards and increasing width of fire breaks by burning.
	December	Control burning according to Sept/Oct minutes on 3 year cycle in autumn.
1939	May	Start cool burns.
1941	November	Control burn of "reafforested" area NE of Subiaco Lodge.
1942	December	Control burning in early morning, but not at night due to wartime security risk.
1943		Control burn of "reafforested" area NE of Subiaco Lodge.
1944	November	About 630 acres (243ha) control burnt during last five weeks.
1946	September	Burning debris in bush. Late autumn burn of hillsides agreed in March.
1947	December	"In accordance with 3 year controlled burning cycle, about 700 acres (283ha) burnt over the last six weeks." (This presumably includes 300 acres reported burnt in previous months when "some of the burning had been more severe than was consistent with good controlled burning, but this would not cause permanent harm to the trees").
1949	November	100 acres (40ha) control burnt.
1950	December	Plan shown to Board, ? 4 year burning cycle map showing 4 sections, or this may be in another plan of August 1958.
1956	November	100 acres (40ha) control burnt.
1959	June	120 acres (49ha) control burnt during previous year.
1961	June	100 or 80 acres (40 or 31ha) control burnt mainly at night during previous year. Burning debris in bush areas.
1962	June	150 acres (61ha) control burnt during previous year.
1973	June	7ha burnt in strips along paths and fire breaks during previous year.
1974	June	16ha burnt in strips and small blocks during previous year.
1975	June	10ha burnt in strips during previous year.
1976	June	8ha burnt in strips and small blocks during previous year.
1977	June	22ha burnt in strips and small blocks during previous year.
1978	June	13ha burnt in strips and one block during previous year.
1979	June	21ha burnt in strips during previous year.
1980	June	16ha burnt in strips during previous year.
1981	June	7ha burnt in strips during previous year.
1982	June	13ha burnt in strips during previous year.
1983	June	11ha burnt in strips during previous year.
1984	June	2ha burnt in a small block during previous year.

The details 1973 to 1984 inclusive have been recorded on maps.

Prepared by P.R. Wycherley (1992) for Kings Park and Botanic Garden Bushland Management Plan

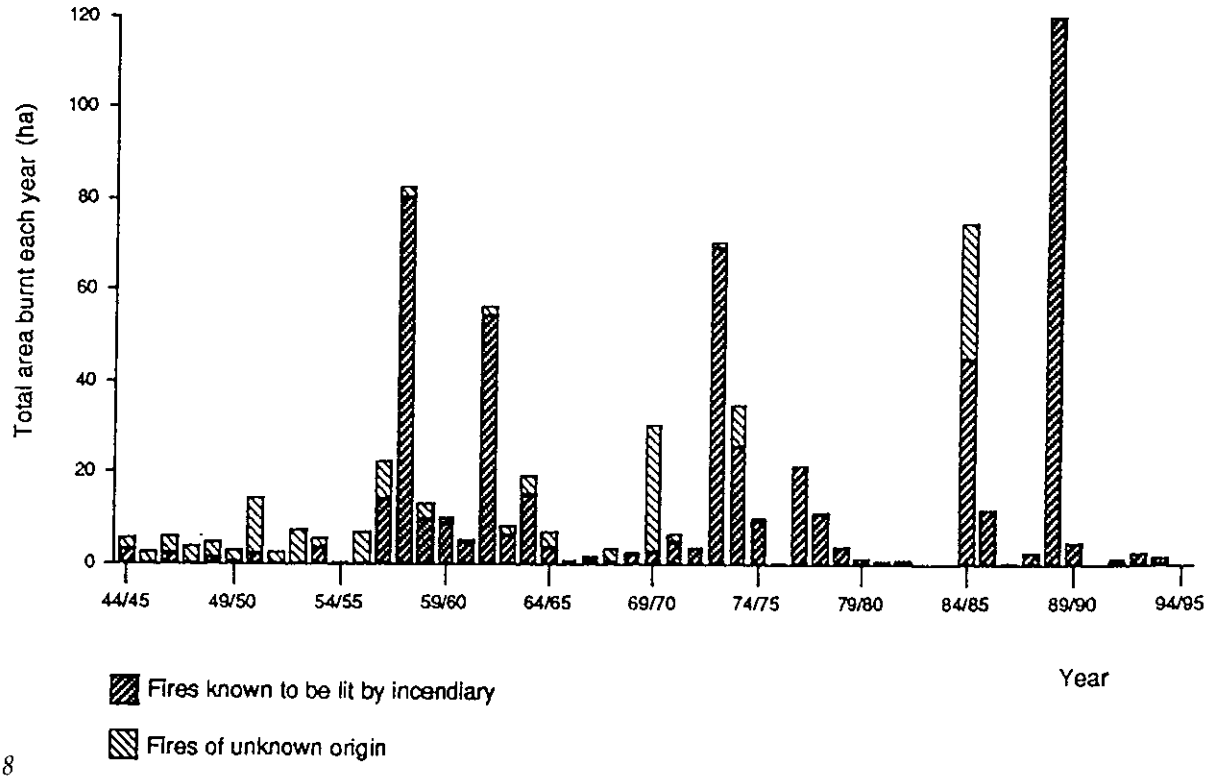
Graphs based on Wycherley 1993. Updated to cover 50 years of fire records in Kings Park.



Management regimes

Prescribed block burning	No burning	Buffer strip burning	Integrated management

1944 1962/63 1973/74 1984/85 1994



Fire and human disturbance regimes and impacts on plant communities at the Star Swamp Bushland Reserve

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Introduction

Star Swamp Bushland Reserve is an 'A' Class Reserve located at North Beach in Perth's northern suburbs and is vested in the City of Stirling for conservation of flora and fauna and passive recreation. The reserve contains about 100 hectares of mainly Banksia woodland with scattered tuart and jarrah overstorey, tuart woodland and heathland.

Most of the bushland around Star Swamp was earmarked for development in the early 1970s, but concerted community action influenced its conservation. Community involvement remains an important feature of management of the reserve.

The determination of human disturbance and fire regimes is useful in understanding how the present composition of plant communities has changed over time and, likewise, important to properly determine future management practices. Human disturbance regimes include clearing, trampling and grazing of domestic animals. Fire regime attributes include fire coverage, season (timing) and frequency. The link between the two regime types to weed invasions and reduced conservation values of urban vegetation is widely accepted (e.g. Wycherley 1984).

Methods

Human disturbance and fire regimes of the reserve over 39 years (1948-1985) were determined from several sources. Tracks, clearing and fire scars were traced from aerial photographs and maps from the Battye Library, City of Stirling and Department of Land Administration, and corroborated in part by oral history from local residents. A grid reference system comprising 184 data points was used as the basis of a database for a range of ecological data in wider study of the reserve (Pigott 1994). Geographic Information Systems (ARC/INFO® and ArcView 2®) were used to capture and store data in the reserve database, create the coverages and required maps. Fire coverage, timing, number of fires and length of fire-free period were determined by hand and stored in the database. Fire frequency values were calculated by dividing the number of fires by 39 (number of record years). Floristic data were collected at the reference sites for classification and mapping of plant communities.

Results and Discussion

Human disturbance

Figure 1 illustrates the many human activities which have occurred at the reserve since the turn of the century. Grazing, clearing, pipeline excavation and the proliferation of tracks have fragmented and degraded the remnant bushland, resulting in weed invasion and increasing the risk of fire (see Hobbs 1987).

Before the development of housing, which began in the 1960's, the area now known as the reserve was easily accessed through the large area of surrounding uncleared bushland. The layout of tracks found at the reserve shows that some of these were a direct result of concentrated periods of activity at various times (Fig. 1).

Since the early 1980s, community action, combined with the development and implementation of a management plan for the reserve (City of Stirling 1987), has moderated the impacts of human activity. Actions taken include restricting access by fencing the reserve, closing and rehabilitating tracks, and using signs to educate the general public about managing the bushland.

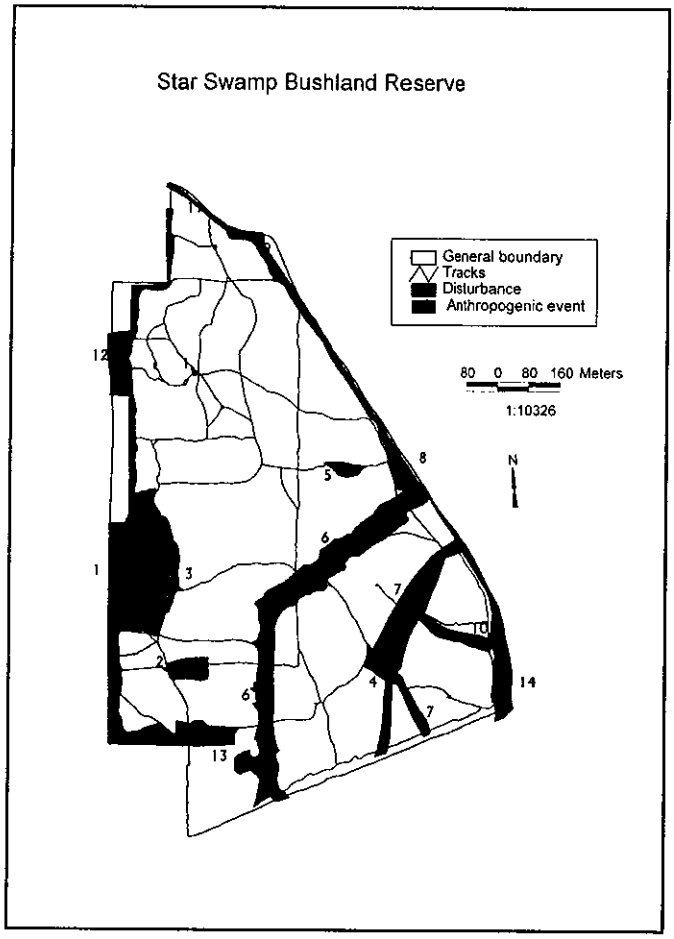

Figure 1: Patterns of human disturbance for the Reserve from circa 1900 to 1987.

Fire regimes

Fire coverage and timing

A total of 34 fires were recorded in the area now known as the reserve for the period 1948 to 1987, and occurred every two to five years (Pigott 1994). As a consequence of changing human activity in and around the reserve, fire coverage has diminished from 100 per cent of the area between 1953 and 1961 to smaller fires covering about 25 per cent of the reserve. Recent data show that a fire covering 25-50 per cent of the reserve in 1989 is the only major fire recorded from 1987 to the summer of 1994/95 (Table 1). The earlier pattern of broadscale burns has been replaced by the small-scale mosaic burning pattern, except in 1981 when backing-burning was used to control a wildfire resulting in an extensive fire.

A feature of the recent burning pattern is that areas unburnt in one fire are burnt in successive years, typified by six separate fires that occurred between 1984 and 1987 (Table 1). Most of the significant fires at the reserve between 1948 and 1990 occurred in summer (Table 1), the period when urban bushland around Perth is most prone to burning because annual grasses (mostly introduced) have dried off and there is little rainfall. An exception was the extensive autumn fire of 1985, which occurred after drought conditions in the area (Pigott 1994). Since 1989, most fires have been brought rapidly under control by fire brigade units after they have been alerted by local fire-spotting volunteers. Control of grasses with selective herbicides along major tracks has assisted in reducing reducing fuel loadings in parts of the reserve by up to 80 per cent, allowing natural regeneration to reduce flammability (B. Wilkins[1], personal communication).

Fire frequency and fire-free periods

At least four fires were recorded for each reference point, a maximum number of 14 fires and a median of nine fires, less than half the average for Kings Park bushland during the same period (Pigott 1994). Relative fire frequency for the reserve was mapped for the period 1948-1987 (Fig. 2). Fire frequency values were assigned to one of five arbitrary classes where each class is a relative description of the values for fire frequency (e.g. very high, high etc.).

The pattern of fire frequency appears to be complicated by the locations and intersection of several main fire breaks. Very high classes of relative fire frequency (Fig. 2) show up near track intersections but mostly away from access points. Areas of relatively very low and low fire frequency occur in the wetlands on the west side of the reserve and also in woodlands in the northwest and southeast corners of the reserve, indicating some protection by tracks (Fig. 2). The relatively high fire frequency in southern part of the

Year	% cover of fire(s)	Timing of fire
1948	>75%	na
1953	100%	na
1958	100%	na
1961	100%	Summer
1963	50-75%	Summer
1964-66	25-50%	na
1968	50-75%	Summer
1970-72	25-50%(x2)	Summer (72 only)
1974	25-50%	Summer
1976	>75%	Summer
1977	50-75%	Summer
1981	>75%	Summer (Jan 81)
1984	25-50%	Summer
1985	50-75%	Autumn (16 Apr)
1986	25-50% (x 4)	Summer (Dec 85 & Jan 86)
1987	25%	Summer (Feb 87)
1989	25-50% (x2)	Summer
1990-94	Spot fires (var)	Summer
1995	Spot fires (x2)	Summer

*area approx 500m²

Table 1: Coverage and timing of fire at the Reserve between 1948 and 1995.

reserve appears to be associated with the major drain and sewerage pipeline installations between 1972 and 1987 (Pigott 1994). Details of fire regimes for other urban reserves are limited, however, the number of fires recorded at the reserve is more than the number reported for Woodman Point and Yule Brook Reserves, but considerably less than the number reported for bushland at Kings Park over a similar period. The differences between numbers of fires at these urban remnants can be explained in terms of vicinity to urban development and levels of human activity (Pigott 1994).

Between 1948 and 1987, fire-free periods at the reserve have ranged between two and 20 years with an average of 4.5 years (Pigott 1994). No sites were found to have been burnt in successive years or fire-free for one year only but, the majority (>80 per cent) were fire-free for five years or less. A strong negative correlation between mean fire-free period and fire frequency was calculated for the period 1948-1987 Fig. 3), that is, the lowest mean fire-free periods corresponded with samples of high fire frequency and vice versa.

Using the periodicity data a prediction is made that areas of bushland not burnt for five years or more are likely to be burnt the following summer. As there are other important factors prevailing on the likelihood of bush fires such as public usage, fuel accumulation for vegetation in different parts the Perth area and the time of year, this prediction is conservative (Pigott 1994).

Impacts on vegetation

Vegetation communities

Five plant communities were defined by classification for the reserve (Fig. 4). Sites with *Melaleuca raphiophylla* were easily defined as the Swamp Paperbark (community I). The four remaining communities, mainly of the upland, were named after prominent physiognomic species in their respective sets of floristically important species (Table 3). Mixed Banksia community being the most common (40 per cent of the reserve), the Macrozamia community (25.9 per cent), the Mixed Eucalypt community (18.6 per cent) and the Bottlebrush community (11.3 per cent) (Fig. 4).

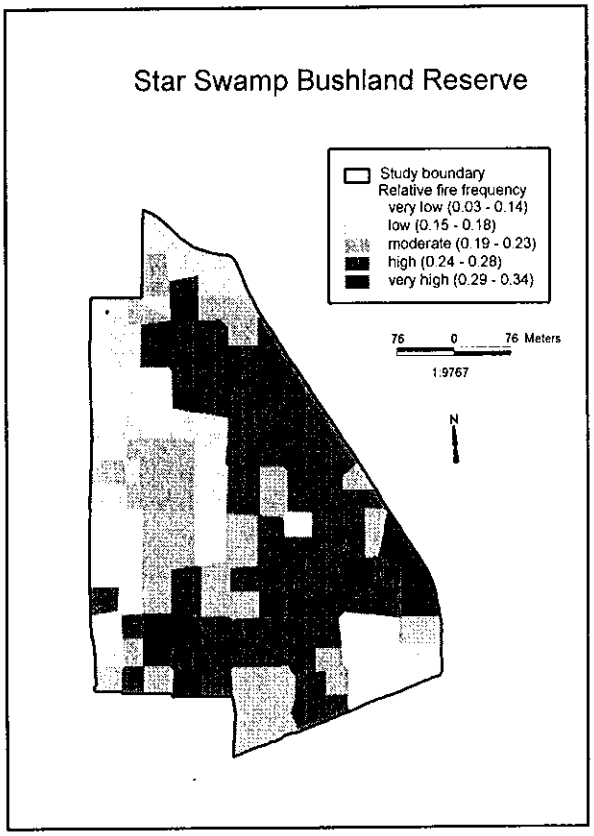

Figure 2: Relative fire frequency for the Star Swamp Reserve based on fire regime data for reference sites, 1948-1987.

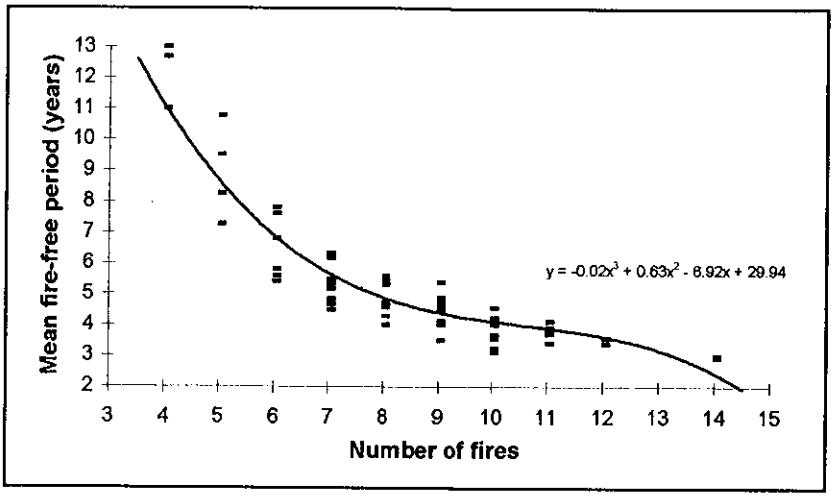

Figure 3:
Correlation between fire frequency and fire-free periods

The post-fire regeneration mode of the floristically important species for the communities were determined (Table 2). Native resprouters were found to be dominant for the Swamp Paperbark, Bottlebrush, Macrozamia and Mixed Eucalypt communities and to a lesser extent the Mixed Banksia community. This pattern indicates that despite increased fire frequency and reduced fire-free periods at the reserve plant communities are dominated by native species capable of resprouting. Many important weed species (e.g. *Arctotheca calendula*) were found to be seeders although some perennial weeds (e.g. *Homeria flaccida*) resprout vigorously after fire.

Individual species

Altered fire regimes pose particular difficulties for conserving plant communities characterised by species killed by fire [e.g. the obligate seeder *Banksia prionotes* (Loneragan et al. 1984]. These species require a minimum of three to five years for the juvenile period and up to 11 years to reach maximum seed production (Cowling and Lamont 1986).

Vegetation community	Mode of regeneration (based on Bell et al. 1994 and field obs.)
I **Swamp Paperbark**	
Melaleuca raphiophylla.	Resprouter
II Bottlebrush	
Calothamnus quadrifidus, Eucalyptus marginata, Allocasuarina humilis, Lomandra caespitosa, Homeria flaccida.*	Resprouters
Arctotheca calendula, Carpobrotus aequilaterus* , Ehrharta longiflora*, Bromus diandrus*.*	Seeders
III Macrozamia	
Sowerbaea laxiflora, Haemadorum paniculatum, Lomandra hermaphrodita, Phyllanthus calycinus, Macrozamia riedlei.	Resprouters
Cerastium glomeratum.*	Seeder
IV Mixed Banksia	
Lechenaultia linarioides, Banksia attenuata, Burchardia umbellata, Laxmannia aff. *squarrosa, Ptilotus polystachius, Cerastium glomeratum*.*	Resprouters
Ursinia anthemoides, Trachymene pilosa.*	Seeders
V Mixed Eucalypt	
Hardenbergia comptoniana, Eucalyptus calophylla, E. gomphocephala,. Sparaxis grandiflora, Oxalis* sp.*	Resprouters

* Weed species

NB. The species referred to in this table only assist in separating communities in the classification and are not necessarily exclusive to a particular community.

Table 2: Vegetation communities showing floristically important species and their mode of regeneration.

NB. The species referred to in this table only assist in separating communities in the classification and are not necessarily exclusive to a particular community.

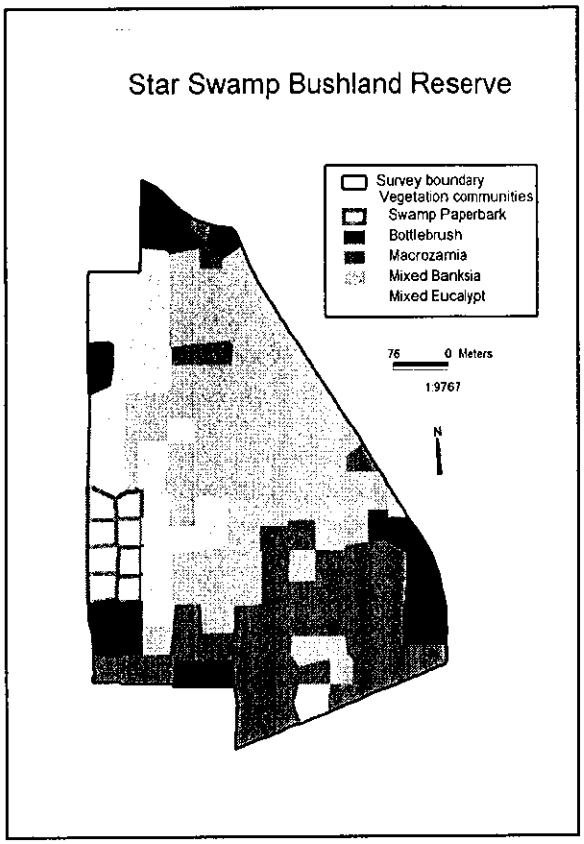

Figure 4. Plant communities for the Star Swamp Reserve.

Despite these problems, species such as *Banksia prionotes* has survived high fire frequencies and reduced fire-free period at the reserve. Some mature individuals on the edges of tracks are not killed during fire and others survive in patches where the fire is cooler (unpublished data). However, overall population sizes can be dramatically influenced. For example, before the 1981 fire one area with a population of *Banksia prionotes* had a population of 50 stems per hectare which increased to 2150 seedlings per hectare following the fire (Loneragan et al. 1984). Ten of these individuals survived a fire in 1986 to reach juvenile status, flower and set seed (Pigott 1994). Although another fire in 1989 killed all 10 individuals, 51 seedlings were counted at the site in 1990.

Altered fire regimes are also thought to be responsible for the rapid decline in tuart (*Eucalytus gomphocephala*) (Fox 1980), an important overstorey tree in the Perth area, including the reserve. Tuart canopy in woodland around Star Swamp is estrmated to have declined from 27.8 per cent in 1953 to 11.8 per cent in 1973, then to 4.8 per cent in 1988 (Pigott 1994). Seven or eight fires, a relatively moderate fire frequency for the reserve, were associated with Tuart and Tuart/Banksia woodland in the west and south of the reserve (Fig. 2 and Fig. 4). These fires, combined with other factors such as insect prediction, have caused sufficient crown scorch and bole damage during the period to be responsible for this decline.

Conclusions

Human disturbance and fire regimes

Past and present clearing practices have reduced areas of native vegetation available for conservation at the reserve. Lack of planning for development of utilities left a legacy of negative disturbance requiring attention and application of rehabilitation procedures. Since the implementation of a management plan in 1986, access has been restricted by fencing the reserve, tracks have been closed and rehabilitated and major tracks sealed for use as firebreaks and walk trails.

Increasing frequency of summer fires, from complete coverage to a mosaic of smaller fires, and shorter fire-free periods have posed a major problem of control for the community and management authorities. A prediction made that a fire could occur every five years in most parts of the reserve has serious implications for fire protection of the bushland and component species as well as for adjoining houses. At present the policy of fire exclusion in the reserve recommended by the current management plan is successful, due to a volunteer fire warning system and prompt fire control by local fire brigades. However, the threat of a serious fire such as occurred in 1985 remains.

Impacts on vegetation

Five plant community types were classified floristically and mapped for the reserve. Despite altered fire regimes and the invasion of exotic species, native resprouters remain important components of the remnant bushland. Two important tree species, *Banksia prionotes* and *Eucalytus gomphocephala*, have been negatively affected by altered fire regimes, but improved fire protection and planting of seedlings will allow these species to regenerate and sustain their populations.

To restore the conservation values to urban reserves such as Star Swamp Bushland requires a management plan as well as community support. Various programs since 1986, such as restricting access, building sealed firebreaks and controlling flammable grasses with herbicides, have significantly reduced the likelihood and subsequent spread of wildfires at the reserve.

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Fire ecology and fire management of Garden Island

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Introduction

Garden Island is located about 35 kilometres south-west of Perth where it forms the western boundary to Cockburn Sound. It is about 10 kilometres long and one to two kilometres wide, with an area of approximately 1200 hectares. The island is aligned roughly north-south and has an exposed western side and a relatively protected eastern fringe. The 'backbone' of the island is a core of Pleistocene limestone, largely covered by Holocene calcareous sand dunes. Beach ridges on the eastern side have formed benches at six to seven metres and two to three metres above sea level.

Site preparations for a Naval Establishment, to be known as HMAS STIRLING, were begun in 1972. The causeway to the mainland was completed in 1973 and the establishment was commissioned in 1978. When fully developed HMAS STIRLING will occupy about 20 per cent of the island. Otherwise, the island remains a near-natural ecosystem consisting of coastal plant species in distinctive communities, with associated fauna. This is in sharp contrast to conditions on the adjacent mainland and neighbouring Rottnest Island where such communities have disappeared or have been significantly modified.

Maintenance of Garden Island as a vigorous, diverse natural system has become a prime objective of the Navy. The purpose of this paper is to consider the landcare issues for the Navy in managing fire on Garden Island, both wildfire and prescribed burning. Clearly, it is important to be able to predict the outcome of burning. Our basis for prediction is published and unpublished accounts of changes in vegetation patterns in relation to fire history and some experimentation.

History

There is no evidence of Aboriginal presence on Garden Island in the period since limestone high-points of the former coastline, including Garden and Rottnest Islands, were separated from the present mainland by sea level rises up to 15,000 years ago (Department of Defence, 1995). Moore (1884) relates a legend about the separation of the islands: "The natives have a tradition that Rottnest, Carnac and Garden Island once formed part of the mainland, and that the intervening ground was thickly covered with trees; which took fire in some unaccountable way, and burned with such intensity that the ground split asunder with great noise, and the sea rushed between, cutting off these islands from the mainland." Hallam (1979) argues that the legend demonstrates that Aboriginal burning was practiced in the area prior to the sea level rise.

Garden Island has a long history of European contact, with visits by Dutch, French and British expeditions from the 1600s and first settlement in 1829 (Department of Defence, 1995). Fortunately, early descriptions of the vegetation would equally apply today. Charles Fraser, the New South Wales Botanist who joined Captain Stirling's 1827 exploration, noted areas "...thickly covered with cypress" (*Callitris preissii*), and also "... extensive thickets of arborescent metrosiderous" (*Melaleuca lanceolata*).

When Stirling returned in June 1829 with the first settlers for the Swan River Colony, he established a temporary base at Cliff Head on the eastern shore of Garden Island, before transferring to the mainland over the following months. Captain Charles Fremantle sent in a gun boat to protect the colonists,

hunted "plentiful small kangaroos or rats" (tammar), and described the vegetation as "... being covered in a small kind of pine", noting that "...from the thickness of the trees and underwood it was impossible to move". The settlers, estimated at the peak to exceed 450, cleared native vegetation in the vicinity of Cliff Head for livestock and gardens. However, most were present for less than a year and most of the structures were destroyed and natural vegetation presumably reestablished in 1834 when a fire was started by "unruly" soldiers.

Garden Island was a popular holiday retreat from early this century, with several areas of dwellings, except when resumed for army use during both World Wars. The Army Survey Corps produced the first Garden Island topographic map in 1943. This was used as a basis for siting roads, gun emplacements and bunkers, and also shows distribution of major vegetation types.

The vegetation

The Garden Island vegetation communities are dominated by five trees, *Callitris preissii, Melaleuca lanceolata, Melaleuca huegelii, Acacia rostellifera* and *Pittosporum phylliraeoides*, and three shrubs, *Acacia cochlearis, Beyeria viscosa* and *Diplolaena dampieri*. Each has distinctive characteristics, such as growth rate, longevity, and tolerance to natural and imposed conditions. These dominant species combine to form communities which are distributed in relation to various factors, including landforms, soils, water, aspect and exposure to wind and salt spray.

The communities have been described and mapped in McArthur and Bartle (1981) and Garden Island Environmental Advisory Committee (1990, unpublished). *Acacia rostellifera* scrub is the most widespread community and occurs mainly on the older dunes. Low scrub and heath communities, with many species, occur along the western coast on exposed slopes. Low forests of *Callitris preissii* and *Melaleuca lanceolata* in monocultures and intermixed, are best developed on the bench landscapes but also occur in some valleys. *Melaleuca huegelii* is a component in both scrub and low forest and also forms pure stands.

From a study of many observations and reports on the vegetation, McArthur and Bartle (1981) concluded that the different communities are continually undergoing change, mainly due to natural forces, including senescence, competition for light and water and predation. There was little or no evidence of seedling regeneration and an inference that these were grazed by tammar. Eighteen permanent quadrats, in all major communities, were established so that changes could be monitored.

Superimposed on these changes are the effects of human intervention and the most dramatic of these are due to fire. Garden Island was not subject to Aboriginal burning prior to European settlement and natural (lightning strike) fires were probably infrequent, judging from the fact that none have been recorded in the 170 years of settlement. Paradoxically, however, it is clear from observations of the wildfires that have resulted from European activity over this time that the major plant communities are driven by fire.

Effects of burning

All dominant Garden Island species, both trees and understorey, are sensitive to heat and the above-ground parts are readily killed by leaf scorch. Following long periods without fire there is a build-up of flammable material to as much as 30 tonnes per hectares and the summer wildfires have been intense and completely removed all vegetation. With competition removed, there is prolific regeneration the following winter but with differences in type and speed of recovery. The trees *Callitris preissii, Melaleuca lanceolata* and *M. hueglii* and most shrubs are killed by leaf scorch and regenerate only from seeds. *Acacia rostellifera* and *Pittosporum phylliraeoides* sprout very quickly from damaged roots and also regenerate from seeds. Several shrubs, including *Leucopogon* spp, *Acanthocarpus preissii, Acrotriche cordata*, and the creepers *Hardenbergia comptoniana* and *Clematis microphylla*, regenerate from a woody root stock.

The first evidence of vegetation community response to burning comes from the topographic map produced by Army Survey Corps (1943) based on 1942 air photos

(McArthur, 1957). This map shows the distribution of "pines" (stands of *Callitris preissii* low forest), many still existing, which subsequent studies of growth rings show to be of an even age, originating about 1920. There is anecdotal evidence that a fire occurred at about that time. The extant stands of 75 year old trees are healthy with no signs of senescence. The map also shows most of the island to be covered by scrub and some stands of "titree" (*Melaleuca lanceolata*) mainly along the east coast, much the same as at present.

The next piece of evidence is more direct and comes from effects of a fire which extended over most of the central part of the island in 1956. Regeneration following the fire was described by Baird (1958) and later by McArthur and Bartle (1981). Regeneration of the low forest was prolific and rapid, and by 1978 had formed very dense stands. These stands are still dense but undergoing natural thinning. The *Acacia rostellifera* scrub that regenerated from this fire had reached maturity by 1978 and, though still vigorous on the bench landscapes, is declining on the dunes.

It had been inferred that regeneration from seedlings is restricted by tammar grazing. An opportunity to check this came in February 1991 when an accidental fire in the northern part of the island extended over about nine hectares. The burnt area included *Acacia rostellifera* scrub, *Callitris preissii* low forest and *Melaleuca lanceolata* low forest. In order to examine the effects of tammar grazing on regeneration, a pair of 20 by 20 metre quadrats, one fenced and one unfenced, was established in each of these communities and the regeneration monitored at about three monthly intervals.

A "fire weed" community dominated by *Solanum symonii* rapidly established over the entire burnt area for the first two years, followed by *Acacia rostellifera* of up to three metres height by the third year. There was some grazing of acacia by tammar but it was the establishment of other species beneath the acacia that differed dramatically between the fenced and unfenced plots. *Callitris preissii* was highly favoured by tammar. Plentiful 30-60cm high seedlings of *Callitris preissii* established in the former Callitris forest within the fenced plot but there were no specimens outside the fences.

In the former melaleuca forest, *Melaleuca hueglii* grew more vigorously than *M. lanceolata*, with *M. hueglii* of up to 2.5 metres over-shadowing *Melaleuca lanceolata* within the fenced plot after three years. However, *M. hueglii* was selectively grazed by Tammar and was absent where accessible to tammar. Other species grazed by Tammar and therefore exclusively or mainly recorded inside the fenced plots were *Stipa flavescens, Thomasia cognata, Rhagodia baccata,* many introduced annual plants, and the problem weed bridal creeper (*Myrsiphyllum asparagoides*).

Fire ecology

The likely pre-historic fire regime was occasional ("one in a hundred years" or less) lightning-strikes which caused extensive, intense fires that razed large areas of the island. The vegetation communities which regenerated would have differed between sites depending on local conditions and changed over time as shorter-lived, more vigorous dominants senesced. The tammar population was presumably severely reduced by such fires, which allowed stands of edible shrubs and trees to establish and for edible herbs to complete their cycles and replenish seed stores.

This system is susceptible to changes to the fire regime. More frequent fires would prevent the slower establishing, longer-lived communities maturing, while burning on a smaller scale would allow tammar to invade from adjacent vegetation and eliminate edible seedlings. Callitris forest has been devastated in other coastal regions by frequent fire combined with grazing pressure, from quokka in the case of Rottnest Island and rabbit on the mainland (which can be more damaging because of its capacity to escape fire in burrows). CALM, in a current assessment of the status of WA vegetation communities, is classifying callitris woodland as "vulnerable and endangered", with the last strong-hold being Garden Island (John Blythe, pers. comm.).

Fire management options

The ideal management regime for maintaining the stands of mature callitris-melaleuca coastal forest on Garden Island is probably no fire except for very occasional ("one in 100 years"), extensive wildfire. However, as in most situations in today's world, the Navy does not have the option of "letting nature take its course" without management intervention. The Navy management strategy must be to reduce the risk of wildfire occurrence because the risk of wildfire is much greater than in the past, and to restrict and suppress any wildfire that does occur in order to protect HMAS STIRLING staff and facilities and public recreational visitors.

HMAS STIRLING has developed a Garden Island Bushfire Emergency Sub Plan to specify the organisation and actions required of Navy personnel (and CALM via the Ranger seconded to STIRLING under a State-Commonwealth agreement) to suppress bush fires occurring outside the naval perimeter fence. Although immediate suppression activities will almost certainly fall to Navy personnel, suppression of major bush fires would invariably be beyond the capacity of STIRLING resources. To ensure further rapid and coordinated assistance, STIRLING has developed an Inter-Agency Fire (Suppression) Agreement with the Bush Fires Board, WA Fire Brigade and City of Rockingham and conducts joint training exercises. The fire suppression strategy is based on containment from four east-west firebreaks which divide the island.

Three fire prevention management options are available to the Navy - "no prescribed burning", limited "safety zone burning" and "prescribed burning".

The minimum option to reduce fire risk is to maintain firebreaks and clearings around naval and public facilities and arterial roads. This is the current policy. From an inspection in 1992, the Chief Fire Safety Officer, Defence Facilities and Property Division, concluded that the placement and extent of the cleared perimeters and firebreaks are sufficient to protect life and property without the use of additional procedures such as limited safety zone burning.

Rotational "prescribed burning" of small compartments of natural bush outside the bush fire season is the recommended CALM approach to ensure that fuel loads are kept to safe limits in native vegetation (Sneeuwjagt, 1994). The Navy does not consider prescribed burning a necessary or appropriate procedure for Garden Island.

Prescribed burning would be difficult to conduct and of dubious merit on Garden Island. Early trials found that the Garden Island vegetation generally carries high salt loads which inhibit a fire starting (J. Maher, pers. comm.). Burning the deep, compact litter of the low forest communities is particularly difficult outside the gazetted summer "no burn" period because of high humidity beneath the dense canopy. Nor would it be easy to conduct a prescribed burn in the *Acacia rostellifera* scrub where the dense low *Acanthocarpus* (sometimes known as "kerosene bush") and the senescent acacia would explode once a fire got going.

There might be some ecological merit to selectively burning short-lived communities followed up with tammar exclusion fencing. However, as elaborated in other papers at this conference, controlled burning has ecological draw-backs due to limitations on our capacity to replicate the natural situation in terms of frequency, intensity, extent and season. An alternative may be to invigorate communities using the smoke-induced seed germination methods being developed by Kings Park (Dixon, Roche and Pate, 1995). Kings Park researchers commenced smoke-tent experiments in two vegetation types at Garden Island in May 1995. The germination responses being obtained elsewhere are equivalent to those from summer wildfire but there is no risk of the fire "getting away". Hopefully large-scale smoke germination will soon be achievable using smoke-infused water or the triggering chemicals themselves.

Conclusions

It is evident from the fact that Garden Island has some of the best remaining examples of coastal plant and animal communities in the Perth region, despite several extensive bush fires that have occurred since European settlement, that the island ecosystems are

adapted to re-establish after occasional fire. Furthermore, monitoring of the vegetation communities indicates that absence of wildfire creates ecological problems.

In most other areas where occasional, extensive summer burning is not a management option, the approach generally adopted is to conduct small "cool" burns to reduce heavy fuel loads and to "invigorate" the communities. The Navy is seeking to avoid this compromise for Garden Island.

In the Navy's favour are an exceptionally high capacity to control access and behaviour of people and the unusual geographical characteristics of a long, narrow island. Reducing the risk of fire occurrence and the risk to life when fire does occur are major considerations in the Navy's policy of restricting public access to Garden Island to private boats with a limited number of amenity areas. Access by Navy personnel to the bushland of the island is also strictly controlled. The imperative of protecting life and property from the inevitable accidentally or deliberately lit wildfire is being met through a well coordinated fire suppression procedure based on a series of trans-island firebreaks, well-cleared buffers around developed sites, and a well coordinated fire-fighting procedure.

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Regeneration and flowering responses of plant species in jarrah forest plant communities

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Summary

Fuel reduction burning of jarrah forests in the South-West of Western Australia is critical to wildfire control. The frequency of burning is determined by a number of factors including the rate of fuel accumulation and the strategic location of the forest, but is usually around six to eight years. The ecological effects of fire on forest ecosystems are many and complex, and the Department of Conservation and Land Management (CALM) has been studying the long term effects of various fire regimes on forest ecosystems for several decades. These studies, one of which was established in 1970, are providing valuable information about the effects of fire frequency and season on forest flora. This information is being used to continually modify fire management practices.

Basic knowledge of the regeneration strategies and life histories of plants is important for interpreting the likely impacts of various fire regimes on floristic composition. A study of some 300 jarrah forest understorey species at three upland sites revealed that 70-75 per cent of species re-sprout following fire and the remainder regenerate from seed. All understorey species flowered within three years and four years of fire in high rainfall and low rainfall forests respectively. As a rule-of-thumb, a fire-free period equal to twice the juvenile period is needed to allow adequate seed production so that species can replace themselves to pre-fire abundance levels. The current fuel reduction burn intervals for various upland jarrah forest types caters for this requirement. Seasonally wet sites, which are likely to contain species which are fire sensitive, have longer juvenile periods and depend on fire for regeneration, are rarely burnt during low intensity spring burns. Prescribed burns at infrequent intervals in autumn ensures the regeneration of these assemblages. A fire response data base developed by CALM now contains information on about 500 plant species.

Introduction

Plants and animals in the forests of South-West Western Australia have evolved a wide range of physical and behavioural traits which enable them to persist in this fire-prone environment (Gardner 1957, Christensen and Kimber 1975). While forest ecosystems have evolved with fire, they have probably not evolved to cope with all possible fire regimes. The fire management goal of the Department of Conservation and Land Management (CALM) is to minimise the adverse impacts of wildfires and to maintain biodiversity. A variety of managed fire regimes are applied in South-West forests including low intensity fuel reduction burning, which is an effective technique for minimising the damaging impacts of wildfires (Underwood et al. 1985). In some forest ecosystems, special prescribed fire regimes (including fire exclusion for long periods) are applied to protect or manage plant and animal species, communities and habitats (see Shea et al. 1981, Underwood and Christensen 1981).

The responsible use of fire as a management tool requires a firm understanding of the long term ecological effects of fire regimes, whether they be prescribe burn regimes or fire exclusion regimes. Critics of the practise of

fuel reduction burning claim that this regime is ecologically damaging, although there is no published scientific evidence to support this view (Christensen and Abbott 1989). While there is a substantial amount of scientific literature on the ecological effects of a single fire event for many fire-prone ecosystems around the globe, including the South-West of Western Australia, there is very little published data on the long term, cumulative effects of various fire regimes on forest ecosystems. Recognising the importance of long term fire ecology information, Dr Per Christensen (WA Forests Department, now CALM) established an experiment to determine the long term effects of various fire regimes on vascular plants in high rainfall jarrah forest (1,200 mm per annum) west of Manjimup in 1970. In 1984, we expanded this study to two other sites; McCorkhill forest (1,000 mm per annum) west of Nannup and Yendicup forest (750 mm per annum) north-east of Manjimup. In addition to this study, CALM scientists and field staff systematically observe and document the effects of fire on declared rare flora throughout the estate managed by CALM.

The forest fire ecology study outlined here is one of only a few in Australian forests which have been on-going since 1970 and is therefore extremely valuable. Specific aims of the study are to:

1. Investigate the long term effects of fire frequency and season on the structure and floristic composition of upland jarrah forests. Specifically, to measure over time;
- vascular plant species richness
- species composition and understorey structure
- seedling regeneration and development
- post-fire regeneration strategies
- age to first flowering (and flowering calendar) and age to seed production after fire
- soil seed bank dynamics
- growth rate of jarrah and marri trees.

2. To provide current fire ecology information to ensure that fire regimes are applied which meet protection and conservation objectives.

Methods

A series of two to four hectare plots have been established at each of the three locations representing high, low and intermediate rainfall upland jarrah forests. Five fire regime treatments are applied to two plots at each location. These are;

- No fire (fire exclusion)
- Burn in summer/autumn (dry soil conditions) as frequently as fuels will carry fire under moderate to high fire danger rating conditions. This is to to three years for high rainfall forests and three to four years for low rainfall forests.
- Burn in spring at the normal fuel reduction burn interval which is six to seven years for high rainfall jarrah forests and eight to10 years for low rainfall jarrah forests.
- Burn in autumn (dry soil) at the normal fuel reduction burn interval.
- Burn in spring at twice the normal fuel reduction burn interval.

Plots are assessed and measured prior to and annually after burning and flowering inspections are made every three to four weeks.

Results to Date

A considerable amount of data have been gathered over the past 25 years and collation and analysis of these data is ongoing. A fire response data base has been established and contains information about post-fire regeneration strategies and age to first flowering after fire for some 500 forest species, representing more than 50 families and 100 genera (including species beyond the study area). Some of the data to emerge from this study are presented below.

- Seventy to 75 per cent (depending on site) of species at the study sites re-sprout following fire and 25-30 per cent depend on seed stored either in the soil or in the canopy for regeneration.

- Time to first flowering after fire (juvenile period) depends on species, season of the fire, season of flowering and on rainfall, but is

largely independent of regeneration strategy, although resprouters tend to flower sooner than seeders. In intermediate and high rainfall jarrah forests, about 90 per cent of all recorded understorey species at the study sites flowered within 24 months of fire and 100 per cent within 36 months of fire. In low rainfall forest all understorey species flowered within 48 months of fire (Figure 1). In dry forests, time to first flowering was 12-18 months longer for the same species than in wet forests. Trees (jarrah and marri) take up to 48 months to flower after fire which has been sufficiently intense to damage the crowns.

- Flowering occurs throughout the year, but as expected, there is a seasonal peak with about 75 per cent of species flowering in spring (Figure 2).

- Time to first flowering depends on the season of fire and the season of flowering. For example, at one site, *Baeckea camphorosmae* flowered in February, six months after a spring burn and, at a nearby site, plants first flowered in February, 11 months after an autumn burn. On the other hand, some plants such as *Burnettia nigricans* flowered in September, 12 months after a spring fire, but at an adjacent site, flowered in September, six months after an autumn fire.

- The season of fire does not appear to significantly affect the floristic composition of seedling regeneration, but dry soil fires (summer/autumn) result in higher numbers of initial seedlings and higher survival rates in the first year. Fire ephemerals and herbs comprised most post-fire seedling germination. Tree species and hard seeded species (e.g., legumes) are favoured by 'dry soil' fires. There is very little germination of trees or woody shrubs in the absence of fire.

- Preliminary investigations of seed bank in the soil under different burning regimes do not show any significant trends. This needs further work into methods of germinating seed and more detailed analysis at the taxon level. While there is limited information on the time for adequate build-up of seed store following fire for jarrah forest species, studies in other ecosystems suggest that a period of about twice juvenile age is necessary to replenish seed banks (see Gill and Nicholls 1989). Juvenile period varies with species, but a fire free period of about six years for intermediate and high rainfall forests and about eight years for low rainfall forests is deemed adequate for all species on upland jarrah forest sites to restore seed banks. These intervals are compatible with fire intervals currently applied for fuel reduction burning and probably explains why there have been no observed species losses under this regime.

- Species richness (plant form) is lowest in plots which have not been burnt for 12 years or longer and highest in plots which were burnt four years previously.

- At this stage, there is no significant difference in species richness between experimental plots burnt in spring and plots burnt in autumn every five to eight years. However, some obligate seed species (e.g., *Crowea angustifolium* var *dentata, Bossiaea laidlawiana*) appear to be gradually declining in numbers on sites burnt very frequently (two to three years) in summer/autumn over 25 years.

- No species have gone extinct as a result of any of the above fire regimes, although some species are not present in plant form on the long unburnt plots (seeds probably still in soil though).

- There is no significant difference in tree diameter growth rate due to the treatments

- A fire response data base has been established and now contains data on fire response and flowering after fire for about 500 forest species, including a number of declared rare flora.

Conclusions

The jarrah forest ecosystems studied are quite resilient to fire and so far, there are no indications that these ecosystems are suffering a loss or decline of plant diversity under the current fuel reduction fire regime (six to eight year interval). Fire vulnerable species, or obligate seed species with long juvenile periods, mostly occur on seasonally wet sites such as creek lines, sparsely treed swamps and around granite outcrops. These sites rarely burn during low intensity spring burns

and probably should not be burnt at frequencies less than 12-14 years. Plant diversity is likely to decline on sites where fire is excluded for long periods as many species regenerate poorly, or do not regenerate, in the absence of fire (or some other disturbance). Frequent (two to three year intervals) burning of an experimental plot in high rainfall jarrah forest over 25 years has resulted in the gradual decline in the density of some obligate seed species. Density of seedling regeneration is favoured by fire under dry soil (summer/autumn) conditions, but repeated and frequent burning under these conditions could lead to depletion of the seed bank, especially on seasonally wet sites.

Remnant urban bushland which has been invaded by annual grasses has the potential to burn very frequently (less than three years). Data on juvenile period and fire free periods required for seed bank restoration for jarrah forest vegetation suggests that burning at such high frequencies will lead to loss of plant diversity in these remnants. Research into the regeneration strategies, juvenile period and seed bank dynamics should be a high priority for remnant urban bushland vegetation. To avoid increased weed invasion and native plant species losses, every effort should be made to exclude fire from remnant urban bushland for at least six years.

Information to hand suggests that for most jarrah forests, a mixture of spring and occasional autumn (dry soil) burns, with occasional long fire free periods is the most appropriate regime to satisfy protection of human life and property and plant conservation objectives in jarrah forests. For wet jarrah forests, a regime of two spring burns every six to seven years, followed by an autumn (dry soil) burn six to seven years later, followed by an extended fire free period of about 10 to12 years, returning to a low intensity spring burn should achieve these objectives. Clearly, there are risks associated with leaving fuels unburnt for extended periods and operational difficulties associated with safely burning old fuels, but these can be minimised by careful planning.

There are practical and logistical difficulties in maintaining long term experiments such as the one described here. Apart from the uncertainty of ongoing resources for such research, it is difficult to prevent wildfires from ever impacting on the study sites. Studies of this nature need to be expanded into other forest habitat types, particularly seasonally wet habitats such as creek lines, swamps and around granite outcrops where fire sensitive taxa, which are usually dependent on infrequent fire for regeneration, are most likely to occur. These habitats rarely burn under cool, moist spring conditions but can burn intensely under warm dry summer/autumn conditions.

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Helping to control fire in urban bushland

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We all love our bushland and hope to maintain its beauty for ever. Some controls are therefore necessary. By this I mean control of excessive litter, leaves, and so on, which eventually become dry fuel.

The leaves, twigs, etcetera are part of the beauty. The softness under foot of deep litter is a wonderful feeling when bush walking. Ignition of this litter is our main concern here today.

Reducing the number of fires starting is possible, but prevention is impossible.

This litter can be ignited accidentally by lightning, power lines, motor vehicle accidents, glass, or general carelessness, or by arsonists. We need to try to prevent this happening. Lightning is always going to happen somewhere, sometime (See Landscope, Winter 1995, p48). The infamous Dwellingup fire of the 1950s is an example.

How to reduce fuel on the forest (bushland) floor should be our main concern. CALM staff have developed methods of measuring this hazard and we should take heed of their skills.

An example I would like to put before you is this: We have an urban bushland area of say 100 hectares, or 50 or 25. If left alone and never managed the result, eventually, will be fire. So we should be thinking of a five year rotation. (This time frame will vary depending on the location.) Strategic parts of the bushland should have the litter removed when necessary on a continuing basis, preferably in strips for the added break-up effect. The native animals can seek refuge in the old areas. We have yet to develop alternative ways to do this, as fire has always been our tool. Something like a side delivery hay rake is what I have in mind; the cost would be low, and little or no damage to plants.

In orchards, a mulching machine is used to dispose of prunings. This is a possibility in the lighter soils, but not economical in stony soils. Slashing in certain areas has great value. For example, the Harvey Rifle Range, when it was used, was a mass of Kangaroo Paws when slashed constantly. Now the range has been re-located, the Kangaroo Paws have nearly all disappeared in the old area.

Each area will need to have its own special management.

Faunal response to fire in urban bushland

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Introduction

Changes to the vertebrate fauna of the Perth metropolitan area over the past 160 years were summarised by How and Dell (1993). They stated that changes are "a consequence of one or several modifications imposed by European settlement — these being urban and agricultural development, fire frequency and intensity, introduced exotic species and the draining and filling of wetlands". They concluded that vertebrate species exhibited a wide array of responses to fire.

In 1993 the WA Museum began a three year study of the vertebrate and invertebrate assemblages that presently occur on urban bushland remnants. This study is concurrent with a study commenced the previous year in Kings Park.

In this paper we present data on a selection of faunal groups, primarily those that are sedentary and/or habitat specialists and that are likely to be adversely impacted by the direct or indirect effects of fire. We have chosen some birds (the small insectivorous bird guild), reptiles and some invertebrate examples to examine differences in assemblages in areas with different fire regimes. Mammals have not been included because virtually all native species no longer occur in isolated bushlands in the Perth metropolitan area.

Birds

Data on the direct and indirect effects of fire on birds of coastal parts of south-western Australia are scarce and were not part of a major symposium on fire (McCaw, et al. 1995).

However data from the 20 sites studied by us since 1993 show that those species of birds most dependant on the resources associated with dense shrub vegetation are represented on few of the census sites (Table 1). The best assemblage (six of the twelve species) occurs on a small isolated remnant of Quindalup dune system at Woodman Point which has not been burnt for a considerable time. In 1981, Powell and Emberson commented on the then age of the vegetation as being upwards of100 years. Therefore, at the time of our study in 1995 the census sites were in the order of at least 115 years since the last fire and possibly in excess of 170 years. This number of species mirrors that of Bold Park, a large reserve of 320 hectares which has a mosaic of areas of different fire ages. Kings Park now has few examples of these species, no doubt largely attributed to the fire frequency detailed in Dixon et al (this publication).

All of the species (except Painted Button-quail) included in Table 1 are small insectivorous passerines that primarily feed among dense low vegetation. The Painted Button-quail feeds on seeds and small insects taken from among fallen leaves and twigs.

It is noteworthy that four of the species included in Table 1 were not recorded on any of the 19 study sites. These sites include some of the vegetation associations in which those species occur outside the region. All were previously known from the region. The Red-winged Fairy-wren and the Red-eared Firetail previously occupied thickets associated with swamps and lakes, the Southern Emu-wren inhabited dense low heathland and the Rufous Tree-creeper was present in coastal woodlands, especially Tuart.

Brooker (this publication) discussed the effects of wildfire on birds of the Darling Scarp and Reilly (1991) examined the effects of wildfires on birds in coastal habitats of Victoria. Brooker's study area included many of the

Table 2: Lizard species diversity (∝) of the six trapping sites in Kings Park sampled intensively between July 1992 and April 1995.

	SAMPLING SITES					
Year	KP2	KP3	KP1	KP7	KP4	KP5
1992/93	2.48	2.29	3.65	1.91	3.48	3.08
1993/94	1.88	1.91	2.64	2.55	2.15	3.06
1994/95	2.26	1.99	2.80	3.20	3.43	3.30

species included in our study. It is important to note that Brooker's study area had a vegetation continuum with other areas. Accordingly species were able to retreat from fires and then recolonise from adjacent unburnt areas. This is not possible on coastal plain reserves which are isolated by urbanisation and provide no linkage to allow recolonisation.

The recolonisation of birds is dependent on a range of factors including the rate of post-fire regeneration, the mobility of different species, the amount of (pockets of) unburnt vegetation, and the distance and corridor linkages to other populations. Concomitant with the above factors there must also be an ability by the invertebrate populations to regenerate as these provide essential food resources of dietary specialist birds.

Reptiles

In this paper we examine lizard communities in study sites with different ages since the last fire. We have excluded snakes for the reasons outlined in How and Dell (1994) that upward of eight years trapping is required for a full documentation of the assemblage.

At Talbot Road Reserve we compared the number of lizard species and total number of individuals (Figure 1) in two Banksia woodlands sites on Bassendean sands. The 28 day trapping period prior to a wild fire in December 1993 recorded 10 species at site TR4 compared to five species recorded over 28 days after the fire. Lost species included those that live and forage above ground e.g. *Cryptoblepharus plagiocephalus, Ctenotus fallens, Diplodactylus spinigerus, Lialis burtonis* and *Pletholax graxilis.*

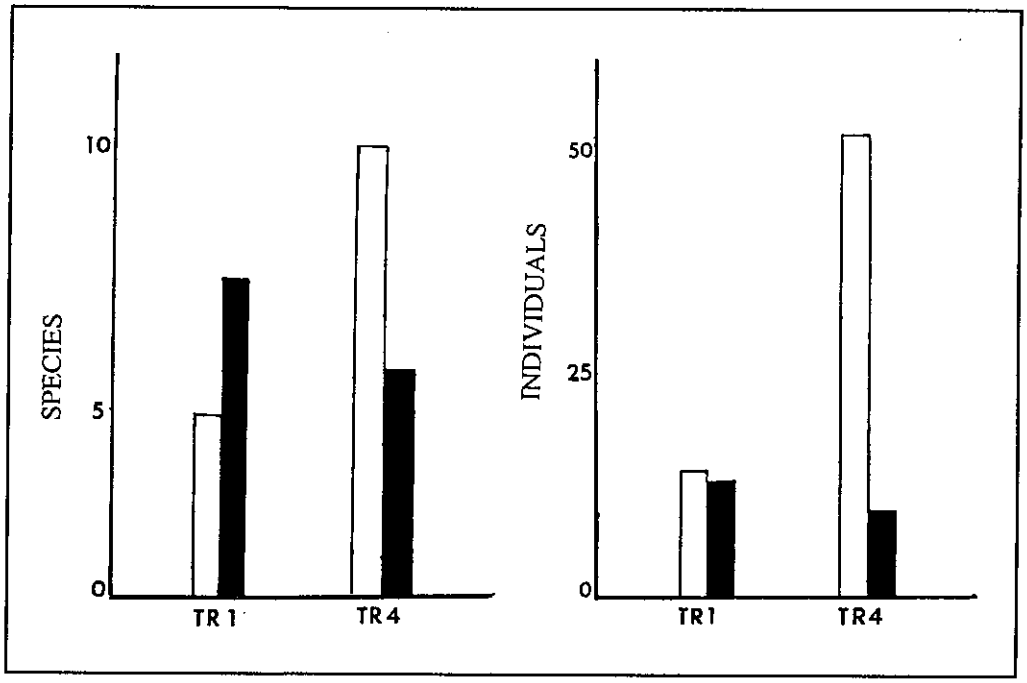

Figure 1: Number of species and number of individual lizards caught in pitfall traps in 28 days sampling Sites 1 and 4 at Talbot Road Reserve before the fire of 3 December 1993, compared to the number of species and number of individuals caught during 28 days sampling after the fire.

In the adjacent site TR1, which was not burnt by the 1993 fire, there was an increase in species over the periods. *D. spinigerus, L.*

Table 1: List of habitat and/or dietary specialist bird species and the number of days they were recorded in the 18 census sites on urban bushland. Census sites are Dianella Open Space (DO), Jandakot Airport (JK), Mount Henry (MH), Woodman Point (WP), Bold Park (BP), Kings Park (KP), Inglewood (IW), Tuart Hill (TH), Perth Airport (PA), Talbot Road Reserve (TR). Note that BP and KP are a composite of both recording years.

	SURVEY SITES																			
	1994-95										1993-94									
SPECIES	**DO**	**JK1**	**JK2**	**MH1**	**MH2**	**WP1**	**WP2**	**WP3**	**BP**	**KP**	**IW**	**TH**	**PA5**	**PA6**	**PA7**	**PA8**	**TR1**	**TR2**	**TR1**	**TR2**
Observation days	**54**	**53**	**53**	**53**	**53**	**53**	**53**	**53**			**58**	**58**	**58**	**58**	**30**	**45**	**58**	**51**	**58**	**51**
Painted Button-quail									x	x							1			
Golden Whistler				1				1												
Grey Shrike-thrush			6					1	x											
Broad-tailed Thornbill						32	24	39	x	x										
Yellow-rumped Thornbill						1		2	x	x			3		8		9			
White-browed Scrubwren						10	6	22	x											
Splendid Fairy-wren		9	9			3	6	29	x				2							
Red-winged Fairy-wren																				
Scarlet Robin																				
Southern Emu-wren																				
Rufous Tree-creeper																				
Red-eared Firetail																				

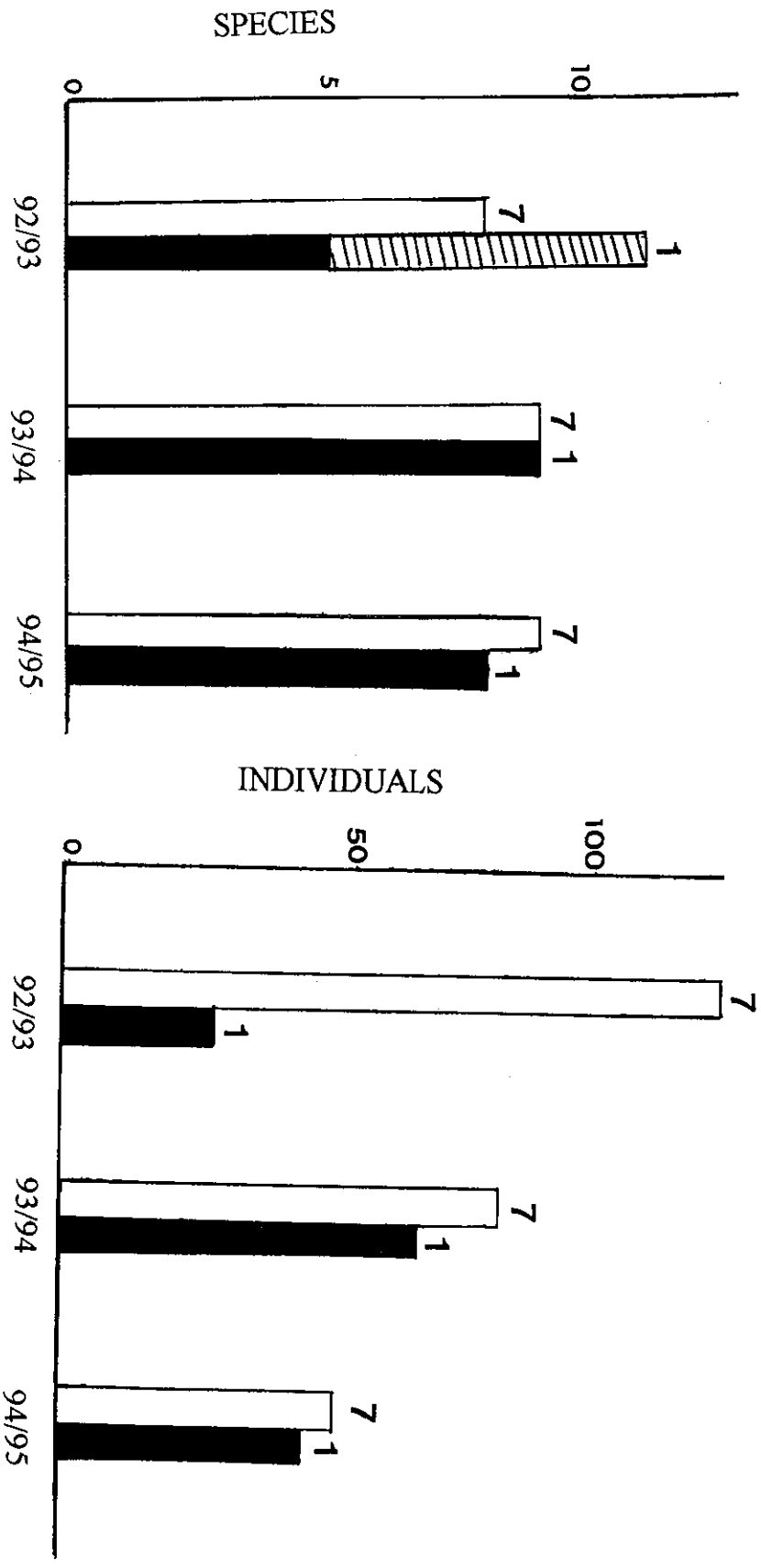

Figure 2. Number of species and number of individual lizards caught in the three sample periods in Sites 1 and 7 in Kings Park after the fire of February 1993 which burnt Site 1. The dotted column in Site 1 shows the total number of species captured before the fire.

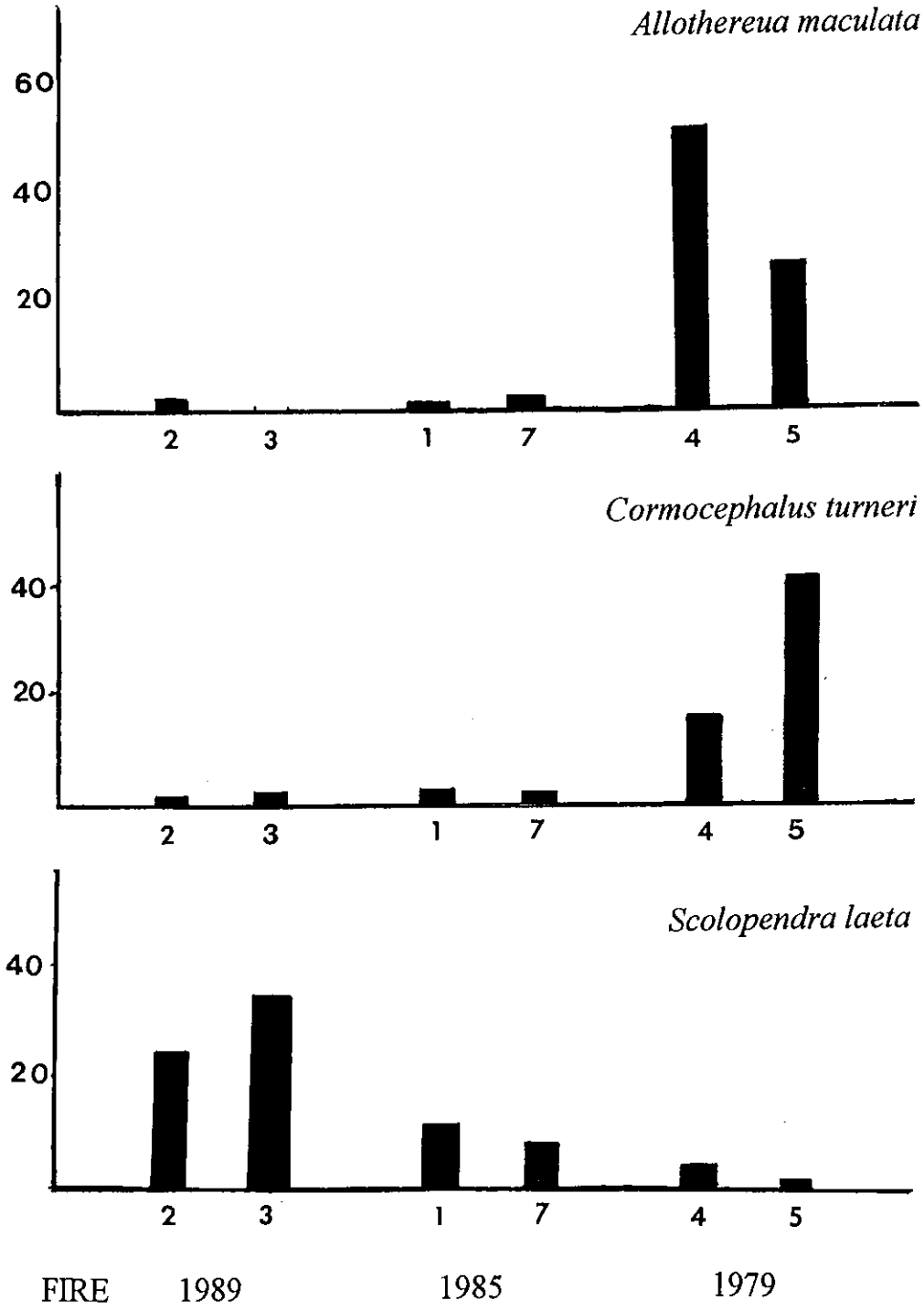

Figure 3. Number of captures of three species of centipede from pitfall traps in six sites located in vegetation with different ages since burning in Kings Park. Sampling periods were 1992-1995.

burtonis, Pogona minor and *Varanus gouldii* were only recorded after the fire. These are vagile species, possibly recruited from the adjacent burnt area.

In 1992 we established six pitfall trap grids in Kings Park as part of a three year survey of areas with a variable fire history. Two grids, consisting of a three by three matrix of 20 litre buckets placed 10 metres apart, were located in each of three areas with different times since they were last burnt. Sites 1 and 7 were placed in habitats last burnt in 1985, Sites 2 and 3 were placed in habitats last burnt in 1989 and Sites 4 and 5 were placed in habitats last burnt in 1979.

The lizard diversity of sites, as measured by μ of the log-series, is presented in Table 2. This table shows that those sites with the highest lizard diversity are those that have remained unburnt the longest, while those with the lowest diversity are those burnt in 1989. Several species are not recorded in Sites 2 and 3 between the fourth and the sixth years after fire despite their presence in Kings Park in the longer unburnt sites. These include the gecko, *Diplodactylus polyophthalmus*, the legless lizard, *Lialis burtonis* and the skinks, *Lerista elegans, L. lineopunctulata, L. praepedita* and *Morethia obscura*.

Site 1, near the northern side of the Park, was burnt on 3 February 1993 by a mild fire but most of the adjacent vegetation remained unburnt. We continued monitoring the burnt site and also established a new site (Site 7) in the immediately adjacent unburnt area, such that the two grids were contiguous.

Figure 2 shows that the number of species and the number of individual lizards in the burnt Site 1 declined markedly the first year after burning when compared to those captured in the unburnt Site 7. In the second year the number of species was equal in the two sites and the number of individuals in the burnt site was only marginally lower. A similar pattern was evident in the third year after fire but the lower number of species and individuals may be attributed to the extreme drought conditions. Several individuals that were marked on Site 1 prior to the fire were recaptured in Site 7 immediately after the fire.

Bamford (1995) sampled reptiles on the northern Swan Coastal Plain in Banksia woodlands with between zero and 23 years since the previous fire. The greatest amount of variation in the assemblage occurred in the first few years after fire. However, enhanced recruitment of some species from adjacent areas, particularly of immature lizards, was perhaps an important factor in determining the post fire reptile assemblages.

Invertebrates

Six invertebrate sites in Kings Park were sampled between 1992 and 1995 for large invertebrates (> than 10 mm long). Two sites were located in each of three different vegetation ages since the last fire viz 1979, 1985 and 1989 (data from Dixon et al. this publication). Altogether over 100 taxa have been documented with a total of about 5500 records.

Most of these taxa still await identification and, although detailed data analysis is yet to be undertaken, several centipede species have been identified which reflect different patterns of response in habitats of different ages since they were last burnt (Figure 3). *Allothereua maculata* and *Cormocephalus turneri* were considerably more abundant in Sites 4 and 5 that had remained unburnt for more than 13 years. Conversely, *Scolopendra laeta*, was most abundant in Sites 2 and 3 which suffered a severe fire only three years before our study began.

Conclusions

Data in this paper indicate that fire in urban bushlands is inimical to the survival of many species of fauna. Faunal groups that are sedentary and/or habit specialists are more severely affected by fire.

Several species of birds that are dependent on the resources associated with denser shrub vegetation, e.g. fairy-wrens, scrub-wrens, thornbills, are most affected by fire burning out the understorey. Species in this group are poorly represented on isolated reserves and no reserve has a complete assemblage of all species that previously occupied the area.

At Talbot Road Reserve a hot fire eliminated some reptile species, whereas adjacent unburnt areas had an increase in species diversity, possibly recruited from the burnt area.

Our study showed that, three years after the hot and extensive fires of 1989 burnt 45 per cent of Kings Park, areas that were burnt in 1989 had a different lizard and invertebrate assemblage from those that remained unburnt for more than 13 years. A cool burn over one study site in February 1993 has been followed through for two years to evaluate shorter term responses to fire. There was a marked decline in the number of species and the number of individuals the first year after the fire. The long and short term impact of fire on the fauna of other urban bushland remnants surveyed in the last two years is being evaluated.

Acknowledgments

We would like to thank the Western Australian Heritage Council and the Kings Park Board for funding this research. Numerous volunteers assisted with the trapping programme and Melissa Humphreys drew the graphs.

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Wildfire and its effect on the birds of the Darling Scarp

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The Darling Scarp, the scenic backdrop of Perth, is an area rich in animal and plant diversity that is now highly prone to wildfire each summer. Once started, these fires are difficult to control because of the steep and rocky topography and the increasing necessity for all fire-fighting efforts to be directed toward the protection of property.

In 1973, Ian Rowley began to study a population of Splendid Fairy-wrens (*Malurus splendens*) living on the scarp between Gooseberry Hill and Helena River — an area of approximately 120 hectares (Figure 1). The vegetation is dominated by heath species with an overstorey of Marri and Wandoo trees. During the 23 years since 1973, 10 wildfires have impinged to a greater or lesser extent on the study area. Almost all of the fires have been deliberately lit. In this paper I concentrate on the effects that these fires have had on the wrens, on other species of animals, and on the plants.

Following four partial burns in the 1970s, the numbers of wrens living in the most frequently burnt portions of the study area declined to about 10 per cent of their peak density with some territories completely vacated (Rowley adn Brooker, 1987; Brooker and Rowley, 1991).

Numbers then increased during a relatively fire-free period from 1978 to 1984 (Figure 2), until a major wildfire in the summer of 1984-5 burnt out 95 per cent of the study area. This had no immediate effect on the mortality of adult wrens or juveniles either during the actual fire or in the following nine months (Rowley adn Brooker, 1987; Brooker and Rowley, 1991). However, in the nine years since then the population has been in continual decline (Figure 2). The main cause appears to have been an increase in the rate of nest predation by cats and native animals leading to a decline in nest productivity and consequent changes to the age structure of the population and the composition of social groups (Rowley, Brooker and Russel, 1991). Non-breeding helpers, which were common on the area during the fire-free period, are now rare. There have been further fires in 1987 and 1988 which burnt 60 per cent and 20 per cent of the area respectively and another major fire occurred in February 1994, again burning out almost the entire area. Unlike the 1985 fire, however, on this occasion small patches of vegetation remained unburnt in rocky areas and beside roads and tracks. The only wrens to survive this fire and breed the following spring were those whose territories included some unburnt patches.

A computer simulation of the population (Brooker and Brooker, 1994) using the demographic and environmental parameters measured during this study has shown that, if isolated, the wren population could not survive this fire regime in the long term (Figure 3). Fortunately, at present, the study area has an unbroken border with the Kalamunda National Park, thus providing opportunities for recruitment from outside the area.

For other species of birds, the response to habitat destruction by the 1985 fire varied. Most of the resident species appear to survive the actual fires but invariably suffer adverse effects in the following years. Very few Western Thornbills (*Acanthiza inornata*) nested in the first year after fire and, like the wrens, their numbers declined following the 1985 fire. Inland Thornbills (*A. apicalis*) disappeared from the area burnt in 1985 and still have not returned 10 years later. White-browed Scrubwrens (*Sericornis frontalis*) left the area immediately after the fire; at least one pair bred in an adjoining unburnt area the following spring and they returned to the

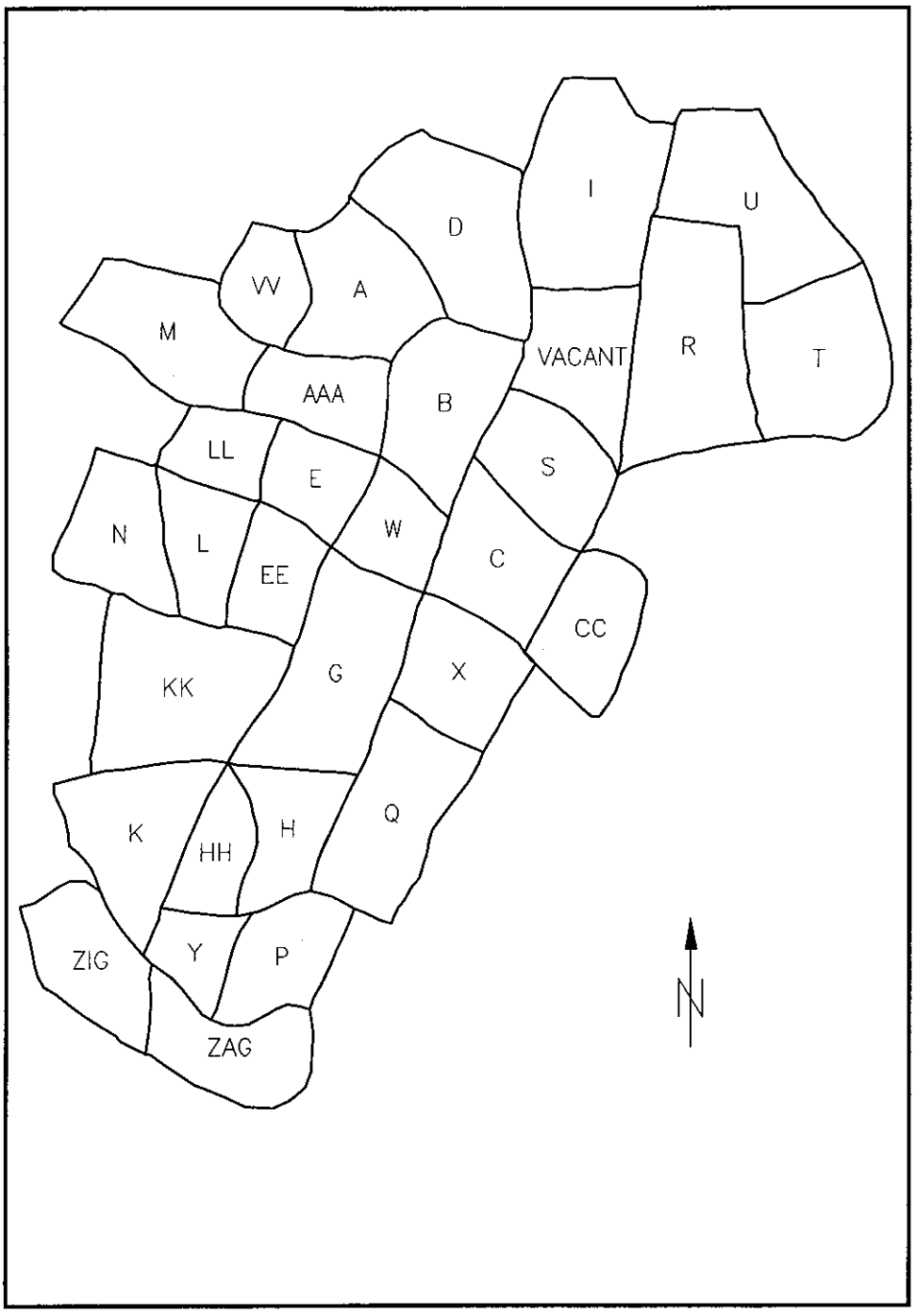

Figure 1. Map of Gooseberry Hill Study Area showing boundaries of Splendid Fairy-wren territories in 1983.

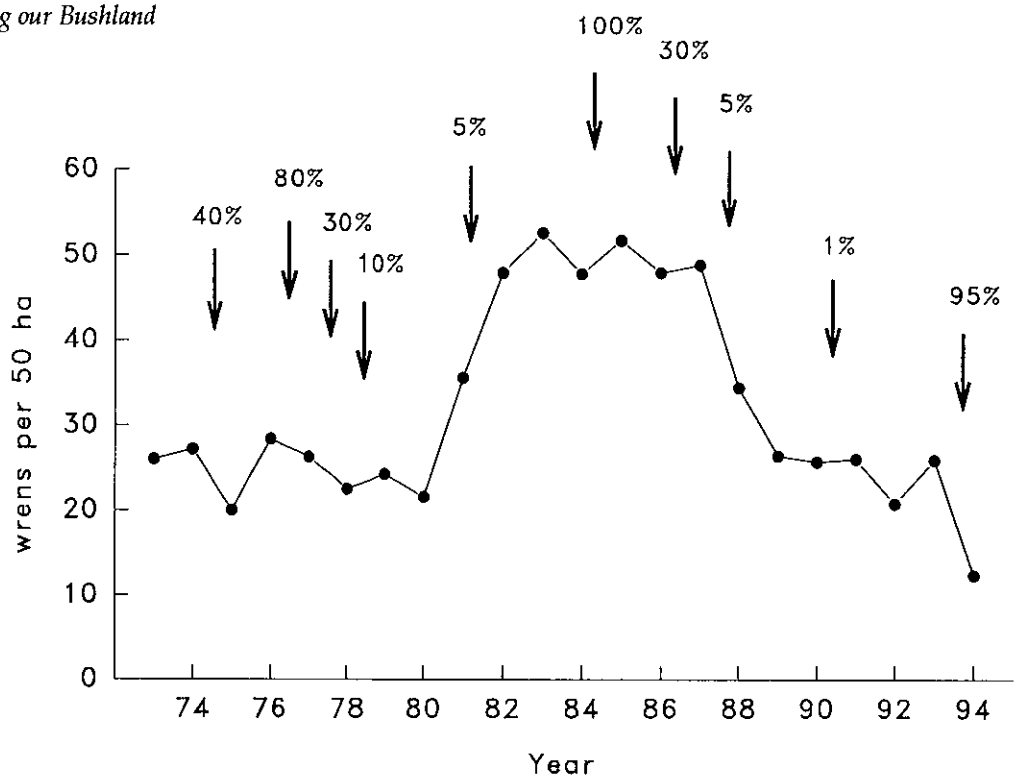

Figure 2. Density of Splendid Fairy-wrens on 50 ha core area of Gooseberry Hill Study Area at September census. Arrows indicate date of fire and percentage burnt.

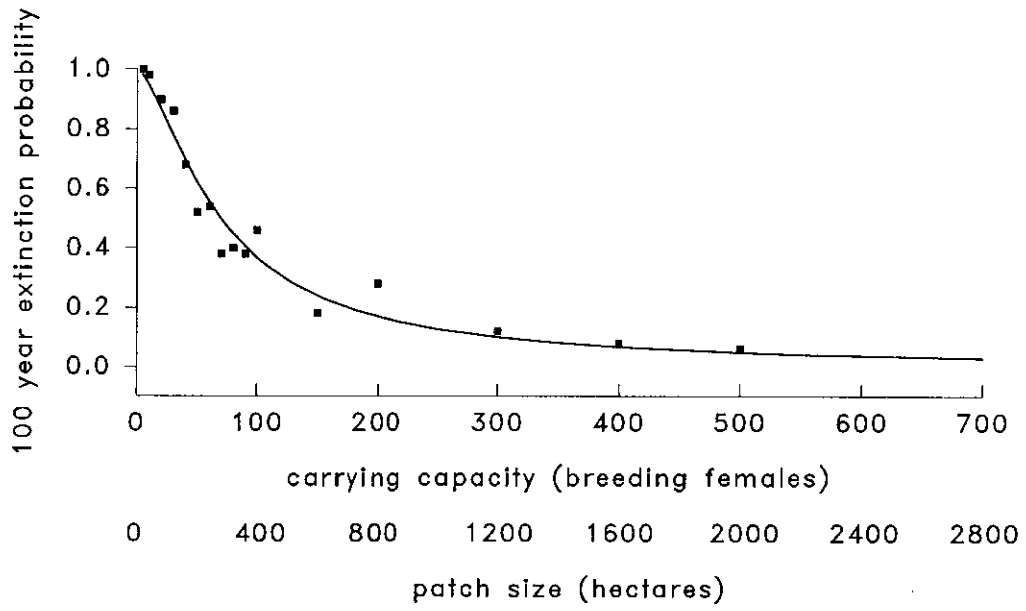

Figure 3. Relationship between extinction probability and patch size for Splendid Fairy-wrens, assuming a fire regime similar to that at Gooseberry Hill. Extinction probabilities generated from a computer simulation model.

burnt area the year after that, two years post fire. White-cheeked Honeyeaters (*Phylidonyris nigra*) did not renest in the burnt area for four seasons after fire. On the other hand, some species, such as the Little Button-quail (*Turnix velox*), Elegant Parrot (*Neophema elegans*), White-winged Triller (*Lalage sueurii*) and Dusky Woodswallow (*Artamus cyanopterus*) nested more frequently on the area in the year or years after the 1985 fire.

Because of its increasing accessability to fire-bugs and the over-riding need for fire-fighters to concentrate on the protection of life and property, fires on the Darling Scarp present a dilemma for the conservation managers of an area rich in native biota — on the 120 hectare study area alone, over 90 bird species and over 600 plant species have been recorded. The problem becomes more acute each year as housing increases along the river frontage and along the top of the scarp. Firebreaks running across the gradient are few and possibly ineffective and vehicle access is restricted. This means that firefighters have to concentrate their efforts on the houses above and below any outbreak and on the State forests inland of the scarp.

Since it may be impossible in such areas to limit fires to the frequencies recommended for heath communities [i.e. 10 or more years apart; (Groves, 1968; Bell, Hopkins and Pate, 1982)] some form of mosaic burning may be preferable to the present regime of major summer wildfires at increasing frequency.

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Fire and fauna

Keith Smith
WA Native Bird Hospital

I run the WA Native Bird Hospital and have worked with distressed wildlife for over 20 years. I am also the fire control officer for my local bush fire brigade, responsible for fire prevention, fuel reduction, and fire fighting in my district. I used to be a shire councillor, but found it difficult fitting three 12 hour days into 24 hours. Through my dealings with various government departments in all three capacities, I have a good knowledge of their positions on the issue of fire.

I say this to demonstrate that I have seen this issue from all sides of the dice.

From the view-point of an environmentally-minded person, primarily working with wildlife, the effect of fire on wildlife can be summed up with one word — disastrous.

Most species of small birds nest within two metres of the ground, medium birds within four metres. Only larger birds use the tree-tops, and many of them only 10 to 15 metres up. A quiet spring fire or preventative burn off can scorch the vegetation to a height of five metres, taking with it all nests within that height range. The majority of adults will escape. A fierce summer fire, when many species are still breeding, will go right through the top to 30 or 40 metres and higher. I'm sure many of you saw such fires on the television footage of the New South Wales fires last year.

Almost all our species of small marsupials and reptiles are dependent on hollow logs (either still standing and vertical or horizontal on the ground) as habitat. In a spring fire or controlled burn many of these will burn. In a summer fire, up goes the lot.

So in a spring fire, controlled or not, the great majority of small and medium bird species' nests are incinerated, and much of the small marsupial and reptile habitat (hollow logs and dense understorey) is lost. A great deal of life is lost also, due to the animals' reluctance to leave their burning shelters. What is left has not only lost its habitat; the great majority of its food source has also been destroyed by the fire. The population left in the bush will be forced to move to surrounding areas, causing territory disputes and pressure on the populations surrounding the burnt area, usually resulting in poor breeding results overall.

In a summer fire it is all lost. Almost the total population, habitat and food source go. Adult birds are even incinerated in flight.

In a bushland situation, these habitats will eventually re-generate (sometimes over many years) to the extent that they can support some of the original species present, but by no means all. Habitat such as hollow trees and logs may take hundreds of years to re-appear.

Many areas are burnt on a rotational basis in spring to autumn. Many species breed throughout this period. These areas will be slowly colonised by the surrounding population, providing the surrounding bushland had suitable habitat for the various species forced out by the fire. It has to be remembered that many of our rarer species usually exist in isolated pockets surrounded by unsuitable habitat. Destroy the pocket; destroy the species in that area.

In an urban bushland situation, the picture is quite different. In many cases, the area is surrounded by urban development, the population left by spring to autumn fire has nowhere to which it can move, other than into the jaws of a foreign environment, including dogs, cats, cars and other hazards. The great majority will perish.

In a summer fire, everything is lost. If there is no safe corridor of bush connecting it to other similar bushland areas, it will never be natu-

rally repopulated with all the species it once supported, no matter how well it regenerates. Only human intervention to try to re-establish all the species formerly present would have any chance of returning the area to normal, and the likelihood of success would be slim. Even many plant species would be lost in a fierce summer fire, on which much of the original population would have depended as a food or shelter source. To properly rehabilitate the area, these plants would have to be re-established. The whole exercise would become economically unfeasible.

It is therefore obvious that protection against fire in urban bushland in important and must be a part of all management plans. This is made doubly important as many urban bushland areas are surrounded by a high population of people, who are known to cause over 90 per cent of fires. Almost every case of urban bushland fire has been found to be caused by human activity. Few have been started by natural means, such as lightning.

Where the urban bushland is in a shire with established bush fire brigades, the local brigades will be part of its protection. Management of reserves should include the brigades using careful winter burning techniques, using windows of opportunity in the weather (such as dry spells). The area could be burnt on a patchwork basis, never burning more than 20 per cent in a year. Burning in this manner would reduce the easily flammable fuel level that could cause disastrous fire, but not completely remove it. Little habitat or life would be lost. The brigades would continue to play an important role in fighting any fire that occurred and minimising damage. It should be realised, however, that any brigade would need considerable community support to undertake this type of burning regime. It is very time consuming and costs the brigades money. It must be recognised that they are volunteers, and need every bit of assistance available.

Areas of bushland within the metropolitan fire district are covered by the WA Fire Brigade. In these areas there are no established volunteer fire brigades and the problem is different. Rightly so, the WA Fire Brigade's main responsibility is to protect life and property. These fire-fighters receive little formal training to combat bush fires and, in many cases, their equipment is unsuitable for the task. They also seldom perform any preventative fuel reduction burning of bushland, due to the high costs involved in using paid staff.

The establishment of specialist bush fire brigades, to protect significant areas of urban bushland, would be fraught with problems, but none of them insurmountable. One could not count, however, on the local government authority funding the venture. Most bush fire brigades exist mainly on their own resources, depending on community support for funds. This would require a high level of commitment on the part of the local community. Most established bush fire brigades have funded their own fire sheds, vehicles and equipment for many years, and there is little sign of that changing in the near future.

Where urban bushland is created by development, perhaps the onus of establishing bush fire protection should fall to the developer.

Many areas of urban bushland are the responsibility of government agencies, such as CALM and the Water Authority, who do maintain a fire fighting capability, but their response abilities are severely limited. I do not say this in a derogatory manner. Their limitations come from severe cuts to budgets, and therefore staff, over recent years. The abilities and commitment of their staff and fire fighters cannot be questioned. Cuts have necessitated the regionalisation of the services, and fire fighting equipment may be remote from the areas in question.

A fifteen minute response to a fire in bush is the recognised ideal. In many cases, the resources could be an hour away. Regionalisation has also reduced the resources being sent to a large fire, and created an inability to respond to an emergency in another area. I know of two occasions last season on which this happened.

There has been a move afoot to do the same thing with the bush fire brigade organisation, but this is being fiercely contested (mainly by me). When it comes to fire protection, there is no such thing as being over-resourced. The more equipment and people you have, the less likelihood of any major damage.

But the picture in WA is not all black (excuse the pun). I believe the combination of the Bush Fires Board, the various government agencies, and the WA Fire Brigade makes the best fire fighting service in Australia. We just do not have fires of the magnitude that have become a common occurrence in other states, sometimes burning for months. This is not good luck, or that we don't have difficult terrain, or that our bush does not burn as fiercely; it is due to the commitment, expertise and experience of our fire fighters, from all agencies.

I also believe that the level of community interest in preserving our bush and fauna has increased dramatically in recent years. In my brigade area, which is over 400 square kilometres, there are only 360 rateable properties. (This is due to the area's rural and forest character.) Thirty-four of these — almost 10 per cent — are represented by members on the bush fire brigade. They are committed to the prevention and suppression of fire in the area. Many others give financial and service support. This level of interest is there throughout the community, it just has to be harnessed and directed.

We owe it to ourselves and the wider community to do all we can to protect our bushland and its fauna, so it is there to enjoy. Even more important, it is our duty to ensure it is there for future generations to enjoy. We have to recognise that the cost, financial and moral, of preserving these areas is far out-weighed by the cost of their loss.

Fire is the biggest threat to any area of urban bushland and its fauna population. Dogs, cats, traffic and human activity can affect it, but to fauna, fire can be final.

Impact of fire on fauna in remnant vegetation — a summary of key research findings

Gordon Friend
CALM Science and Information Division

The following is a brief summary of the major findings from research projects examining the impacts of experimental fires on small vertebrates and invertebrates inhabiting remnant shrubland and woodland vegetation in the Wheatbelt and South Coast Regions of Western Australia. These studies have focussed on Tutanning, Durokoppin and East Yorkrakine nature reserves in the Wheatbelt over the past seven years (1987-93), and on the Stirling Range National Park between 1989 and 1992. For further details on these areas, study design and results, the reader is referred to Friend et al. (1989), Friend (1993), Friend (1995a, 1995b), Friend and Friend (1993), Friend and Williams (1996), Little and Friend (1993) and Strehlow (1993). Current research is examining the impact of spring and autumn prescribed fires on fauna in jarrah forest east of Collie.

Research findings

1. The small vertebrate and invertebrate fauna inhabiting semi-arid woodlands and shrublands in Western Australia appears to be relatively resilient to single fire events of small scale and low to moderate intensity.

The impact of repeated fires, however, is unknown.

As a corollary, it is essential that whole reserves are not burnt in one event, especially by a high intensity fire.

2. A review of the response patterns of invertebrates to fire across a broad range of habitats throughout Australia (Friend 1995a) suggests that resilience may be greater in the seasonally dry shrublands and woodlands than in the more mesic but less seasonal habitats. Adaptations for seasonal aridity may impart considerable resilience to fire. This does not mean, however, that fauna will not change greatly under a high frequency fire regime, since there are fire-sensitive species and habitats that require special consideration.

This has important implications for fire management, since it shows that prescriptions developed for one ecosystem do not necessarily apply in others. Ideally, some details of life history and habitat preferences are needed for a range of species in order to decide appropriate management regimes.

3. Frequency and scale of burning are probably the two most important factors to consider in fire management. There is no evidence from our studies in semi-arid habitats (eg. in the Stirling Range National Park) that season of burn is of major significance to fauna (Friend and Williams 1996).

4. Post-fire response patterns of most small vertebrate groups are closely tied to (and may be predicted from) their shelter, food and breeding requirements (life history parameters; Friend 1993).

This is particularly so for small mammals. Species that survive fire and/or favour early post-fire successional stages generally shelter in burrows in relatively open areas with low ground vegetation and leaf litter cover. They have non-specialised diets, and can vary their reproductive patterns in response to climatic or habitat cues. Mid-successional species require denser vegetation and shelter in more flammable refuges (eg. hollow logs and grass

trees), are less general in their diets, and have a more rigid seasonal (though polyoestrous) breeding strategy. Finally, late-successional species show considerable specificity in diet, shelter in flammable refuges in relatively dense vegetation, and may have a seasonal and highly synchronised breeding season. There is thus a trend of increased specificity and reduced flexibility in small mammal species' life history parameters concomitant with increased impact of fire, and later post-fire recolonisation.

For reptiles there appears to be a strong relationship between the shelter and foraging requirements of species and their abundance in various successional states. The high incidence of burrowing among the mallee/heath amphibian fauna imparts considerable resilience to fire, and most species' abundance and distribution patterns seem to be more closely linked to moisture regimes that to fire per se.

5. A model to predict the broad impact of fire on small vertebrates is thus possible and has been developed. A data base of species' life history characteristics and probable post-fire response patterns can be linked to such a model. This needs further input of data and needs to be made accessible to managers.

6. Given the above, fauna can be considered and grouped in terms of Life Form Categories based on shelter and food requirements. This would greatly simplify the amount of information that managers need to consider when developing fire management plans.

7. Results from space-for-time studies of potentially sensitive species in the Stirling Range National Park [eg. Honey Possum, (*Tarsipes rostratus*)] indicate clear abundance trends with post-fire age of vegetation. Abundance is low in recently burnt stands (<5 years), but increases rapidly as vegetation ages, levelling of after about 15 to 20 years. If optimising the conservation of the Honey Possum is a high priority for management, these data suggest a minimum time between burns in the park of 15-20 years. In the lower rainfall areas of the Wheatbelt Region, where vegetation growth is slower, the minimum is likely to be 20-25 years. These findings agree closely with those gained from studies of vegetation in these regions (L. McCaw and A. Hopkins, personal communications).

8. For invertebrates the level of taxonomic resolution (ie. Orders vs species levels identifications) influences the results of studies on fire impact. This is because individual species may be markedly affected by fire (increases and decreases), but at the Order level of identification these trends will tend to cancel out and thus not be apparent.

9. With respect to animal abundance and composition, the effects of season, locality and year-to-year variability in climate, and stochastic events like droughts, generally outweigh any changes attributable to fire (Friend and Williams 1996). An excellent example of such synergistic impacts is the post-fire locust plague that eliminated Allocasuarina from an area burnt at Tutanning. This may lead to long-term impacts on stand structure and faunal abundance and composition, simply because of these two events happening in tandem (Friend and Friend, 1993).

Fire managers thus need to take account of pre-fire conditions (eg. is drought in force or imminent?) before burning, but many post-fire events and outcomes are beyond the managers' control.

10. Studies of the responses of ground-dwelling spiders in Durokoppin nature Reserve (Strehlow 1993) showed that invertebrate post-fire succession does not necessarily return to the pre-fire state, but instead to a new transient state also occupied by undisturbed communities. This has profound implications for land managers because there is no "climax" community or baseline against which we can measure long-term change, and thus no "ideal" stage or normal condition towards which management can aim. In essence, every stage in community development is important (Strehlow 1993) and managers need to be flexible enough in their operations to allow for such diversity.

Conclusion

Given the importance of season, climate and stochastic events in determining species abundance and distribution patterns, the need for and use of fire as a routine management tool to maintain/increase (faunal) diversity needs to be carefully evaluated. At this stage in the development of our knowledge base it is clearly better to err on the side of conservatism in developing any fire regime for these remnant shrubland and woodland habitats. As a general rule, larger scale block burning should only be used for special purposes, experimental research or where it contributes to a well considered strategic fire management objective. Protecting areas from large scale, high intensity wildfires through a system of internal and external low fuel zones should remain a high priority for managers of remnant vegetation.

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Management Guidelines for Urban Bushland and Fire Effects

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Introduction

Urban bushland areas are generally isolated islands in a sea of hostile environments, which form barriers between areas and impact on the bushland in a variety of ways. Many of these impacts constitute unnatural disturbance regimes, that is they affect the bushland's capacity for self maintenance. Such disturbance factors include partial clearing; fragmentation; selective removal of species (by timber cutting, wildflower picking, mowing; dieback and other plant diseases); fire frequency, both periodicity and intensity; 'enrichment plantings' (that is plantings of species not found in that plant community); weed invasion; animal impact (horses, foxes, rabbits, cats, dogs, camels, goats etc); soil movement, both removal and dumping; changes in water regime (flooding, drainage and watering); rubbish dumping; fertilizer drift and along waterways nutrient influx; mining (particularly that for roadworks); grazing (stock, and overgrazing by native mammals); proliferation of tracks, fire breaks and walk trails; off road vehicle use and use as service corridors by the SEC, Main Roads, Water Authority (Keighery, 1994).

While change in response to periodic natural disturbance is a feature of bushland, much of this disturbance in urban bushland does not occur in natural systems or else the pattern of disturbance is unlike that found in natural systems.

Fire is essentially a natural disturbance in Western Australia and bushland plants and animals have mechanisms for recovering from fire events. However, in urban bushland the pattern of fires is generally not natural and this affects the bushland's ability to regenerate. Differences relate to: fire frequency (generally too often), intensity, time of fire; floristics of individual bushland areas and interaction with each of these and other disturbance regimes.

Recent detailed floristic work and concurrent observations of bushland remnants on the Swan Coastal Plain (Gibson et al. 1994, Keighery and Keighery 1991 & 1993, and G.J. Keighery, unpublished) provide some specific insights into the last two factors and actual bushland management.

Flora of the Urban Area: A Diverse Assemblage

Our bushland is chracterised by high levels of floral diversity. This is well illustrated by just six areas from across the Swan Coastal Plain (Table 1) that collectively contain some 800 species of vascular plants occurring together in a series of plant communities.

Table 1: Bushland Areas and the geomorphic units (McArthur and Bettanay 1960) on which they occur. Areas are listed from west to east

Bushland Area	Geomorphic Unit
Garden Island (M96)	Quindalup Dunes (island) (holocene aeolian sands)
Becher Point (M106)	Quindalup Dunes
Bold Park (M47)	Spearwood Dunes with some Quindalup Dunes (pleistocene/ holocene aeolian sands)
Wandi Nature Reserve (M97)	Bassendean Dunes (pleistocene aeolian sands)
Brixton Street Wetlands	Pinjarra Plain (pleistocene alluvial soils)
Talbot Road Bushland	Ridge Hill Shelf (pleistocene sands, laterites and loams)

Each of these species will have an individual life history and response to fire. However, for the purpose of this study, the flora of each area can be catergorised according to the regenerative strategy of the native and weedy plants. The regenerative strategies recognised being:
(a) seeding: regeneration is from seed stored in the soil or on plants, these plants are seeders (or sometimes called reseeders). This group is divided into annuals and perennial.
(b) resprouting: regeneration is from trunks and branches or underground stems, tubers, bulbs etc (perenating organs), these plants are resprouters.

This comparison (Figure 1) shows some interesting patterns. Offshore islands such as Garden Island contain very fire sensitive communities (*Callitris preissii* woodlands), many species (49 per cent) killed by fire and regenerating from seed. The tree components, Rottnest Island Cypress (*Callitris preissii*) and Rottnest Island Tea Tree (*Melaleuca lanceolata*) are very slow to achieve reproductive maturity as are the communities in which they occur. Most of the mainland communities (encompassing Eucalypt woodlands, Banksia woodlands, heaths and shrublands from Becher Point, Bold Park, Wandi and Talbot Road) contain similar proportions of resprouters (48-62 per cent) to reseeders (25-36 per cent). The same pattern is not evident on the clay based wetlands at Brixton Street where there are a high proportion of native annual herbs (26 per cent). Also, although not shown, the resprouters on these clay based wetlands contain a high proportion of plants that resprout from bulbs and tubers. That is, while some areas have similar regenerative strategies at this very broad level, there are still significant differences between areas. These differences need to be appreciated when attempting to predict the effect of fire on communities of native plants. For example the flora of the Brixton Street Wetlands could be drastically altered by frequent repetitive fires as there is evidence to suggest that such fires effectively reduce the size of tubers or bulbs of annually renewed geophytes (K. Dixon pers. comm.). The time of the fire is also relevant as orchids burnt in leaf may be unable to renew themselves (A. Brown pers. comm.).

The weeds of most areas are predominantly annuals. In the clay based wetlands bulbous weeds are very common, this group effectively functions in the same manner as the annuals in other areas.

Such information on regenerative strategies highlights the depth of the floral diversity in our bushland both at the specific and community level. This level of diversity is characteristic of the entire area of southern Western Australia where we have an immensely diverse and rich flora which changes rapidly over short distances. Case studies of fire responses in one area should not be adopted unilaterally as the basis for fire management in all bushland areas.

Interaction of disturbance factors - Setting the scene for weed invasion

In relatively undisturbed bushland native annual species such as *Stipa compressa*, Apiaceae species (eg *Trachymene coerulea*) and Asteraceae species (eg *Waitsia suaveolens*) germinate enmasse after fires. A series of factors appear to alter this response and these native taxa are replaced by annual weeds and perennial seeder weeds. These changes appear to be associated with a series of interacting factors.

Frequent fires

The disturbance most closely related to this change in flora in remnants appears to be frequent fires which create large, bare, nutrient enriched areas throughout the bushland. The regeneration of native annuals declines with this frequency. The basis of this decline is not known but observations suggest it could be related to a series of factors, such as seed dormancy period and lack of protection of the seeds (on the surface immediately after a fire, buried in the soil over subsequent periods). Interestingly the native species that are so common after fire are present in low numbers on an annual basis. This annual renewal of the seed bank may be important in augmenting the seed stored in the soil and the subsequent availability of seed in sufficient numbers to respond to infrequent fires.

Increased fragmentation of bushland areas

Fragmentation results in bushland areas being subjected to a rain of weed seed from surrounding alienated areas. In the past this 'seed rain' would have been of native taxa from surrounding bushland areas.

Nodes for weed invasion

Weeds invade bushland areas from nodes of weed infestation ("nascent foci", Hobbs 1995). These nodes are created in urban bushland in a variety of ways. A characteristic of these nodes is localised nutrient enrichment, soil disturbance, lack of native overstory and direct or indirect weed propagule introduction. Some common ways in which these nodes are established are:

- soil dumping from outside the area and from within the bushland when firebreaks, tracks and drains are formed
- by the creation of invasion corridors along pathways, tracks, firebreaks, drains and service corridors; the activites of people, dogs and horses augment the natural dispersal of weeds along these corridors.
- 'enrichment plantings' of non local native species. For example Geraldton Wax (*Chamelaucium uncinatum*) an uncommon and restricted species in the metropolitan area is commonly planted in bushland and regenerates prolifically from seed after fire, forming dense stands that shade out the local native species.
- rabbit infestation creating many areas of localised disturbance with their burrows and dung mounds.
- using irrigated lawn areas in and around bushland which act as reservoirs for invasive weed species (Odgers 1994)

Many of these nodes are created by management practices and are effectively degrading activities.

Managing Urban Bushland After Fire - Opportunities Missed

While fires cause immediate massive destruction in urban bushland sensitive, informed management after fires can augment the natural regeneration and create opportunities to deal with past disturbance regimes. Accessibility within the burnt area effectively creates opportunities for post-fire actions to

- remove and control weeds (also rapidly growing resprouters will be most vulnerable to herbicides)
- remove original 'enrichment plantings' and their progeny
- control rabbits
- remove dumped soil.

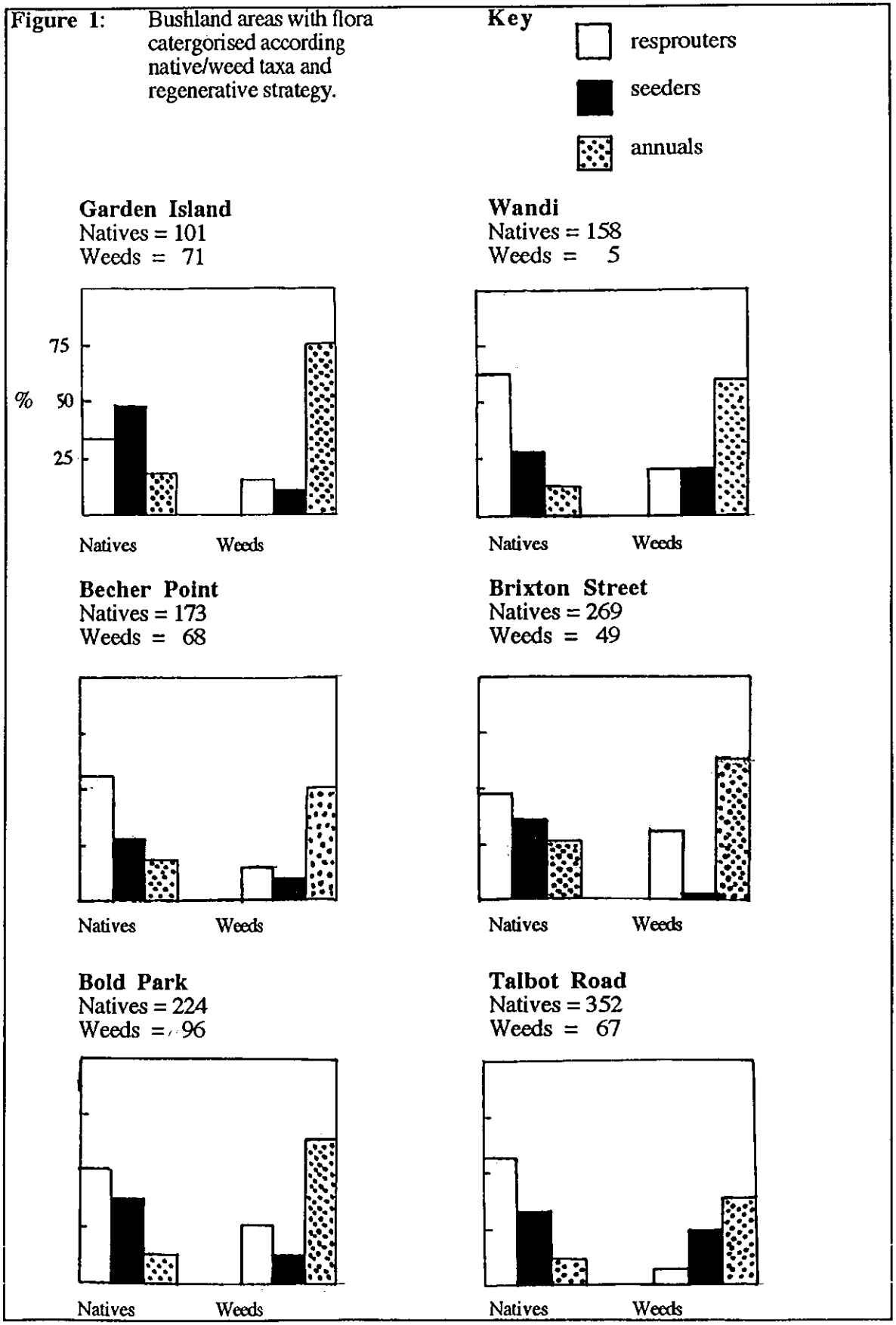
Carrying out these essential management activities also helps maintain a positive attitude among those people who have been working tirelessly to manage the bushland only to have their bushland 'burnt out'.

Unfortunately all too often management begins and ends with fire control during the fire which creates another series of disturbances associated with both new and over used firebreaks and soil dumps. For example, Cardup Nature Reserve was burnt in 1992, a new fire break was created and the fence burnt down. A year later neither of these had been remedied effectively creating a further track and horse access throughout the reserve. Management should centre on lessening these disturbances, as much as the fire, which in the longer term will lessen weed invasion and subsequent greater fire hazards.

Fire Management in Urban Bushland - An Individual Approach

Observations of patterns of disturbance and fire throughout the Swan Coastal Plain indicate that there are patterns of management for fire which lessen, or have the potential to lessen, the deleterious effects of fire on remnant bushland on the Swan Coastal Plain. Most of these suggestions have not been tested but the opportunities exist for them to be trialed. All trials should be supported by a monitoring programme designed to test their effectiveness. Friends groups, with their local knowledge and experience, are in an ideal position to be involved in the implementation and monitoring of these approaches.

Figure 1: Bushland areas with flora catergorised according native/weed taxa and regenerative strategy.



Know the flora of your bushland

To understand the effects of fire on the flora of each bushland area it is necessary that each area be well documented before the fire. To be most useful in monitoring, this documentation should include some reference sites and refer listed flora to mapped communities (Keighery 1994 and Keighery, Keighery and Gibson 1995).

Using local native annuals

Determine which species would fill the role of annual species such as *Stipa compressa,* Apiaceae species and Asteraceae species in your bushland area. Implement strategies for maintaining the soil stored seed bank of these species which may require direct seeding into bushland before or after a fire.

Consider the values of the bushland as paramount

Focus on the values of the bushland, protecting the bushland from fire and from disturbance associated with fighting the fire. Avoid dilemmas about protecting property by not building structures in or alongside bushland. Most problems with property in and adjacent to bushland have been created by poor planning. For example, recreation facilities in the middle of the Warwick Open Space. Any structures that must be built in bushland should be designed to be fire proof. Inappropriate recreation facilities in bushland should be avoided; such as:

- fireplaces for barbecues, particularly woodburning barbecues, that indicate it is acceptable to light fires in bushland as well as encouraging collection of wood in the bushland
- grassed areas which are watered, fertilized and mown, and create nodes for weed invasion — all disturbances which raises the level of weed invasion and consequent fire risk.

Rationalise firebreaks

Small bushland areas surrounded by roads are effectively 'firebreaked' by the road and the verge. Additional firebreaks within the reserve effectively result in a line of three fire breaks and proportionally clear large areas of the reserve. Recent firebreaks placed in the land acquired by the State Planning Commission for the Yule Brook Reserve in Kenwick cleared substantial areas of vegetation alongside a cleared road verge and road.

Fire retardant belts

Belts of fire retardant vegetation should be used in place of traditional fire breaks. A species such as the summer growing and flowering *Jacksonia sericea* is suitable for this purpose. This example also illustrates the value of local knowledge of the flora as the possible use of this species was recognised on several occasions (Kirsten Tullis pers. comm.). Grassed areas are often justified in this context but they are essentially a degrading development.

Patch burning

In the past, when bushland covered the state, regeneration after fire would not only have been from seed and perenniating organs within the area of the fire, but from seed dispersing into the fire area from unburnt areas. This effect can be replicated on a small scale in remnant bushland. Observations of such burning in the Crampton Nature Reserve found that there was selective regeneration of native taxa rather than weed taxa.

Some General Thoughts in the Management of Urban Bushland

The aim of management of isolated urban bushland should be to lessen the impacts of unnatural disturbances. From the survey work on the Swan Coastal Plain it is unfortunately apparent that bushland left alone is usually in the best condition and the most intensively 'managed' is often in poor condition with extensive weed invasion. Much of the 'management' of our fire prone vegetation apparently causes greater disturbances than the vegetation can cope with leaving it more prone to weed invasion and degradation than 'unmanaged' stands of bushland. Kings Park bushland which has had a dedicated management authority for 100 years presents a classic example of such misguided management. The bushland is severely impacted by frequent fire, rubbish tips, proliferation of tracks, 'enrichment plantings'

and their progeny, wood fired barbeques and grassed areas adjacent to most bushland.

These observations lead to some generalisations about the general effectiveness of management plans. While all areas need a management plan, many are complex, unachievable plans that sit on bookshelves, never to be fully implemented. Aspects of the plans that are implemented are activities associated with capital expenditure (roads, tracks, toilets, barbecues, shelters etc) which generally require clearing of bushland and have little impact on the management of general disturbance in bushland. In practice, such documents are not bushland management plans. Plans for bushland management should be developed through two processes:

- Process 1 - Production of a limited release background biological and physical assets document
- Process 2 - Preparation of a brief, public approved and funded 'action plan' that details the management actions required to maintain the biological assets. What should not happen in the area should also be clearly set out in the plan.

The action plan should be simple with clear aims, goals and be accountable (ie: no waffle about 'desirable' management activities which will not happen in the life of the plan) with responsibilities and resources allocated to management rather than a focus on capital expenditure. Monitoring of all major management actions should be detailed to enable an audit of the plan to be undertaken periodically. These are not new concerns and most are periodically raised at seminars on bushland management (for example see Australian Institute of Urban Studies Seminar 1993).

Integral with this problem of lack of sensitive effective management is the general lack of appreciation, knowledge or feeling for the Australian bushland prevalent amongst many urban dwellers and the people responsible for putting management plans into action. Normal European horticultural practices (irrigated lawns, fertilizers, inappropriate plantings) are not appropriate for complex areas of natural Australian bushland. While community based groups of people who have this appreciation and understanding of bushland are working and will continue to work tirelessly on such sensitive effective management, an "Urban Bushland Advisory Service" as promised in the Government's Urban Bushland Strategy (1995), is urgently needed. This service, designed to "....assist local authorities and the community in issues such as management planning, fire prevention, land tenure information, fencing rehabilitation and planting" (page 12), should provide a support and focus for both the community and government. A similar service was proposed in the Urban Bushland Policy developed by the National Trust (1992) and has been endorsed by many groups including the Wildflower Society and the Tree Society. This service should be responsible for developing and disseminating the broad principles of urban bushland management and supporting the local groups in developing the individual approach required in each bushland area.

Conclusion

In southern Western Australia we have an immensely diverse and rich flora which changes rapidly over short distances. Management needs to recognise and then mimic this diversity to help us maintain this unique asset for present and future people of Perth.

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Integrating fire control into bushland management

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Introduction

Fire is one of the most important issues confronting best bushland management. However, it is not an isolated issue and has to be viewed within an integrated context of other management issues. That is, within the context of weed control, access, disease control, bushland restoration, and the maintenance and enhancement of bushland conservation values.

My talk today will be on the integrated approach to bushland management and the role that fire management has in this process.

Increasing urbanisation decreases the area of bushland. This increases the importance of management and adequate resources. The variation of remnant size and the vegetation communities they contain will have a direct bearing on the fire management techniques we employ. For example, the impact of hazard reduction burns on small remnants will, in most cases, be much larger than on larger remnants.

Fire control objectives

The three main objectives associated with fire control in bushland areas are:

1) Protection of human life;
2) Protection of property;
3) Protection of the bushland's biological and ecological values.

Generally, the three main methods by which these objectives are achieved are:

- Firebreaks;
- Fire trails;
- Hazard reduction burns (fuel reduction);
- Ignition control measures;
- Fire suppression (fire fighting).

Firebreaks, access and bushland integrity

One of the main methods of protecting life and property adjoining bushland is through the construction of firebreaks. Section 33 of the Bush Fires Act authorises local authorities to require owners or occupiers of land to construct firebreaks and/or remove fire hazards as specified in by-law on a notice (Robley, 1984). Generally, most firebreaks are constructed by machinery in the form of a three metre wide cultivated tracks surrounding the bushland remnant and, sometimes, breaking it into segments. Firebreak construction is most often carried out by contractors. While firebreak construction is an important aspect of fire management, there are some concerns about the planning, design and construction of these systems. These include:

- The maintenance of a disturbed site which augments weed invasion;
- The fragmentation of the bushland into unmanageable units (ie greater edge to area ratio);
- The lack of disease protection measures undertaken by firebreak construction operators;
- The use of firebreaks as bridle trails further facilitates disturbance and weed invasion from horse manure;
- The construction of tracks at acute angles to contours which increases risk of erosion;
- The construction of tracks at the intersection of structurally different stands of vegetation — these transition zones are often very diverse areas;
- The unnecessary duplication of firebreaks (ie next to existing duel use paths);
- Access for off-road vehicles and rubbish dumping.

These factors tend to decrease the biological values and ecological functioning of remnant bushland, further adding to the disturbance of the system and thus increasing weed invasion. Firebreaks need to be carefully planned so that they fulfil their desired objective (protection of life and property, and acting as an access path for fire fighting operations), yet minimise their impact on the bushland.

Factors that need to be considered when planning and designing firebreaks include:

- Risk areas (life and property; high, medium, low), position and size;
- Vegetation communities and flora, ie declared flora;
- Vegetation condition;
- Topography;
- Firebreak size;
- Method of construction;
- Disease;
- Alternatives;
- Fire history.

While it may be necessary to maintain a fuel free zone to protect property in some areas, alternatives should also be considered, such as an integrated system of pedestrian/cycle access-ways and fire trails. These consist of sealed paths, generally one to 1.5 metres wide with low fuel verges of one to 1.5 metres on at least one side, or both. Low shrubs and herbaceous perennials are used interspersed with the occasional tall shrub or tree to break any visual corridor effect and improve aesthetic quality. This allows fire fighting vehicles access while maintaining vegetation and minimising weed invasion.

The integration and rationalisation of firebreaks and access-ways through a process of good design will enhance the integrity of the bushland and assist in maintaining its ecological functions. Tracks superfluous to requirements should be closed and rehabilitated.

Hazard reduction burns and weed control

A method employed by land owners to minimise fire risk is hazard reduction burns (prescribed burns). These burns are usually carried out, or should be carried out, after some form of fire threat assessment. A fire threat is not constituted by flammable material and fuel loads alone, but when something of value is nearby, such as a building or fence, as well as a chance of ignition taking place (Sharp, 1993).

The use of hazard reduction burns has variable impacts on bushland quality depending upon:

- Frequency of fires;
- Seasonality of fires;
- Intensity of fires;
- Distribution of fires.

Some of the factors that need to be considered before undertaking hazard reduction burns include:

- Fuel load (fire hazard) determined by field measurement;
- Fire history;
- Landform — slope, aspect, wind direction;
- Known fire trails;
- Size of bushland;
- Properties under threat;
- Fauna habitat value;
- Bushland condition.

One of the most important factors is the fire hazard determined by the fuel load and flammability of the material. In most cases grass weeds and dry stems and leaves of some bulbous species represent flash fuels and pose the greatest threat. There is ample evidence that continuous firing of weed infested areas perpetuates weed growth to the detriment of native species (Wycherley, 1984). Therefore, weed control should be seen as one of the most important foci of fuel reduction to minimise fire risk.

Fire suppression

Suppression of fires is related to resources available in terms of equipment and the fire fighting force, and response time from alarm. Bushland management authorities need to identify the resources available to them and ensure that they are adequate. This may involve pooled contributions from

neighbouring local government authorities to facilitate an effective bush fire control unit.

Fire fighting authorities also need to be involved in the preparation of management plans so they can contribute to the plan and become aware of access points, water sources, and the biological and ecological values of the area.

Likewise, the neighbouring community should be involved in fire watch schemes.

Bushland restoration

Although fires, particularly regular fires, can have a negative impact on the conservation and recreation values of bushland, they also provide opportunities for bushland restoration.

Part of the activities of bushland restoration involves removing exotic species and replacing them with endemic native species, re-establishing natural habitats. Some sites are heavily infested with large and difficult weeds, such as pampas grass, typha, and blackberry. Weed control under these circumstances is rendered virtually impossible due to the impenetrable nature of the site. Once burnt, however, particularly by a relatively hot burn, access is readily available. This gives the opportunity to control the weed species using selective means (chemical or otherwise) — for example, direct application of chemicals on new and active regrowth. Sites are also available for broadcasting native seed and revegetating with young seedlings. Some weed species (eg *Pittosporum undulatum*) are killed by fire. Hence, under some circumstances fire can be a useful tool for regenerating bushland.

Performance measures

Finally, in order to measure the effectiveness of fire control strategies advocated in management plans, we require some performance indicators. These include:

- Loss of life;
- Loss of property;
- Regeneration of bushland;
- Minimisation of weed species and biomass;
- Minimisation of sediment movement.

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The problem of weeds in bushland — implications for fire management

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The weed problem

Most bushland remnants within the Perth metropolitan area have a naturalised weed flora. Although there are some remnants which have a very low cover of weeds and a seemingly intact native flora, there are many other remnants where weed species dominate the understorey (Gibson et al. 1994). This is particularly the case where remnants are small in size and/or have been surrounded by urbanisation for a long time. Around 37 per cent of the known flora of both King's Park and Bold Park are exotic species (Keighery, Harvey & Keighery 1990; King's Park and Botanic Gardens 1993). Some of the more serious weed species of the Swan Coastal Plain are listed in Table 1.

As weeds begin to dominate the understorey of remnants, they will start to out-compete native plants for resources and space. The abundance of native plants then decreases and it can be expected that native plant species richness would gradually decline over time as weeds take over (Hobbs & Huenneke 1992). This pattern has been demonstrated at a number of bushland remnants within the Perth metropolitan area. At Kings Park, Baird (1977) found that as sites were progressively invaded by perennial veldt grass (*Ehrharta calycina*), some native seeding species (such as native peas) were gradually eliminated. Plot studies of remnants on the Spearwood dune system demonstrated that native species richness was negatively correlated with increasing degrees of weed invasion (Bridgewater & Kaesehagan 1979; Bridgewater & Backshall 1981).

Today, some areas of our bushland remnants consist of little more than an overstorey of Banksia and/or Eucalyptus species and an understorey dominated by exotic grasses and other weeds with only a small number of resprouting native shrubs present.

The change in understorey from a shrub dominated one to a grass dominated one may result in alterations to faunal habitat which may, in turn, result in changes to the abundance and richness of animal species. How and Dell (1989) found that where weed invasion was extensive in Banksia woodlands, the amount of open ground beneath shrubs was severely diminished and this resulted in a decreased abundance of reptile species which normally utilise open ground for feeding (such as *Ctenotus lesuerii*). Decreases in the abundance of flowering shrubs which follow weed invasion would tend to result in decreases in the number of honeyeaters and other nectivorous birds and mammals at those sites.

As well as reductions in native plant and animal species, weed invasion can lead to a decline in the aesthetic and visual quality provided by our bushland remnants. Although such things involve personal values, exotic species can impact on the feelings of naturalness and "Australianess" which we derive from bushland.

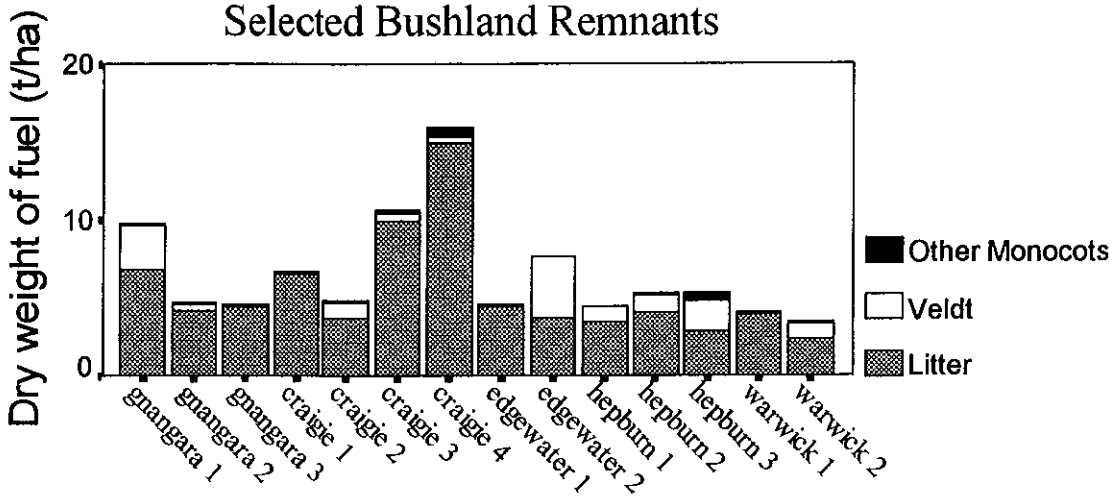
Many studies have demonstrated the role of disturbance in promoting weed invasion (see Hobbs 1991). For many species, weed invasion appears reliant on disturbance events. There are many types of disturbance relevant here. Fire is an important and regular disturbance type occurring in all local remnant bushland. Many people have made the observation that fires in remnant bushland around Perth promote weed invasion (eg Baird 1977; Bridgewater & Backshall 1981; Wycherley 1984; Hopper & Burbidge 1989; Hopkins & Griffin 1989; Hussey & Wallace 1993) and this

Table 1: Some of the more Serious Weeds of the Woodland Formations on the Swan Coastal Plain around Perth.

SPECIES	COMMON NAME	CHARACTERISTICS		
Avena fatua & A.barbata	Wild oats	GR	A	f
Arctotheca calendula	Capeweed	HD	A	
Allium triquetrum	3-cornered Garlic	M	G	
Bromus spp.	Bromes	GR	A	
Briza maxima	Blowfy Grass	GR	A	
Carpobrotus edulis	Pigface	HD	HC	
Cortadenia selloana	Pampas Grass	GR	HC	f
Conyza albida	Fleabane	HD	A	
Cynodon dactylon	Couch	GR	HC	
Ehrharta calycina	Perennial Veldt Grass	GR	HC	f
Ehrharta longiflora	Annual Veldt Grass	GR	A	f
Eragrostis curvula	African Love Grass	GR	HC	f
Freesia spp.	Freesia	M	G	f
Gladiolus cariophyllaceus	Wild Gladiolus	M	G	
Homeria flaccida	One leafed Cape Tulip	M	G	
Hypochaeris glabra	Flatweed	HD	A/HC	
Ixia spp	Ixia	M	G	
Lagurus ovatus	Hare's Tail Grass	GR	A	
Lolium rigidum	Annual Rye-grass	GR	A	
Lupinus consentinii	Sandplain Lupin	HD	A	
Medicago polymorpha	Burr Medic	HD	A	
Myrsiphyllum asparagoides	Bridal Creeper	M	G	f
Narcissus tazetta	Jonquil	M	G	
Pelargonium capitatum	Wild Pelargonium	HD	P	
Raphanus raphanistrum	Wild Radish	HD	A	
Rhynchelytrum repens	Red Natal Grass	GR	HC	
Romulea rosea	Guildford Grass	M	G	
Trifolium spp.	Clovers	HD	A	
Vulpia spp.	Fescues	GR	A	

Key:
GR=grass; M=monocot; HD=herbacious dicot;
A=true annual (therophyte); G=geophyte; HC=hemicryptophyte; P=perennial shrub
f= has been measured or reported to be an important contributor to fuel loads in remnant bushland

Figure 1: Fuel Loadings at Sites within Selected Bushland Remnants



Gnangara = Banksia woodland; Hepburn = Tuart/Banksia woodland

Craigie, Edgewater & Warwick = Jarrah/Banksia woodland

Table 2: Fuel characteristics of adjacent areas of Banksia woodland (* indicates significant differences at $p<.05$)

Fuel Characteristic	Level of Weed Invasion	
	HEAVY	LIGHT
FUEL LOAD (t/ha)		
litter	6.8	4.5
grass*	2.6	0.08
total shrub*	2.1	7.0
live shrub*	0.5	2.5
dead shrub*	1.6	4.5
total fuel	11.5	11.6
COVER (%)		
shrub	32%	56%
grass	38%	2%
FUEL HEIGHT (cm)		
litter	2.3	1.7
grass	36.9	43.5
shrub	82.0	64.2
BULK DENSITY (kg/m^3)		
litter	29.9	27.4
grass*	0.7	0.02
shrub*	0.25	1.1
total (litter+grass+shrub)	2.7	3.0
litter + grass*	5.8	18.1
MOISTURE CONTENT (%ODW) (Feb.)		
litter	7.5	7.9
grass	8.4	7.9
dead shrub	11.2	12.5
live shrub	23.8	25.5

phenomenon has been demonstrated using controlled experiments in Banksia woodlands north of Perth (Hobbs & Atkins 1990; Milberg & Lamont 1995) and in woodland remnants of the wheatbelt (Hester & Hobbs 1992). Most of these authors also mention that increased weed levels following a fire would increase the frequency, intensity and likelihood of future fires, particularly where there is a persistent ignition source such as occurs in urban areas (from arson, accidents etc). Future fires lead to yet more weeds which in turn lead to more fires and so forth. This vicious circle of fire and the further invasion and proliferation of weeds has been termed the "fire-weed cycle" (Wycherley 1984; D'Antonio & Vitousek 1992)

This "cycle" is one of the more serious threats to the ecological integrity of our bushland remnants as the frequency and intensity of fires can end up being greater than that which would naturally occur. Pigott (1994) found that the average fire-free period of Star Swamp Reserve in the period 1948-87 was 4.5 years with many areas having a fire frequency in recent times of one every three years or greater. Perennial veldt grass, although killed by fire, can re-establish quickly and, where infestation of the weed is heavy, can carry another fire two years after a fire (B. Dixon, pers. comm.). Some areas of Warwick Open Space have been burnt twice within two to three years. Fires of these sorts of frequencies will tend to eliminate or reduce populations of obligate seeding species as the fire period is often not sufficiently long enough to allow regenerating plants to flower (Muir 1987) and/or build up an adequate seed store above or below ground (Cowling, Lamont & Enright 1990; Muir 1994). Resprouting plants may also be affected by frequent, intense fires as insufficient time for replenishment of epicormic buds and/or damage to regenerating buds and organs can occur. In many areas of Kings Park, frequent and intense fires have eliminated or severely reduced the abundance of eucalypts, Banksia and orchids over the years (Wycherley 1984; Bell et al. 1992). The fact that many remnants contain few or no areas that have been long unburnt (eg see Pigott 1994) has serious implications for those species (both flora and fauna) which depend on the habitat characteristics provided by such areas (eg. deep litter, thick bark, grass-tree "skirts").

Although we know with relatively high certainty that fires in remnant bushland can increase the amount of exotic grasses and other weeds, very little investigation has occurred into the other side of the "fire-weed cycle", that is, how do weeds change fuel characteristics, fire behaviour and fire regimes? The rest of this paper will look at these aspects and then finish with a discussion of approaches and techniques for managing fire in weed-infested remnant bushland.

Changes in fuel characteristics and fire behaviour

Various fuel characteristics, important in influencing fire behaviour, were measured for a number of remnants with varying degrees of weed cover. Sites were selected in both Spearwood (Jarrah-Banksia woodland) and Bassendean (Banksia woodland) dune systems.

Fine fuel is usually taken as being dead plant material less than 0.6 to 1.0 cm in diameter (depending on fuel type), and live vegetation less than 0.2 to 0.5 cm in diameter (depending on moisture content of fuel). Fine fuel plays the primary role in carrying a fire through vegetation and, therefore, the quantity of this fuel is usually the most important and most frequently measured fuel characteristic. For woodland formations of the Swan Coastal Plain, fine fuel components include ground litter (mainly leaves and other fallen plant parts), grasses (mainly weed species) and, at times, small shrubs (depending on diameter of leaves and branches, moisture content and the amount of dead material). Of these, litter and grass are the most important due to their smaller diameter and lower moisture content relative to the shrub layer.

Figure 1 shows the quantity of non-shrub fine fuel components for five different remnants of Perth's northern suburbs. The results show that although litter levels within most remnants are similar (no significant differences at $p<.05$), differences in the

amount of veldt grass largely determines significant differences in total fine fuel between sites. At some remnants, extensive cover of veldt grass has resulted in a doubling of (non-shrub) fine fuel levels. An exception to this pattern occurs at Craigie Open Space where significant differences in litter can be attributed to differences in fire age, with fuel being sampled from a long unburnt area (20 plus years since last fire) and a more recently burnt area (five years?). Perennial veldt grass was by far the main weed species contributing to increases in fuel levels. Other grasses and monocots (mainly Iridaceae) made up only a small component of the fuel loadings even when they were a visually conspicuous element of the vegetation. For instance, sites at Craigie had combined densities of *Gladiolus cariophyllaceus* and *Homeria flaccida* ranging from 1.8 to 7.4 plants/m^2 yet only made up from 0.3 per cent to 0.8 per cent of the total (non-shrub) fine fuel quantities.

Adjacent sites within Banksia woodland at Gnangara, one with heavy weed cover (about 35% cover) and other with light weed cover (about 2 per cent cover), were measured in detail to contrast a variety of fuel characteristics. The results are summarised in Table 2. The two sites had a similar recent fire history and more-or-less the same amounts of fuel in total. However, the various components of the fine fuel differed, with the weed infested site having significantly greater levels of grass fuel and lower levels of shrub fuel than the site with minimal weed cover. These differences can be explained by the invasion of the weed-infestated site by perennial veldt grass and the lower cover of native shrub cover there. Native shrubs may have been lost at this site through competition with veldt grass as has been reported elsewhere (Kings Park & Botanic Garden 1993)

The grass component of the fuel has a lower bulk density (a convenient measure of fuel bed compactness), moisture levels (as measured in summer) and average particle size than the shrub component. Therefore, despite the overall similarity of fuel levels, the fact that the weed infested site has far greater grass and lower shrub fuel will mean that a fire occurring in summer or autumn will be of much greater intensity and have a faster rate-of-spread (ROS) than a fire in bushland with few weeds. Fire behaviour models predict an increase in intensity and ROS in the order of two to three times is possible when weed invasion to this degree occurs (Rothermel 1972; Luke & McArthur 1978). Flame heights would be expected to be higher than previous.

Fuel accumulation in Banksia woodland is normally rapid after a fire and then stabilises at about six to eight tonnes per hectare after about five or six years (Burrows & McCaw 1990). Burrows & McCaw (1990) estimate that fuel levels are sufficient at four years after a fire for a new fire to carry. Sites that are heavily invaded with grassy weeds would accumulate fuel more rapidly, given the recolonising abilities of veldt and other grasses after a fire. The potential fire frequency would therefore be expected to increase as sites were invaded by exotic grasses.

In summary, areas of remnant bushland which have been heavily invaded by grassy weeds have altered fuel characteristics due to the dryness, aerated nature and small particle size of the grassy fuel component. Fires occurring will be faster and therefore more intense. Fires would also be expected to be more frequent given the rapid rate of grass re-establishment. Grassy weed invasion will therefore lead to an altered fire regime (more frequent and intense fires). The potential impact of this on the native biota has already been alluded to. As grassy weeds tend to be patchy in their distribution, fires could also become more patchy and cover smaller areas than before weed invasion as litter, the main fuel component without grassy weeds present, has a fairly uniform horizontal distribution.

Management implications and options

Two broad approaches to fire management should be adopted in remnant bushland prone to grassy weed invasion. This would include most coastal plain remnants within the Perth metropolitan area. Where weeds have already invaded an area, weed control should be implemented to reduce fuel levels and, secondly, where weed levels are low or non existent, disturbances should be minimised to prevent weed invasion and intensification.

For a particular plant community, certain types of disturbance may enhance weed invasion to a greater degree than other types (Hobbs 1991). Hobbs (1989) suggested that disturbance will enhance invasions only if it increases the availability of a limiting resource. Fire has been shown to enhance invasions within local woodland remnants presumably by increasing the availability of nutrients, light and/or space. The detrimental effect of weeds on the native biota both directly, through competition and habitat alteration, and indirectly, through altered fire regimes, have already been alluded to. Management should therefore aim to minimise the occurrence and extent of fires. Some strategies to achieve this are:

- Fuel reduction burning should generally be avoided, particularly within remnants with some grassy weed component;
- Fires will inevitably occur in remnants because of arson activity and accidents - reducing ignition sources is difficult in a urban context but may be possible through well targeted education programmes, greater surveillance and greater enforcement of laws and regulations;
- Aim to minimise the area and intensity of fires by extinguishing fires rapidly - could include increasing detection capabilities by utilising local residents as 'fire-spotters', improving access to fire-fighting crews; increasing suppression capacity, decreasing response times and conducting pre-fire plans for remnants;
- Increasing protection to buildings and facilities by fire-breaks, buffer strips and keeping them physically separated from bushland.

A policy of no prescribed burning, although controversial in some quarters, is often justified within metropolitan remnants of the Swan Coastal Plain because of the current high frequency and inevitability of arson/accidental fires in many remnants, the fact that fires can promote weed invasion and therefore ultimately increase fuel levels, the detrimental effect of frequent fires and, finally, the lack of long unburnt habitat (important refuge areas) within many remnants. In addition, rapid fuel accumulation and relatively low fuel levels, at least for Banksia woodlands (Burrows & McCaw 1990), can mean there is only a short-term (one to three year) benefit in purposely reducing fuel levels by burning.

Weed invasion has been found to be favoured most where certain combinations of disturbances occur. Therefore fire is by no means the only disturbance type which should be avoided within our remnants. A common pattern of weed invasion is for it to occur from edges (particularly roadsides) and adjacent to tracks (Panetta & Hopkins 1991; Milberg & Lamont 1995). Therefore the construction of firebreaks and access tracks is likely to lead to weed invasion into the core of the bushland as well as increasing the fragmentation of the bushland. A solution to this potential dilemma is to construct sealed, multi-purpose, access tracks (of crushed limestone which is visually less intrusive than cement, gravel or tar) as suggested by Kaesehagan (1994). A low fuel buffer strip is maintained on both sides of the track where weeds are controlled (see below) and indigenous low shrubs planted and maintained to suppress weeds. The extent of tracks should be kept to a minimum required for fire and public access — all other tracks should be closed and rehabilitated if resources are available. Grazing by introduced mammals and trampling are other disturbances which encourage weed invasion (Keighery 1991) and should be avoided.

Most remnant bushland around Perth is susceptible to dieback disease caused by *Phytophthora*. A collapse of the overstorey sometimes occurs in local remnants as all banksias and, to a lesser degree, jarrah are susceptible to the disease. Many grassy weeds appear to favour gaps and edges possibly because light is a limiting factor for such species. Therefore dieback disease may, indirectly, enhance weed invasion within our remnants. Integrated dieback management as practised by CALM (mapping disease risk and presence, restricting vehicular access, hygiene measures such as washdowns etc.) should be implemented in our urban reserves to prevent further introduction and spread of this disease (Shearer & Tippett 1989).

Where weed cover is relatively extensive and is contributing to fuel loads, weeds should be controlled to decrease the level of fuel. The

weeds of most concern here are perennial grasses such as veldt and African love-grass (see Table 1). Although hand-weeding has been shown to be effective for some species, it is often ineffective for extensive areas of perennial grasses as it causes large amounts of soil disturbance and so creates ample sites for weed re-establishment (Hussey & Wallace 1993; Pigott 1994). For perennial veldt grass, re-establishment following a disturbance is typically rapid as it maintains a seed store in the soil (Pierce & Cowling 1991). Chemical control is often the only option we have to reduce perennial grass cover. Trials at Kings Park have demonstrated that overspraying with a grass selective herbicide called fluazifop effectively reduced veldt grass cover, but did not kill any native plants (Dixon, Dixon & Bennett 1988). In most instances this chemical would have little effect on the native vegetation of local remnants as native grasses are often uncommon and most native species are dormant when spraying is typically done (ie. winter for veldt grass). For other species (eg bridal creeper), other chemicals may be required (eg glyphosates), however the chances of affecting non-target species would be greater. Spraying of extensive outbreaks of weeds would leave quite large bare areas which can be opportune sites for weed re-establishment. Planting and/or seeding with indigenous species together with mulching should occur in such areas to suppress weed re-growth, facilitate rehabilitation of the site and reduce the frequency of follow-up spraying. Effective chemical control of weeds is currently the only real means we have to break the "fire-weed cycle".

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Fire in the urban-bushland interface

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Introduction

The South-West of Western Australia combines the hot, dry Mediterranean summer climate with tall eucalypt forests, which produce large quantities of combustible litter and vegetative fuels. This results in conditions ideal for the start and spread of intense forest fires. These wildfires are caused by lightning, industrial and domestic accidents, and escapes from various types of burning off. Regretfully, a large majority of wildfires are also deliberately lit, often during severe weather and in locations designed to create difficulties for fire fighters.

Fire is no stranger to the forests of the South-West. The Aborigines regarded it as an integral part of the landscape and regularly used it as a tool to assist their hunting and food gathering. It was also used to "clean up" the dead wood and litter for easier access, to encourage regrowth of vegetation and to flush animals from cover. Such fires, together with those ignited by summer lightning storms, fashioned the landscape over thousands of years before the arrival of European settlers. Plant and animal communities in the South-West have evolved in the presence of fire and have developed adaptive traits that enable them to survive and prosper under a range of fire regimes.

However, where once vast forests and woodlands stretched untouched across the South-West, today there is a mosaic of farms, forests, towns and settlements. In some places the landscape has been so fragmented that entire species are restricted to a handful of small reserves. Additionally, there are water catchments, timber supplies, national parks and conservation areas to protect. All these valuable assets — and human lives — could be threatened if summer wildfires were allowed to spread unchecked.

Bush hide-aways

The past few decades have witnessed a rapid expansion of residential developments in the Hills of the Darling Range, east of Perth. Improved transport and communications, greater leisure time and growing environmental awareness have led to many people escaping the bustle of the city in favour of outlying suburbs. There they can enjoy the tranquillity of the bush and be close enough to the city to share most of its advantages. Homes in these suburbs are often set among dense forest, perched on steep rock hillsides or tucked away at the end of narrow winding roads. Very often the bushlands neighbouring the urban developments suffer from weed and grass intrusions which result in an annual fire hazard, unlike the native understorey which takes several years to build up to hazardous levels following fire.

The undoubted attractions of living among the forest must, however, be tempered by considerations of the threat posed by wildfire. In several Australian states, tragic loss of life has occurred regularly at the urban-bushland interface, where the forests and residential areas meet. Who could forget the dramatic television footage of the serious wildfires in and around Sydney in January 1994? The 1983 Ash Wednesday fires in Victoria and South Australia resulted in the death of 75 people, property losses totalled many millions of dollars, and the environmental impact may never be fully measured.

Unfortunately, some residents remain unaware of this threat. Others are reluctant to take the steps necessary to protect their families and homes, especially if this requires some modification of the local environment.

Individual home-owners can do much to reduce the threat to their property from

wildfire. Reducing fuel loads near a house by mowing, slashing or removing flammable litter and shrubs will greatly increase the chances of it surviving a wildfire. Fallen leaves and twigs should be cleaned from roof gutters each year before the onset of the fire season, and the roof should be inspected to ensure there are no gaps where burning embers could enter. Flammable materials, such as petrol, should be stored in a properly constructed garden shed well away from the house.

People building new homes in fire-prone areas should carefully consider the siting, design and choice of materials for their house. Desirable features include brick or masonry walls, and enclosed eaves and under-floor areas.

More people are now living in parts of the Perth Hills near CALM-managed forests and parks. The Department's fire managers take this into account when planning fire protection programmes for the bush adjoining these residential areas.

Taming the fires

Fire protection on CALM-managed lands is based on two complementary systems — suppression and fuel reduction. The first involves maintaining an efficient and effective fire suppression system in areas where the risk of fire is high. This includes areas of high environmental value and those where there are community assets.

The second uses fire to reduce the amount of flammable material by prior burning within strategic zones of the forest. This fuel reduction burning aims to limit the intensity of wildfires, thereby reducing the difficulty of fire suppression and the likely damage to areas at risk.

Fuel reduction burning has been widely used in Western Australian forests since the early 1960s. The practice was spurred on by the recommendations of a Royal Commission established to inquire into the disastrous 1961 wildfires, which destroyed the township of Dwellingup and burnt huge tracts of forest and farmland in the South-West. Before this time, fire had been deliberately excluded from much of the State Forest for more than 30 years.

Over a period of five years, about eight tonnes of flammable litter and scrub accumulates on each hectare of jarrah forest. Under average summer weather, fires burning in such fuels can generally be attacked directly by fire fighters equipped with water tankers and machinery. However, where heavier fuel loads exist, suppression is far more difficult as direct attack is generally too dangerous. Such fires are more intense and there is a greater likelihood they will spread into the crowns of the trees. When this occurs, burning bark and leaves, known as firebrands, can be thrown many kilometres ahead of the flame front to create new fires. In such cases, recently fuel-reduced areas provide effective defensive positions from which wildfires may be fought, improving the chances of success and lessening the risk to fire fighters.

Starting a burn

Scientists have long researched fuel accumulation and the effects of different wind speeds, temperatures, relative humidity, fuel dryness and slope on fires in the jarrah and karri forests. Their work forms the basis of a fire behaviour prediction system and a planned burning guide, used by field staff carrying out planned burns.

The proposed burn is planned up to eight years ahead, a period that allows CALM staff to plan for the needs of other forest activities, such as tourism, commercial operations, and habitat regeneration. Buffer zones (400 metres to three kilometres wide) are identified where fuel reduction will be needed. In the year of the burn, environmental impacts are assessed before the burn is approved; then all involved people, assets, properties or operations are identified. A detailed prescription is then prepared: a set of objectives, a calculation of the type of burn that will meet them, the weather and fuel moisture that must exist on the day of the burn, and the lighting pattern to be adopted. Boundary tracks are then cleaned up, and other preparations undertaken.

As fuels in the forest begin to dry, CALM alerts neighbours about proposed burns. Warning signs are placed, and announcements

are made of ABC radio on the day of the burn. Staff compare the day's weather forecast, fuel moisture conditions and so on with the conditions prescribed. If the conditions match, guidelines for smoke dispersion are checked. If these are acceptable, the burn goes ahead, controlled by skilled, professional crews.

At the end of each day, edges are made safe. A senior officer inspects the burn before it is considered to be safely completed.

Restrictions

The planned burning programme has a wide range of constraints. Some occur naturally, such as weather, limits to funds and staff, and the need to avoid special areas. Others are statutory. For example, the Bush Fires Act states, among other things, that burns cannot take place on days of very high fire danger. Burns are usually undertaken during a period determined by the local government authority. Smoke would occur with or without planned burns, but CALM sets management guidelines anyway to match the Environmental Protection Authority's air-quality standards. (See "Where There's Fire, There's Smoke" in Landscope, Autumn 1993.)

The constraints have resulted in a decline in the areas burnt each year. Forty-six per cent of land managed by CALM in the South-West is now carrying fuels that are six years old or older. The figure is as high as 66 per cent in conservation reserves. This is of concern, especially in buffer zones, where fuels should generally be six years old or less. At present, 52 per cent of buffer zones carry older, heavier fuel. This means bigger wildfires are likely. Average fire size in 1988 was 14 hectares; in the summer of 1992-93 it was 46 hectares. The warning signs are ominous.

Maintaining the record

Western Australia has had a good record in forest fire control since 1961. There have been no major property losses, few large fires, few injuries or deaths and many significant "saves", even under extreme conditions. More than 90 per cent of the fires that CALM staff attend in the forest are kept to less than 10 hectares. Most large fires have been in the more remote sections of the forest well away from settlements and occurred under extreme weather. There have been many cases (eg Manjimup 1978; Walpole 1987; Augusta 1992) where planned burning is the reason major wildfires did not burn out towns and large areas of forest.

Clearly, fuel reduction burning is important in limiting the threat wildfires pose to life, property, community assets and areas of high environmental value. Although the community as a whole accepts the need for measures to minimise the social and environmental costs of uncontrolled fires, there is often debate about how this can best be achieved. Preventative programmes, run by the fire services to educate the public about the danger of wildfires, play an important part. Furthermore, CALM, as manager of much of the remaining bushland around Perth, is constantly refining its techniques. An extensive fire research programme conducted over the past four decades has helped provide a better understanding of the consequences of repeated burning and fire exclusion on our forest ecosystems.

CALM has a legal and moral responsibility to ensure that uncontrolled wildfires on the land it manages do not threaten life and property. But the Department also has the responsibility of ensuring that the ecosystems on this land are sustained and that public use for a variety of purposes is optimised. Planned burning is just one of the management strategies that are achieving this vital, delicate balance.

Fire prevention — a Victorian view

Mark Norton
Environmental Management Student
Edith Cowan University
& former volunteer fire-fighter, Victorian Country Fire Authority

Introduction

As the populations of our major cities increase, so too does the need for somewhere to live. More and more of our natural bushland is bull-dozed to cope with the ever expanding urban sprawl.

The expansion of our suburbs into the surrounding bush brings many new problems, but none is more devastating or terrifying than that of bush fires. Every summer, houses, industry and people's lives are threatened by uncontrollable wildfires. If people are to live amongst this country's natural surrounds then they must be fully aware of the threat that a bush fire poses.

The key to living with this threat is preparedness.

In many instances the most modern-equipped fire brigade is no match for an out of control bush fire. Bush fire prevention and active pre-fire planning can reduce the chance of major damage being caused in the event of a fire. It may even save lives.

The fire prevention programs I aim to outline in this paper have been tried and tested in Victoria. I have also included an insight into the Country Fire Authority — a fire service not only responsible for fire suppression, but also for fire research, fire protection and active fire prevention.

The Victorian Country Fire Authority

The Country Fire Authority (CFA) is Victoria's largest fire fighting service. The CFA provides fire protection for the majority of the State of Victoria including 50 per cent of metropolitan Melbourne (CFA, 1993). This equates to fire protection for well in excess of 2.3 million people (CFA, 1993). The CFA operates in conjunction with the Metropolitan Fire Brigade (MFB), which is responsible for fire protection for the other 50 per cent of metropolitan Melbourne and the Department of Conservation and Natural Resources (DCNR) which has responsibility for fire protection in areas such as National Parks.

The CFA is substantially a professional volunteer organisation. The CFA's personnel consists of nearly 80,000 volunteers and more than 800 full time officers and support staff (CFA, 1993). The role of the CFA can be likened to that of the WAFB and the Bush Fires Board, combined. Each CFA brigade is trained to handle any fire emergency incident within its gazetted fire area. This could include anything from a car accident to a full going bush fire.

There are nearly 1200 brigades scattered throughout the Victoria (CFA, 1993). All CFA brigades are separated into groups, with no brigades run by local shires. This enables quick and thorough response to any brigade requiring additional fire fighting units. Emergency calls are received by phoning 000 or dialling the brigade direct. This means that response times to incidents are prompt and always at a minimum.

In 1983 thirteen fire fighters lost their lives fighting the fires that became known as Ash Wednesday ("Module to save lives", 1994). The equipment used by the CFA today has been designed and built locally to ensure that the chances of that ever happening again are very low. The majority of vehicles used by the CFA are of a standard design, with the exception being older vehicles and those owned by individual brigades.

Rural brigades operate 2000 or 3000 litre water tankers. Tankers are designed to allow the crew to fight a fire from the rear of the vehicle. All pumps run on diesel and in the event of the vehicle being trapped in a fire, crew survivability has been increased by the addition of protective heatshields.

Urban brigades run with pumpers as their primary response vehicle. Large residential areas, where urban fire risk is high, have permanently staffed stations. Aerial and rescue trucks are not uncommon in these stations.

Training is an ongoing occurrence within any CFA brigade. Six months of intensive part-time training is required before a new member is eligible to turn out to an incident. To keep up to date with fire fighting skills, operational volunteer firefighters attend training sessions at least once a week.

Pre-fire planning

Should a fire fighter never go to a fire then she/he has done his/her job — that job being fire prevention. Fire prevention should be approached from two angles :
- Firstly, by the people responsible for fire suppression. The fire fighters.
- Secondly, by the people who suffer the effects of fire. The community.

This section will look at fire prevention that can be conducted by the fire fighters themselves and is known as pre-fire planning.

Pre-fire planning involves assessing areas of potential fire risk within a brigade's gazetted fire area. This includes areas of bushland as well as building structures, such as halls or even petrol stations. It is designed to give the officer in charge and the fire fighters on the ground an edge over the fire they are fighting.

These plans should carry all available information about the site that may become important in the event of a fire. For instance a pre-fire plan for an urban structure should look like the following page. All information about the site is contained on the single page with a map on the other side. The plan is preferably A4 in size, for easy handling, and should be enclosed in a clear plastic folder to prevent damage.

A pre-fire plan for an area of urban bushland should include the following information:

- Type of bush.
- Location of nearby houses or buildings.
- Nearest available water fill point. (Not just one).
- All vehicular access trails.
- Vehicular entry points.
- Map of the area showing north direction.
- Any special conservation values, such as rare flora and fauna.
- Location of existing fire breaks.

Pre-fire plans could easily be used by fire brigades, anywhere in Western Australia. They would be particularly useful for brigades in outer metropolitan areas and small town brigades that are geographically isolated. Smaller isolated towns are bound to experience a long delay should they require assistance from other units.

Pre-fire plans are intended to provide the people that matter with the most up to date information about the area in which the fire is burning. Therefore they should be continually updated and carried where they can be properly utilised — on the fire ground.

Community Fireguard

On February 16, 1993, ten years after the devastating Ash Wednesday Fires, the Country Fire Authority launched the Community Fireguard programme. Community Fireguard is a fire prevention programme designed to reduce the loss of lives and homes in the event of a bush fire (CFA, 1993). The Community Fireguard programme targets residents who live in areas of high fire danger. The following is an insight to the Community Fireguard programme.

A 'Group' is formed among the residents. This group is then encouraged to take responsibility for devising means by which their homes and surrounding neighbourhood may survive a major bush fire threat. The groups work closely in conjunction with local fire brigades or any existing conservation

groups. The groups are then taught by a trained Community Fireguard facilitator who, after the initial training period, is able to provide continual advice and support. The groups are made aware of the fact that in the event of a major bush fire a fire truck cannot be placed outside their front door to protect their house. Therefore individuals and communities must work together to ensure that houses are able to survive the onslaught of a bush fire.

This is done by teaching the groups the principles of fire behaviour and how their local fire service operates. They then become familiar in what to expect as a bush fire approaches and what survival options they have. Some examples of pre-bush fire plans devised by existing Community Fireguard groups have included the following:

- The organising of working bees to reduce fuel levels on private property and nearby firebreaks (CFA,1993).
- The introduction of alternative water supplies. This came from the realisation that in a major fire the town's water supply is quickly diminished.
- The gathering of fire fighting equipment such as pump and hoses.
- Some houses even installed sprinkler systems on their roofs ("Bushfire Proofing the Home", 1994).
- The nominating of a safe house in the area so that in the likelihood of an evacuation they have a designated spot to retreat to (CFA, 1993).
- The developing of communication systems, so that each resident has up-to-date information on the fire's progress (CFA, 1993).

Residents of the hills to the east of Perth would benefit immensely from such a fire prevention programme, as would people living in Perth's outer suburbs or any small town in the South-West of the State. The flexible nature of the Community Fireguard programme means it could be adapted for use anywhere in the State where a risk to life and property exists from the threat of bush fire.

This program also gives the people involved a tremendous amount of satisfaction. They know that the plans devised are all their own work. Work which will ultimately save their house and in some instances, their life. The work concerned is cheap, yet still very effective (CFA, 1993).

There is no need to become a bush fire statistic.

The proof of success

By June 1995 there were approximately 100 Community Fireguard groups operating throughout Victoria (CFA, 1995). Most of these groups operate in the most fire prone areas of Victoria, such as the Dandenongs, The Mornington Peninsula and along the Great Ocean Road (CFA, 1993).

Last summer was a proving ground for the Community Fireguard programme, with groups tested on two separate occasions. In November last year, a fire spread through the Moggs Creek area, south-west of Melbourne. About 45 residents constituted the Moggs Creek Community Fireguard group (CFA, 1995). Prior to the fire, active planning and assessing had been undertaken in the area. Properties involved in the Community Fireguard programme suffered minimal amounts of damage in comparison to other properties (CFA, 1995).

In February of this year a huge fire burnt through the Berringa-Enfield area. A nearby Community Fireguard group became threatened at the height of the fire and began instigating prepared plans. Non-Community Fireguard members of the community were continually advised and the fire's progress was monitored via hand held scanners. Residents decided to stay with their homes, protecting them with independent water supplies and all residents were dressed appropriately. Fortunately, the fire fighting skills of the South Dereel residents were not tested, as the fire never reached them (CFA, 1995).

The Community Fireguard programme was put to the ultimate test and passed with flying colours. All appropriate measures were taken by residents involved in the programme and damage was kept to a minimum. In both cases it was the residents who were responsible for the eventual outcome. They took

responsibility for their own fire protection, relying on well prepared plans and confidence in their own work.

Acknowledgements

I would like to thank Mr Jon Boura of the CFA's Risk Management Department in Victoria for supplying very detailed and up to date information on the Community Fireguard Programme. Also to Captain Mike Willmott and Lieutenant Andrew Ellams of the Baxter Fire Brigade for their guidance, and allowing me to use a copy of a pre-fire plan, used by the Baxter Fire Brigade.

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Fire management: Co-operation between the Country Fire Authority (Victoria) and Conservation Groups

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Introduction

The purpose of this paper is to present a case study from Upper Beaconsfield in Victoria of co-operation between the Country Fire Authority (CFA) and conservation groups.

I am a forester with many years of fire fighting, fire prevention planning and extensive experience assisting private property owners protect remnant vegetation. Protecting remnant vegetation was not only a battle against the weeds and other encroachments but also with the fire prevention arms of shires and the CFA. I often played a mediation role between the land owner and the fire authorities, trying to achieve a balance between conservation and fire prevention. I sometimes despaired of bringing the fire fighters and the conservationists together and therefore was delighted when I heard Jon Boura of the CFA give an address about co-operation. I found the talk inspirational and today I would like to present the case study as given by Jon. The opinions, expressed are his own and don't necessarily reflect the views of any organisation involved.

The location is the Dandenong Ranges, a part of Melbourne's urban-forest interface, an area where a suburban population is combined with significant patches of remnant forest.

Co-operation

"Co-operation" is a weird word. It's so often used to describe a process which would be better known as confrontation. This has been the usual form of co-operation between fire brigades and conservation groups: Both trying to enforce their views on the other.

Both organisations have definite opinions about bushland management. The fire brigade will often be advocating actions which the conservationists consider environmentally destructive, the conservationists will often be advising policies which the fire brigade believes to threaten the safety of life and property. Then each side tries to ensure that council or land owners follow their recommendation.

This address is about fire management projects where the definition of co-operation is "working together to achieve a common goal".

The case study

Fire history

The case study involves five hectares of bushland owned by the Shire of Pakenham in Upper Beaconsfield.

Upper Beaconsfield has a population approaching 3,500 living in nearly 900 homes, spread over more than 50 square kilometres. Several areas are considered to be of very high fire hazard - where forest, slopes, and people are combined and the entire area is susceptible to wildfire damage.

In Upper Beaconsfield fire danger isn't an abstract notion. Most people accept that Ash Wednesday 1983 could happen again. Fuel levels build up rapidly after fire and Upper Beaconfields's bushland now has fuel loads that could support another uncontrollable fire given moderate to bad fire weather.

Community attitudes are based on the experience of the Ash Wednesday fire.

The statistics are:
21 people dead (all in Upper Beaconsfield)
238 buildings destroyed (186 in Upper Beaconsfield)
978 livestock dead.

The numbers don't include the dozens injured, the hundreds who were in fear of their lives, the hundreds who spent a wet and miserable winter living in a caravan or shed.

It is widely documented that following a bush fire disaster there is often a period of extreme fire prevention. It is a natural human reaction, but possibly hard to understand if you didn't experience the disaster yourself.

This attitude is still present in some of our residents who are veterans of Ash Wednesday. Not a vague concept of fire hazard, but concrete opinion - "vegetation in that area burnt on Ash Wednesday, it *caused* my home to burn down, and threatened the lives of my family. I'm not going to let it grow there again, and you have no right to say that I should".

Without a knowledge of fire behaviour it is easy to see all bush as a hazard. In fact many homes in the built up area of Upper Beaconsfield were not exposed to high intensity wildfire, but were ignited by embers etc and burnt down hours after the fire front had passed whilst their owners were at evacuation centres.

It is stressed that ignorance of fire behaviour can lead to the risk being underestimated. The sheer intensity of a wildfire burning through natural native vegetation has to be seen to be believed. And if you're not prepared you suffer.

Formation of local conservation group

Partly in response to the threat posed to the local environment by the post-disaster clearing, the Upper Beaconsfield Conservation Group was formed in the mid-1980s, an event which was viewed with some suspicion by a portion of the population who saw some of the vegetation retention policies as a threat to fire safety.

The majority of the Fire Brigade were opposed to interference by the Conservation Group in fire prevention matters. At that time no one even considered that the conservation movement might have a legitimate role to play.

So for a number of years there was the regrettable situation where two of the most active and community-orientated groups held strongly opposing views and did very little in the way of meaningful communication.

Concerns over five hectares of bushland

At the beginning to the 1991/92 fire season some local residents expressed concern over the fire hazard of a council-owned block of approximately five hectares.

The Fire Brigade inspected the area and decided that, whilst it didn't pose a direct threat to surrounding homes which had a high standard of fire protection work, fuel loads were such that a fuel reduction program was appropriate.

Council officials inspected the site, agreed that there was no direct threat to property, and recommended that nothing be done, to avoid damage to the vegetation.

The Upper Beaconsfield Conservation Group to the surprise of all, advocated a controlled burning program designed to simulate the "natural" fire regime, and thus maintain the current vegetation structure.

Beginning to co-operate - designing a fire strategy

The Fire Brigade in consultation with the Conservation Group proposed experimenting with a number of fuel reduction techniques to determine their effectiveness in reducing fire hazard, and also to measure their effect on the environment.

Firstly an ongoing fuel reduction program in which a small area is burnt each year was developed. By dividing the reserve into 10-12 sites, no area is burnt more frequently than once every 10-12 years. Yet at any moment in time at least one third of the total area will be significantly fuel reduced. This assumes that

hazardous fuel loads will have reaccumulated within three years.

Such a fire regime should not only reduce the fire hazard but also maintain a desirable vegetation structure and promote floristic diversity, as vegetation on different areas of the reserve will be at different successional stages.

Secondly there will be monitoring of fuel accumulation and vegetation regeneration following a variety of fuel reduction techniques. Treatments being considered include fires of different intensity and season, and slashing. A portion of the reserve will remain untouched as a control.

In designing the experiment there was compromise between scientific quality and the amount of time given in what is essentially a "spare time" study. It was also necessary to use techniques that were easily implemented by people without formal training in vegetation analysis, and could be used with the same accuracy by any member of the group. With long term monitoring programs it is desirable to involve as many people as possible.

Treatments

Two areas have been treated so far. Prior to burning the site, boundaries were slashed two slasher widths to identify the sides and to provide control lines, as the fuel complex was continuous throughout the reserve.

The first treatment was a burn on a Sunday morning in March 1992. This was quite a cool burn, the lower damp portion of the litter layer was left, and there was very little canopy scorch although fuels such as wiregrass and scrub flared up at times. Flame height peaked at about one metre above the fuel complex.

The high post-fire fuel load is a result of the damp litter layer remaining and unburnt patches which retained the full fuel load. Fire intensity was approximately 400 kilowatts per metre.

The second site was burnt on a Wednesday evening in January 1993. This was a much hotter fire. Fire intensity was approximately 2000 kilowatts per metre.

Almost all of the litter layer was consumed, flame height peaked about three metres above the scrub. There were no significant areas left unburnt. Fire ran up most trees within the perimeter. There was widespread canopy scorch, leading to accelerated litter fuel accumulation due to fire scorched leaves being dropped and decomposition rates having been lowered by the removal of the damp litter bed.

Results

It is too early to discuss results as the data hasn't been analysed yet, however there has been very little weed invasion of the burnt sites despite being near a weed infested road reserve. Also there has been no noticeable increase in erosion due to the care taken not to disturb the soil more than necessary. The only problem has been the use of the slashed breaks by horse-riders causing considerable damage in some of the wetter spots.

The Fire Brigade has refined its prescribed burning techniques to make them more environmentally friendly. For example sympathetic use of hand-tools, limiting vehicle movements off road to reduce soil disturbance, the use of natural or existing control lines whenever possible, and planning long term burning programs which allow fire regimes suited to particular vegetation types.

It has also been a PR bonanza. Following criticism of the slashed control lines in the local paper, the paper received and printed three letters from Conservation Group members supporting the project, and praising the care taken conducting the operations. This public show of support was much appreciated by the Brigade, and may have helped convince some of the doubters that co-operating with the Conservation Group is a beneficial step.

The Conservation Group has also gained from the exercise. They now have an enhanced appreciation of the heat and smoke generated by even slow moving fire when it is burning through an area with high fuel loads, a good basis for informed decision-making.

Future co-operation

By combining the conservation movement's environmental knowledge with the CFA's

knowledge of fire behaviour and control, fire management programs can be developed which go a long way to satisfying the requirements of both organisations. A number of joint projects are now being developed with co-operation between a number of organisations. These joint projects have been made possible by the good faith and willingness to co-operate which is probably the greatest benefit to have come from this case study.

Some members of both organisations are still unsure of the wisdom of co-operating, due largely to a feeling that by co-operating they are selling out their principles.

That is certainly not happening in this case. The Conservation Group are still fanatical about protecting the environment, and the Fire Brigade are still just as serious about reducing the danger from wildfire. Both realise that in the long run working together can often be more effective than competing. Ideological purity has been lost in some eyes, but a more effective and realistic approach to decision making has been gained.

The future should see increased co-operation between the CFA and local conservation groups and this association will be beneficial to the aims of both parties, and to the community as a whole.

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Fire fighting Port Kennedy style

Jeff Anderton
Port Kennedy Land Conservation District Committee.

Written paper compiled by Kirsten Tullis, Urban Bushland Council

The Port Kennedy area has been accreted out of the ocean over the past 10,000 years. Its vegetation and geomorphology have attracted national and international attention. As such, Port Kennedy has been nominated for the Register of the National Estate and for inclusion in the Ramsar Agreement. The Department of Agriculture, in recognising the area's ecological and geological values, created the Port Kennedy Reserve in 1992 under the Soil and Land Conservation Act. Jeff's group, the Port Kennedy Land Conservation District Committee (LCDC), cares for and manages the site. The Committee comprises sea rescue volunteers, fishermen and other recreational groups.

Port Kennedy lies within the Shire of Rockingham and attracts a high number of recreational users — up to 2,000 per weekend. Many of these people are not aware of the area's ecological values or fragility, and some engage in vandalism, including arson. In 1989 the Committee decided to do something about the uncontrolled use of the area to help protect the flora and fauna. They began a programme to control access, which includes fencing, and gathered information on the area's ecology and appropriate management practices. In that year they were upset when a large fire burnt nearly half of the reserve, ensuing in erosion and loss of native plants and animals. It didn't have to be that extensive, but the local fire fighting agencies were not prepared to stem the fire in the early stages. For instance, the Shire's attitude was to leave the fire, unless property was at risk, and that allowing it to burn by itself would mean no fire next year. Jeff's group decided to learn about fire fighting, and to obtain some equipment. They bought two trailer-mounted rigs and three of their members were trained by the local brigade in the first year. Since then more LCDC members have been trained and now make up 12 of the 28 brigade members. Jeff is Treasurer. There are still differences of opinion between the established brigade members and Jeff's group, though a good rapport exists. The Shire's Fire Control Officer at the time, was, however, less communicative and less sympathetic to the ecological needs of the reserve.

The formation of the reserve under the Land and Soil Conservation Act, with the LCDC being responsible for it, meant fire management responsibilities for the Committee. The group needed to obtain equipment for making and maintaining firebreaks and access routes. They came up with a three page fire control plan with the Shire and fire fighters. It didn't help a great deal, though the maps were useful. Their 4WD BeLauris tractor and plough has been useful in containing fires, though the Sea Rescue Group's vehicle was rolled during one fire. Gradually the group has bought and acquired other equipment. The dangerous trailer units were replaced by slip-on units, telephones were brought in, and more recently they have added a 4WD water truck with a 3,500 litre capacity.

Despite active management, a visual presence and the acquisition of new equipment fires still occur at Port Kennedy - an average of five to seven per year. This past year there were seven, though none are easy to pick out on the aerial photograph because they were all acted upon quickly and contained. The biggest one took six hours to contain. Such areas are demonstrating natural regeneration, including seed recruitment from unburnt edges. There was a bit of a hiccup around two years ago when a developer stepped in with a development proposal. The developer wrote a fire management plan, consulting all but the LCDC. It turned out to be horrifically inappropriate for the area - being based on forestry-type ideas. For instance habitat

managment zones, to be burned every seven years, were proposed. Jeff's group, because of the proposed development, was told by the Minister for Agriculture that it should not be involved in the area. He thus withdrew his assistance temporarily and took their tractor away. A fire burning 100 hectares occurred that year. As for the developer, who did have the ultimate responsiblity for fire, little else has been done since the release of the fire management plan and little interest has been demonstrated by him in the effects of fire.

Where a fire occurs, the first hour is the most critical. The LCDC is usually able to get volunteers there within ten minutes due to their being so close to hand - usually volunteers are on site and there is a compound and caretaker in the reserve. Because the local brigade members are workers it takes them longer, and once the brigade has arrived the responsibility of fighting the fire is passed over to the brigade, and the LCDC members will stay to assist if required.

The concept of multi-agency fires needs to be addressed and the various agencies co-ordinated so that each fire is acted upon quickly. Thus, instead of one agency thinking they own the fire (and logging it in their statistics book) every agency should work together — that is, the Bush Fires Board, Rockingham Shire, CALM, the LCDC, WA Fire Brigade and the land manager. At Port Kennedy, there is also the possiblity of calling on the Mines Department and the Ministry of Planning, which has a couple of fire fighting units available.

Part of the LCDC'S strategy is to limit or restrict offensive behaviour of problem people, such as car thieves, vandals and drug users. An effective way is to have a visual presence in the reserve, with car patrols. The LCDC patrols the reserve in a signed-written vehicle around five times per weekend day, and three times on other days. The LCDC has asked the Shire to impose a fire ban, which was in operation last year. Jeff does not believe firebreaks stop fires and he does not agree with low fuel zones (created through a controlled burning regime), but he does agree with low fuel buffer zones, which are created by slashing vegetation. Low fuel zones can also be created by the planting of fire resistant local species. The group believes in socialising with the local brigade and others, and ensuring the other agencies are familiar with Port Kennedy - such as where the safest access tracks are so that vehicles can negotiate the area.

The methods used here are proving to be very effective. They are designed to suit the region and although they probably would not work in big areas such as the forest, they will work in other urban areas. Thus, early detection and a call-out system with direct attack have been implemented. Once a fire has been controlled, someone stays behind to mop up and make sure it is not reignited by sparks in the wind. Planning ahead is most important. Public awareness and the tackling of potential problems arising out of offensive behaviour by some visitors are also important. Of great importance is the forming and maintaining of a good relationship with the local fire fighters. Jeff thoroughly recommends that other bushland groups draw from his group's experiences in the management of urban bushland reserves.

Post script: Since the conference the Minister for Agriculture has begun the process of removing the LCD Reserve status from Port Kennedy.

Improving liaison and moving forward

Richard Robertsen
WA Fire Brigades Board

I am a Senior Officer in WA Fire and Rescue and am involved in liaising with a number of other fire services, such as the Bush Fires Board and CALM. One of my roles is as Executive Officer for the implementation of the John Day Committee Report. John will be talking about that report later on today, but I want to talk about some specific aspects of that because it contains a solution to some of the problems that have come up during this conference.

I'd like to say that I am excited to be here. You should all congratulate yourselves for being here. You are part of the solution. Congratulations.

I'd also like to say that the Community Fire Guard programme that Mark Norton spoke about earlier today is now being implemented here.

I'd like to begin by talking about the strategies within WA Fire and Rescue. We have changed.

Our mission and strategic plan now have a greater emphasis on prevention and risk management. We aim to minimise fire and our priority is to move fast and put fires out quickly. Small fires are easier to put out than big fires. We look at pre-determined plans and resources and a heavy emphasis on prevention.

I hear your comments that are coming out about fire services, especially the comment that fire services thinking they know best. In some ways we do, and in some areas we are deficient. We are certainly good at fighting fires in the bushland and structures but the new approach to environmental fire fighting is definitely an area in which we can improve. In that area we would most definitely welcome your help.

But there are significant changes happening lately.

Now I'm asking for your help to help make more changes.

We need:

- Improved understanding on both sides (Lot of fallacies around on each side — fire fighters and conservationists — about the other.);
- Better liaison;
- Closer liaison;
- To develop an ownership process;
- To build on communication, training and information; and,
- To work closely together on a shared problem.

The John Day report, which I mentioned earlier and which will be covered in more detail later on today, highlights environmental considerations. It brought together many people involved in fire fighting and environmental protection. Some tremendous work has been done.

Recommendation 23 of the Day Report states: "That appropriate legislative changes should be made requiring all fire organisation (including BFB, CALM, WAFB, local authorities and other land managers) to take into account the environmental and ecological effects of hazard reduction burning when such burning is being planned and in fire suppression operations."

We can build on the tremendous work done to date. We can extend that to here. There is enough talent in this room to change things.

I propose that, in response to the things we have heard during this conference and building on from the work of the John Day Com-

mittee, we form a working team to look at fire in urban bushland. That working team should comprise members of:

- Bureau of Meteorology
- Urban Bushland Council
- Bush Fires Board of WA
- Conservation and Land Management
- Department of Environmental Protection
- Local Authorities
- WA Fire Brigades Board
- Others as identified

And I suggest that the team be chaired by John Day.

We need more environmental people involved. We need people to come forward and start showing us the way.

I'd like to finish by again congratulating the Urban Bushland Council. Here in Western Australia we are leading, because we are doing things like this conference.

Let me challenge you. If we come together we will turn this around. We need to do this. We need to work together.

Editor's note:
Since the fire conference, the suggestion put forward by Richard Robertsen in his talk has been acted upon. A working team has been formed and is looking at fire in urban bushland. The team includes representatives from the Urban Bushland Council (Mary Gray) and the Conservation Council of WA (Phil Jennings).

What is the Bush Fires Board doing to reduce the incidence of bush fires?

M.G. Cronstedt
Acting Manager Fire Safety, Bush Fires Board of WA

This presentation will provide you with a brief overview of the Board's operations, examine the extent of the bush fire problem in urban bushlands and detail some of the strategies in place, and proposed, to minimise the impact of bush fires on our communities and environment.

The Bush Fires Board is the statutory authority that oversees State-wide policy regarding the protection of our rural communities from fire. Its mission statement is:

"To protect life, property and the environment by providing a service for the prevention, control and suppression of fire and support other emergency services across rural Western Australia."

The service organisation, consisting of 20 regionally based officers and a Perth support head-quarters, provides guidance and assistance to 124 local authorities, 700 brigades and 15 000 volunteer fire fighters across rural Western Australia.

In 1994-95, Volunteer Bush Fire Brigades attended 2 448 incidents, compared with 1 649 the previous year. Some 30 per cent of the fires attended in the outer-metropolitan area were of a "suspicious" and/or "suspected deliberate" nature. Another 30 per cent of the fires reported by brigades were categorised as of "unknown" or "undetermined" cause. The outer metropolitan area of Perth accounts for about 50 per cent of the bush fires attended.

So what has the Board done to reduce the incidence of bush fires?

For the purposes of outlining the Board's strategies, it is convenient to divide its activities into three distinct areas; fire risk management, fire hazard management and response management. The last area deals with all activities that are to do with preparing for, responding to or cleaning up after incidents. Put another way, it's all about putting the wet stuff on the red stuff.

Fire hazard management is all about reducing the severity of fires and separating people and property from fire. This includes activities such as fuel reduction, fire breaks and access construction.

Fire risk management deals with the reduction of the actual likelihood of fires starting. In other words, it attempts to reduce the likelihood of fires. This aspect of the Board's work is perhaps the most relevant to this seminar.

A number of activities support the Board's risk management strategy. Tasks can be divided into three broad areas: public education, fire prevention planning and cause identification.

The Board has a limited public education program involving school visits by the Board's mascot Koala Bill (run largely by volunteers), radio scatters and pamphlets funded by shire contributions, and Fire Awareness week run in conjunction with the WA Fire Brigades Board.

A report on the bush fire preparedness of the Darling Range (Day Report, 1994) to the Minister for Emergency Services, recommended that the Board, in conjunction with CALM and the Fire Brigades Board, look in to the current school based fire education program and suggest future directions. Thus far, a kit used in Victorian and South Australian schools, known as Project Fireguard, looks to be the most favourable resource and basis for future fire education in Western Australian schools.

In terms of adult education, a project known as Community Fireguard could be adapted to suit Western Australian conditions. Community Fireguard has enjoyed enormous success in Victoria. Largely based on community self help, the project relies on community facilitators, trained and resourced through the Fire Services, promoting sound fire safety practices at the household level. Rather that relying on pamphlets, which require people to read printed matter and transfer it into action, Community Fireguard encourages locals to identify and do something about the risks and hazards around their local area.

Currently, a sub-committee of the Day Report, made up of all stake-holders in the fire protection issue, is looking at how and when a suitable Western Australian version of Community Fireguard can be implemented. The protection of urban bushland would benefit greatly from the involvement of bushland protection groups in such a scheme.

The second area, fire prevention planning, has long been in the forefront of the Boards priorities. In past years Board staff had been active in attempting to formulate "Fire Protection Plans". These plans were largely written by Board staff with limited formal input by stakeholders. This lack of input led to a lack of commitment by those that the plans were written to cover. In order to overcome this lack of community ownership, the Board has designed a process whereby a group of stakeholders such as CALM, WAFB, Volunteer Bush Fire Brigades and Local Government representatives write a Fire Prevention Plan for their local area. The plan concentrates on identifying bush fire hazards and risks, and coming up with strategies to mitigate them. The entire process is intended to be guided by Board staff using a model plan. The Board is yet to endorse the process but interim Fire Prevention Model guidelines have been produced for those that wish to commence work in their communities.

The last area mentioned was that of cause identification. The Board is working closely with the Police Arson Squad in order to improve the identification of suspicious fires. In the near future, Board staff will also be given more training in the identification of fire causes and thus improving the flow of intelligence to the police.

Arson — the real cost to the community

Tony Carter
Arson Council of WA

Arson — a crime!

Arson is a crime. It kills and injures people. It costs the community in this state over $100 million each year. Insurance companies pay out nearly $30 million annually on arson related claims.

There are a number of motives for an arsonist, ranging from fraud to pyromania to vandalism. My colleague from the Arson Squad will touch on these in more detail later. We in the insurance industry found that arson fraud was a problem during the "heady days" of the recession, as a fire seemed to be a possible answer for a failing business. In fact, a managing director of a major insurance company in Australia in 1992 expressed concern about "late night fires" that were having a major impact on his company's claims costs.

However, this morning our focus is more on bush fire, rather than suburban fires. Once again, bush fires in Australia have had a major impact on the insurance industry, not to mention the communities that were affected by these bush fires.

The cost

If we look at the major bush fires in Australia since the 80s, most of these (if not all) involved arson to some extent. The most serious of these fires were the Ash Wednesday bush fires in Victoria and South Australia in February 1983. Of course, most recently we saw the new South Wales bush fires in January 1994, which destroyed hundreds of homes.

In these bush fires, not only were there countless homes, motor vehicles, and personal possessions lost, there were also the deaths and injuries of those caught up in the fires. We should not forget other innocent victims such as the animals that make the bush their home and, last but not least, the damage to the bush and environment itself.

While I don't have details on the loss of life and injuries on these bush fires, the insurance loss was close to $500 million. In my view you can multiply that five times to have a proper perspective of the broader costs to the community as a whole.

Arson investigation

It is an unfortunate fact that the incidence of arson (or incendiarism) is increasing. Looking at the investigations conducted by the Arson Squad since 1989/90 there has been an increase of nearly 100 per cent. I know we have seen an increase in the general crime rate over the past six years, but certainly arson has outstripped all other types of criminal activity.

Nevertheless, and on a brighter note, the Police Arson Squad works closely with our fire services and their investigators to bring these criminals to justice. In my view the close working relationship between these two agencies has resulted in a high proportion of arsonists being caught, charged and convicted. Our record in WA for catching these criminals is better than any other state or territory.

Table one: Bush fires in Australia

1983	Ash Wednesday (Vic., SA)	$294 million
1985	New South Wales	$41 million
1987	Tasmania	$11 million
1990	Victoria	$11 million
1991	New South Wales	$11 million
1994	New South Wales	$51 million

Table two:Police Arson Squad investigations

1989/90	150
1990/01	205
1991/92	243
1992/93	288
1993/94	295

We all own the problem

Obviously, we cannot expect the police and the fire service to do the job alone. There is a role for the community, and certainly the insurance companies, to assist the authorities with the difficult task of apprehending arsonists.

Firstly, from the general insurance industry's point of view, in 1990 we introduced the Arson Reward Scheme to provide an incentive for people who have information that could result in the conviction of an arsonist to come forward. Since its inception in WA the scheme has paid out eight rewards totalling many thousands of dollars.

In addition, the State Government recently announced a similar scheme to provide rewards for information in relation to fire damaged property that was not insured. I believe a reward under the government scheme is already being processed.

Secondly, insurance company investigators work closely with the Arson Squad and the fire services. This interaction ensures that as much evidence and information as possible is gathered to assist in pin-pointing the criminal or criminals responsible for the fire.

Thirdly, in the late 80s a Standing Committee on Arson was formed to assist in tackling arson positively. It had on it representatives from the police, fire services, insurance industry, and a number of government agencies (eg Education Department). This committee has been renamed and is now the Arson Council of WA.

The Arson Council ensures that all interested bodies can come together on a regular basis to consider initiatives to reduce the incidence of arson. The council is being used by the State Government to advise it on arson related issues and policy.

Lastly, from the community's point of view, people should be prepared to not only provide information to authorities where possible, but also to be vigilant, particularly during the bush fire season. At the end of the day, the public are the eyes and ears of the police and the fire service.

Crime stoppers

I could not speak to you today without briefly mentioning Crime Stoppers. This is an initiative established in February this year by the police and corporate sector. Crime Stoppers is now a national operation, although it is autonomous in each state and territory. We are working towards a single national telephone number, which makes good sense.

Crime Stoppers exists to allow people who have information on criminal activity and who prefer to pass their information on to the police anonymously. Rewards are available if necessary. The programme has already led to many criminals being apprehended in WA.

Sentences

One final comment is the attitude of the judiciary to the crime of arson. Unfortunately, and I am not sure of the reason, arson generally does not attract an appropriate sentence. While I concede that loss of life or injury is not common with arson fires, there is not doubt that the potential exists. We should not forget, of course, the aspects I mentioned earlier — the fauna and forests that have been destroyed at the hands of arsonists. The insurance industry is pursuing this issue.

It is about time the judiciary accepted arson for what it is — a serious crime.

Fire and its effects on arson

Peter Jenal
CIB Arson Squad

I am a senior constable in the CIB Arson Squad. I have been there for the past 12 months, and am a qualified Fire Investigator, having attented a Fire/Arson Course held in WA in November 1994 and a National Arson/Fire Course held in Tasmania in March 1995. As a qualified Fire Investigator, I can offer to give expert exidence in the District Court in relation to the cause and origin of fire.

Arson Squad

The CIB Arson Squad was formed in 1982 to create a specialised section to combat and investigate the increase in arson offences. At present the squad has a staff of nine. There are two members on call every day of every week to attend fires. The squad has a close working relationship with the WAFB, especially the Fire Investigation Section. The squad is responsible for determining the origin and cause of fires, where the cause is suspicious or deliberate, and carrying out investigations and apprehending offenders. The Arson Squad is the only section in the WA Police Service that is equipped and trained in fire investigation.

Our office is located at Curtin House, 60 Beaufort Street, Perth.

Bush fires

Bush fire, or wildfire, is any unplanned fire, burning timber, bush, grass or crop land that requires suppression.

Fire causes

Fire causes are divided into three main areas:

1) Accidental

Resulting from misadventure, ie, children playing with matches — experimentation.

- Sparks from motor bikes or vehicle exhaust.
- Lightning — natural causes.

If the fire is determined as accidental and the individual responsible is located, then the department responsible (eg Bush Fires Board, CALM) can take steps to educate the individual to reduce future incidents.

2) Negligence

- Resulting from carelessness — crop fires, harvesters.
- Inadequate precautions when burning off.

There is little excuse for Australians to be negligent when lighting or using fires in open areas.

If the fire is determined as negligent the community has the opportunity to recover the costs of resultant damage or the costs of suppressing the fire or both.

3) Deliberate

- Fires lit without permit or authority. (Permits are issued to reduce the risk of fire or to minimise the risk of what was intended to originally burn.)
- Fire lit with intent to destroy or damage property or life. Such a malicious act is called arson and in WA it is referred to as Criminal Damage by Fire.

Motives of a fire lighter (arsonist)

- Fraud — property loss
- Spite or revenge — hatred, jealousy, scare tactic.
- Crime concealment — burning of cars or property in the bush.

- Vanity — profit: volunteer fire-fighter aiming to receive extra pay or to hire security personnel.
  — hero: attention getting.
- Pyromaniac — uncontrollable impulse to start fires.
- Civil disorders — revolution, political activity, fire as a weapon, destroying property.
- Experimental actions by juveniles of both sexes aged between four and 12 years. (Children over 10 have criminal responsibility.)
- Vandalism — self explanatory, hard to control and usually impulse action.

Duty to investigate fires

It is therefore our duty and that of fire management authorities to endeavour to reduce the incidence of deliberately and carelessly lit fires. To do this we need your help so we can vigorously investigate each fire incident with a view to determine:

1. Origin: Where did the fire start?
2. Cause: Was it natural, accidental, negligent or deliberate?
3. Who caused the fire? Are there any suspects?
4. Any evidence to establish the cause?
5. Any evidence to establish the nexus between the incident and the person who caused the fire?
6. What is the nature of the offence?

Fire prevention

In Western Australia, fire records indicate that about 25 per cent of bush fires are deliberately lit or suspected as arson. A high proportion of all other fires attended are preventable. Fire prevention programmes include four main areas:

1. ENGINEERING — road, track maintenance of fuel hazard areas.
2. EDUCATION — school programmes, public awareness and publicity.
3. EXTENSION — advice, assistance, joint projects of landowners and community groups.
4. ENFORCEMENT — patrols, inspections, compliance with legislation, permits and investigations to determine the cause of fires and the people responsible.

To help us catch a bush fire arsonist we need you to:

- Watch for suspicious vehicles in bushland.
- Watch for suspicious people in bushland.
- Record their movements.
- Obtain a description of vehicles and people.
- Be our eyes and ears.
- **Phone the arson hotline or Crime Stoppers on 1800 333 000.**

Grabbing the ear of the press

Patrick Cornish
The West Australian

Amid millions of sales pitches, advertisements, pleas and warnings, you want your message to get through.

Not easy.

But there are six steps you can take to help make your words more attractive to a media outlet, and thus increase your chances of reaching the news columns or getting air time.

Step one: Agree on what you seek to publicise. A school fete with stall-holders in national costume? A new association for Vietnamese shop-owners? Let's say, as a topical example, you want coverage for a fundraising dinner to help refugees in Rwanda.

Step two: Decide on which media outlets you are hoping to interest. Radio 6NR for a start. Suggest some African music they could use with the mention. Better still, give them a tape.

Local suburban newspapers? Include a picture with your message to them and you may well leap ahead of the rest of the publicity-seeking pack. They may want to take their own picture, but sending yours would be a help.

Step three: As a way of attracting publicity, you're holding the fundraising dinner in national costume. Write a list of all the countries represented.

Step four: this list is for your own benefit. To attract media attention you need to pick about three examples of points to include.

Step five: With the examples, write a 150-word press release.

You could start like this:

The Ethnic Communities Council is doing its bit to alleviate the plight of refugees from Rwanda by holding a fund-raising dinner. All proceeds will go to local charities to distribute much-needed medicine, clothing and food.

This is factual, but too predictable and too similar to many other press releases received by the media every week. Proceeds are always distributed by charities, and medicine, clothing and food are always included in such distribution.

The words "communities" and "council" are grey and lifeless; "ethnic" only slightly more lively. Begin your message in another way.

How about this:

Tear-stained faces of children and pleas from desperate medical staff have been filling our television screens. Refugees walking along roads send a silent but eloquent message to the outside world for help.

The emotion of Africa's latest human tragedy is sufficiently well-known, and few need reminding in a message that has the prime purpose of publicising a local angle. There's no point in starting with a confirmation of what is on TV.

Step six: Throw away these two introductions, and come to the point, concisely and colourfully:

Lola Mendez will wear her sombrero and Frances Kigoma will put on a red-and-yellow dress for dinner next weekend.

Chileans and Kenyans living in Perth are among those helping to raise funds to help refugees in Rwanda.

A dinner organised by the Ethnic Communities Council, at the North Perth Migrant Centre on

Saturday August 27 at 7pm, will show off 19 national costumes and at least 30 national dishes.

"We will eat well, but the main aim is to help those who have little to eat," says Council organising secretary Roger Ramjet. "We hope for 120 guests paying $30 each."

This version offers some personal touches (Lola, Frances and Roger); details of what, who, when, where and why; a quote that makes the narrative more dramatic; and gives the weary news editor something to relate to.

For a local newspaper, you could emphasis the fact that half a dozen of the people in national costume live nearby...or that the entire colourful pageant will parade through the local shopping centre on the way to the dinner.

There is no guaranteed way of getting column space or air time, unless you can have the Princess of Wales arriving by hang-glider dressed in a mermaid outfit. Failing that, remember to keep your message tight and bright, direct but detailed.

Future directions in fighting fire

Pat Hart
Community fire fighter

I come to this conference wearing many hats. They are volunteer bush fire fighter, councillor (deputy mayor, City of Armadale), member of Armadale Fire Advisory, Chairperson of Swan Region Bush Fire Advisory, member of Day report executive guidance team.

While I carry out all these roles, today I have been asked to speak from my role as a voluntary bush fire fighter. I have been a member of the Roleystone Brigade for seven and a half years. I have not played a passive role, but rather an active one. I have gone through many hair-raising experiences, spent many cold hours through the very early morning mopping up fires, and many days burning off. I have the bonding with my fellow fire fighters that only the experiences we have been through can bring — a feeling of brotherhood. While I may have, at times, the occasional disagreement with my fellow fire fighters, goodness help anyone else who dares speak against them.

While I have a deep commitment to the voluntary bush fire brigade, I feel that as we go forward at this time, there are areas that we as volunteers must address, just as we are asking Stage Government and Local Government to look at other concerns.

In the past, the main concern for us was to protect structures and to save lives. The bushland was there to use to achieve these ends. The value of our bushland and the relevance to our ecosystem was not contemplated by many.

Times and knowledge are changing. The community's expectations and our responsibility to acknowledge these values have to be addressed. From the induction of our new members to those members of many years, we must make a concerted effort to address new fire fighting techniques and the increased effort required for fire prevention. It is very hard for some members to accept, particularly those with many years of fighting experience. We must acknowledge their difficulties and work very hard with these people in coming to terms with environmental concerns.

I believe we must communicate on a regular basis with our local bushland groups so that we can be made aware of what they are doing and what they are hoping to achieve — to bring an awareness to us all. We can then explain to the bushland volunteers what we hope to achieve through our burning off programmes, and our understanding of fire behaviour. We have to listen to each other in a positive and constructive manner, so that the outcomes will be appreciated by all.

There is nothing so heart-breaking as being called to a wildfire that is racing through bushland that you know has had many hours put into it by volunteers planting trees, only to see them trampled over by fire vehicles and heavy machinery. The thing is, in these situations the volunteer bush fire brigades are completely unaware of the efforts previously undertaken. Even if it was in the local paper, if bushland regeneration is not your thing, why would you take any particular notice of it? Many people don't realise the consequences when huge gum trees are cut down because of fire in the crown. The solution is communication and education by each other, for the future of our environment.

Another area that I believe is a very sensitive one, is the matter of arson.

This is where that very close relationship we have with each other comes in. Sometimes, and I know it must happen in many brigades, circumstances arise where suspicions are felt about a particular fellow fire fighter with regard to arson. It is a terrible experience as it feels like it is happening to one of your own brothers or sisters, and you don't want it to be

true. You also don't want to face it because of the high esteem in which voluntary fire fighters are held in the community. You don't want to lose that respect.

This suspicion is often whispered about, and unofficial watches are placed on that particular person to try to see if it is true. If the suspicion is quite strong, it is passed on to the Arson Squad for investigation.

What we have to accept is that volunteer fire fighters come from all walks of life and there is always the possibility of this type of person joining a brigade. I believe that arson and its penalties need to be strongly spelt out when new members join the brigades. It must be clearly stated that we acknowledge the possibility and spelt out loud and clear the fact that any suspicious behaviour by fire fighters must be reported to the fire control officer to be investigated. This message should be repeated throughout the fire season. It is no use burying our heads in the sand with this situation because it does happen. We must be strong enough to acknowledge this fact and act accordingly.

When we accept the role of volunteer bush fire fighter, we must embrace the role and responsibilities that are clearly laid down for us all. If we are not willing to give a 100 per cent commitment, then I believe there is no place in the organisation for those particular individuals.

As a volunteer fire fighter, I am very proud of my fellow fire fighters and their commitment to their communities. I know that these new expectations will, with communication and education, be accepted by all.

I have, in wearing my councillor's hat, supported fully the Standard of Fire Cover and its financial implications and will, through my other roles in fire advisory and the Swan Region, give positive support to environmental issues while acknowledging the problems involved with fighting wildfires.

Preventing fires in urban bushland

Philip Jennings
Conservation Council of WA

Effects of fires

Bushland reserves are islands of biodiversity in our urban environment. They provide food, shelter and breeding sites for wildlife and they are essential stopover points for migratory birds.

Although the need to identify and conserve urban bushland has been recognised by Government and the public, the management of these reserves in unsatisfactory. One aspect which is receiving increasing attention is the incidence of bush fires.

Fire is a natural part of the ecology of our bushland and some species are adapted to occasional fires. However, the concern today is the increasing frequency of fires and the inability of some species to recover from excessive burning. Fires can disrupt the woodland ecology and allow exotic species to invade the bushland. Some of these species such as veld, love and pampas grasses recover quickly from fire and begin to dominate the woodland. Eventually the whole reserve becomes adapted to annual fires and many native species are eliminated because they regenerate too slowly.

The impact of fire on urban reserves is even more serious for the fauna. These reserves are their only refuge in a hostile urban environment. If the vegetation is burnt out the wildlife has no food or shelter. It is exposed to feral predators such as cats, dogs and foxes. All the wildlife may be killed by the fire or it may flee to neighbouring reserves (if they exist). If the flora eventually recovers the reserve may remain depopulated by fauna as there may be few sources of wildlife in the vicinity from which it can replenish. The birds will return but the mammals and reptiles may not.

Thus fire can have a devastating effect on urban bushland. Controlled burns may be beneficial in some large natural areas if they are carried out by trained personnel within the context of a management plan. However, wildfires are almost always undesirable from an ecological and property damage perspective. Wildfires often burn out the entire reserve. They often occur on extremely hot days in the middle of summer when the vegetation and wildlife are already under stress. Because they are unplanned they often cause enormous damage (and threaten property). Our concern should therefore be to completely eliminate wildfires in urban reserves.

Causes of bush fires

The police report that most bush fires are deliberately lit. They are regarded as arson — just another aspect of our urban crime problem.

A small proportion of fires is caused by natural events such as lightening strikes but these are very infrequent.

Careless or irresponsible behaviour can also cause bush fires. Discarded cigarettes and barbeques, for example, can cause fires. Controlled burns sometimes get out of control.

To find solutions to the fire problem we need to know the causes and we need to analyse the underlying reasons for them.

For example: Why do people light fires in bushland reserves? Why do people throw cigarettes away without putting them out? Why are controlled burns carried out on days of extreme fire danger?

We need answers to these questions and many more.

From my observations over many years I have noticed that bush fires are more common during school holidays and during very hot weather. It would be interesting to know whether fire-bugs understand the ecological damage they are causing or whether their actions are intended as a social protest or are intended to satisfy some psychological need. (eg they need to attract attention). In this respect arson is quite different from burglary. The motive is to cause damage to public or private property not to acquire wealth or pleasure.

We need a careful psychological analysis of fire-bugs as a basis for our fire control strategies.

Preventing bush fires

There are many steps that could be taken to reduce the incidence of fires in bush reserves.

One simple approach that I have found effective is to fence and sign-post the reserve. Let people know that it is a valuable piece of bushland and not a derelict piece of land intended for use as a dump or housing estate. Many people will respect and value the area if it is given this status. You will find that fires, rubbish dumping, wood-cutting, trail bike use, and so on, will all decrease substantially once the reserve is fenced and sign-posted.

However, this will not stop people with psychiatric problems or the careless smoker. The latter can be addressed by banning smoking in bush reserves and by installing an adequate set of fire-breaks, particularly along boundary roads as many accidental fires start from cigarettes discarded from cars.

I believe that the media has an important role to play in fire prevention. By publicising bush fires it encourages fire-bugs to imitate the actions of others. The media should try to reduce the coverage they give to bush fires and remove the sensational element from the reporting. They could assist by broadcasting messages to the public to take care by emphasising the value of these reserves and the damage caused to animals and their habitat by wildfires.

Other strategies which could be effective include education, community awareness and environmental training for fire fighters.

Children should be educated about the effects of fires in bushland and the value of bushland reserves. The public should also be included in a "Fire Watch" campaign via stickers and leaflets that explain what to do in case of fire. People should also be alerted to the habits of fire-bugs and there should be a number they can call to report arson or suspected arson. The Neighbourhood Watch crime prevention programme could be extended to include Fire Watch.

Conservation groups, CALM and local authorities need to work more closely with the Bush Fires Board and the WA Fire Brigade to ensure that fire fighters recognise the value of bushland. All reserves should have fire control plans and fire drills should be carried out regularly. Fire fighters are trained to protect property, but they have little knowledge about ecology. This can be acquired through training and through the development of fire control plans for reserves. Local authorities should provide some assistance in developing fire control strategies for all of their reserves. The public can assist by watching for fires and by cleaning up flammable rubbish from reserves.

Regional Parks provide a good opportunity to develop integrated fire control strategies for a region and to share resources between reserves. Community advisory committees could provide the avenue for developing fire control plans for Regional Parks. The fire fighting agencies should be involved in this planning.

If a fire does occur, the fire control plan should be implemented by the professional fire-fighters.

After the fire it is important to follow up. The causes of the fire should be investigated. The adequacy of the fire control plan should be assessed and the plan should be amended if necessary. The park managers should immediately respond to the situation by repairing damaged fencing and signs. Dumped rubbish can also be removed more easily after fires. Public access may need to be restricted for some time until the danger of fresh outbreaks

is reduced. Baiting for feral animals should be carried out after fires as this presents an opportunity to remove foxes, cats and rabbits. Injured animals should be rescued and rehabilitated, if possible. The damage should be assessed and a rehabilitation plan should be put in place.

Conclusions

I have presented a common sense approach to fire prevention in urban bushland reserves. It could form the basis for a fire control plan for all bushland reserves. However, it depends on good cooperation between the reserve managers, community groups and the fire fighting authorities. This may be achieved through the establishment of management committees for reserves.

Fire prevention is one of the most crucial management problems for urban reserves and it is important that we direct more attention to it and continue to share our thoughts on how to achieve it. Meetings such as this are important and they should be held regularly to encourage the development of better strategies for fire control.

Acknowledgments

Many thanks to David James, Rob Giblett, Helga Jennings and Joan Payne for sharing their thoughts with me on this important topic.

Issues arising from discussion during question time following speakers

Compiled by Kirsten Tullis, Urban Bushland Council

A discussion period involving all the delegates followed each block of speakers. Points, taken from notes and the taped proceedings, are grouped according to topic. They are not necessarily in the order of the programme, and some are repeated in the section 'Where to from here?' on page 104.

Weeds

The problem of weeds was raised many times. Many people were concerned that an increased or altered fire regime encourages certain weeds to grow, some of which are, in themselves, highly flammable. According to John Dell of the WA Museum three of the major environmental weeds — Bridal Creeper, Watsonia and Pelargonium — not only choke out reptile habitat but the latter two die out seasonally adding to the fuel load. Ric How, also from the WA Museum, said there is little research on the extent to which weeds provide cover for animals and an invertebrate food source for vertebrates.

Our bushland is adapted to fire, but not necessarily to an altered regime. Neil Burrows of CALM said mechanisms to cope with fire break down once the frequency increases unnaturally. For instance, a change in the floristic composition of understory through grassy weed invasion presents the potential for fire to occur at least annually. Urban bushland is often infested with such weeds, so a series of annual fires would put at risk 90 per cent of native plant species in the long term based on CALM's data on flowering and seed set times.

Effects On Fauna

John Dell and Ric How of the WA Museum report that the reptile species reliant on bare sand for feeding, incubating eggs and burrowing are less affected by fire than those more reliant on dense vegetation. Some weeds interfere with the balance by invading bare sand, and altering the fuel load.

John Dell said in the South-West fire affects insectivorous birds more than granivorous species, principally because most of the latter are parrots which feed in large trees. The Painted Quail is one exception.

Firebreaks

Ploughed firebreaks spread weeds and cause erosion. It was the opinion of many that firebreaks do not stop fires — they being mainly for access. Some shires allow negotiation on firebreaks, such that alternatives can be discussed and a permit given.

Fencing

Boyd Wykes, Environmental Manager for Garden Island, related that animal protection has been carefully thought out at the Karakamia Sanctuary at Gidgegannup. Here the fence is designed so that it can knocked down with a vehicle to allow fire units in and give animals an escape route, then repaired afterwards at little cost. Guided walks are run at Karakamia on Saturday evenings — call 572 3169.

Fire Management Plans

If groups wish to begin adding a fire management component to their management plans they should contact Richard Robertsen of the WA Fire Brigades Board (WAFB), and he will direct them to the appropriate fire authority. The Bush Fires Board of WA (BFB) is able to provide expertise and help in conjunction with WAFB and CALM, however beyond that there are no funds available at present to help community groups. Graeme

Williams of the WAFB reminded the audience that with a shift of resources from suppression to prevention there may be room to allocate some of the finite resources toward this.

Prescribed Burning Practices By CALM

Many questions were directed toward Neil Burrows from CALM, who spoke on his department's prescribed burning practices in the forests and fire related research. Some of the discussion points are included under other headings. CALM's prescribed burning practices are based on research in production forests. The Department is not doing research on fire ecology of urban bushland on the Swan Coastal Plain, although Neil believes the same principles would apply. Little fire research overall is carried out in urban bushland, though the University of WA is presently doing some. In addition, little research by CALM is undertaken on microorganisms, fungi and invertebrates, and more is needed. CALM does not pretend to know about all the species in the forest.

Concern was raised at the rapid rotation of prescribed burning by CALM in the forest (ie every six to eight years) to ensure that the fuel load remains below eight tonnes/hectare. There was also concern that burning intervals according to the two times juvenile period (number of years to flowering) allows for a small margin of error, and does not take into account all ecological processes. For instance, climatic fluctuations, animal and plant interactions, individual species differences (such as seed viability and germination rate and the ability to out-compete weeds), disease potential, nutrients and the interactions of plants and associated mycorrhizal fungi.

On the effects of climatic changes and drought factors, Neil stated that with an increased aridity in the South-West (as appears to be happening) there would be a dramatic impact and so time to flowering and seed set could increase. According to weather station data from study sites the seasonal changes of rainfall is proving to be a strong feature, and in some situations it is over-riding fire in terms of flowering, seedling regeneration and survival. Another point raised from the floor was that after prescribed burning there is an abundance of flowering due to stress. Neil, though not sure of the physiological mechanism of post fire flowering, conceded that stress may be the cause but was unable to comment further.

Average fuel loads rarely exceed seven to eight tonnes/hectare in dry forest. When asked why CALM prescribe burns these areas Neil advised that such forest remains drier for longer, is further from fire suppression resources, and would be burnt by farmers if left.

Nutrient Recycling And Leaf Litter Decomposition

There was concern raised that an increased fire frequency and prescribed burning affects nutrient recycling. Fire does not recycle nutrients very well, especially since many are lost to the atmosphere, and an increase in fire frequency impairs the natural decomposition processes. Boyd Wykes related that the nutrients following a fire are in the soil for only a short time after the rains.

In the tropical forests, which rarely burn due to a lack of seasonal drought, recycling occurs through natural decomposition. Neil Burrows commented that whilst our bushland systems have evolved over thousands of years to cope with fire, it does not mean they have evolved to cope with any fire regime. Various mechanisms are in place to replace nutrient loss, such as nitrogen replacement through legume species.

Boyd Wykes said that at Garden Island, where there is a high build-up of fuel load due to naturally infrequent fires, the Tammar Wallabies do not contribute much to the natural recycling process.

Perceptions Of The Effects Of Fire

The difference in opinion on what the term loss means when a fire strikes was highlighted a number of times at the conference. For instance, fire fighters tended to talk in terms of whether there was loss of life or property;

whereas conservationists emphasised that the loss of wildlife and bushland is also important. As a reference to the former, Rick Sneeuwjagt of CALM said that despite 600 bush fires last season there were almost no losses (ie of life and property). This view was quickly picked up and challenged in debate.

Response And Fire Suppression In Bushland

A new strategic plan is being developed where fire prevention, rather than suppression, will be the focus for fire authorities. Richard Robertsen of the WAFB confidently advised that WA has the best fire fighting services in Australia.

Concern was raised in the light of recent severe burns at Bibra Lake, near the Cockburn Education Centre, that an appropriate response to bush fire is made in future. At last summer's event the two WAFB vehicles (the pumper unable to leave the bitumen) and four officers were unable to fight the fire. Ed Bartosiak from the WAFB pointed out that as much as the fire authorities wish to put out fires as quickly as possible, there are not the resources to deal with large scrub fires — most of their equipment is suited to fight property blazes. In fact, there are only three water tankers available for the entire Metropolitan Region. Alan Briggs reported that CALM, in conjunction with other authorities, holds exercises as part of the response plans already in place for large urban bush fire events.

John Day remarked that there is clearly a significant difference between the way the large tracts of Darling Range bushland and smaller urban areas (for example, at Kings Park where there is intensive management there are people available to respond immediately 24 hours a day) should be handled.

Ownership Of Fire

Whilst regional and local government boundaries occur, and with CALM being responsible for State Forests and National Parks etc, there were differing perceptions between conservation groups and fire fighters with regard to ownership of fire. Some group members recounted times when they had experienced fire agencies not involving themselves or other agencies in fighting a fire because of boundaries of jurisdiction (eg at Port Kennedy and at Bungendore). Richard Robertsen stated that fire fighting boundaries do not, or should not, exist and that whichever agency arrives first, or is most competent for the given situation, is the one in charge. However he conceded that in some pockets there may be territorial officers who always want to take charge of a fire in their area of control. Mal Cronstedt of the BFB said there is variation in how each local authority runs fire management within general guidelines.

Fire Fighters And Environmental Values

Bronwen Keighery, a consultant botanist, said she has never taken a group into the bush where each person has not come away without a sense of awe. Perhaps fire fighters could be invited on similar walks. There was general agreement from the fire officers from WAFB, BFB and CALM that until now there has been virtually nothing in the fire training programmes on the values of urban bushland. However, there is a unit on environmental considerations in the senior fire fighter's course. No details on content were given. Whilst everyone understands the values of life and property, environmental considerations will take a higher profile, especially if the public (the customer) calls for it. Some of the training will be included in the new skills enhancement programmes available to all WAFB officers. Ed Bartosiak will be seconded to CALM at Mundaring to share expertise, and learn about environmental aspects. Graham Williams, a fire officer for 30 years, commented that he is still gaining awareness, and that the conference has presented him with a new view of the values of urban bushland and the values placed on it by bushland community groups.

A suggestion from the floor was that at the WAFB's Forrestfield Training Centre, fire fighters have the perfect opportunity to learn about and look after the bush at the centre. It is a System 6 area (M 53) and home for rare flora and bandicoots.

Keith Smith, of the WA Native Animal and Bird Hospital, also belongs to a local brigade. He said some of the local fire brigades are beginning to employ environmental officers. He believed it inevitable that brigades need to do controlled burning to protect property, but they need to choose the right time and degree of care.

Community Education

Educating children is important, however it has to be done in such a way that they do not get the idea of lighting fires. Some years ago a teacher response package was developed, however it is rarely used now. The Bush Fires Board is now developing Community Fireguard and Project Fireguard. Input from bushland community group members is welcome.

Education of community groups is also important. Conservationists can also learn much from fire fighters and a willingness to learn was expressed at the conference.

There was a suggestion from the floor that brigades use their local papers to place large, interesting articles on their growing awareness of bushland values, and ask the public for new ideas. The volunteers from Kalamunda Bush Fires Brigade have experienced a very poor response from the community when they run their annual fire awareness programme.

One problem of dealing with planners and engineers (eg in local government) is that they have a technical rather than an environmental background. For instance, an engineer may see a wetland as a drainage sump and a planner may see open space as somewhere to develop. Local government councillors too, historically think of bushland in terms of dollars, rather than its natural heritage values. Appropriate courses are needed to broaden the outlook of these people.

Tony Carter, who said he enjoys bushland, was asked whether the insurance industry has a particular interest in urban and other bushland. The industry is keen to see appropriate development, access and escape routes, to reduce loss of property and therefore insurance loss.

Arson

This topic generated a lot of discussion, and was a focus for many of the talks given at the beginning of the conference by community group members. The problem of arson is exacerbated by many things. It was generally felt that the behaviour of the media encourages arsonists. Tony Carter of the Arson Council of WA reported that elements of the judiciary do not regard the crime as one that is of great concern.

Some group members reported a lack of interest by local police and fire brigades in catching arsonists, including children, or even accepting a description or information about their activities. All police recruits are told to contact the Police Arson Squad in the case of suspected deliberate fire. Under the age of 10 children are not legally responsible, and sometimes parents are ignorant or uncaring of their off-spring's activities. One question asked of Peter Jenal regarded whether a group should call the Arson Squad about a bush fire that looks like it was deliberately lit. It may be difficult for the officers to determine the cause and there is always the question of prioritising the workload, however it is certainly worthwhile contacting them. Sharing of information may help link it to another event, and thus enable a successful prosecution to be made.

Peter Jenal was also asked if there is variation between investigations for bushland and property. Generally, fires are prioritised according to the resources available to the squad. Public assistance is vital to begin the investigation. On occasions, the information may not be acted upon immediately and, more often than not, there is little feed-back from the officer until a result is obtained. Even if the identity of the arsonist is known nothing much can be done until the arsonist re-appears. It has been the experience of some community groups to be told that unless someone is actually caught in the act and detained the police cannot, or will not, do anything. However, attitudes to bush fires are changing, and the police do not want to see an 'Ash Wednesday' here in WA. The Lesmurdie fire of last summer was a near disaster, which once again alerted the police to the

seriousness of bush fire. It is most important to let the wider public know that the police welcome information on the cause of fire and suspected arsonists.

It was noted by one of the bush fire volunteers that more needs to be done given the following: Most fire events are the result of arson; much environmental and property damage is done, and; great pressures are placed on local brigades. A new angle is needed so that energies are more efficiently directed toward counteracting it. For instance, new prevention strategies need to be devised; the Arson Squad should be increased; a new department added to the Bush Fires Board or WAFB,and; the public profile of arson as a crime lifted.

The question was asked as to whether volunteer fire fighters have psychiatric testing for arson tendencies. Mal Cronstedt of the BFB answered no. The degree of arson is a reflection of society, and in any organisation there will be a range of problem people. Although it is entirely up to the structure of the local authority and brigades to chose who is accepted, Mal agreed that there is a responsibility for his administration to advise brigades to be careful who is taken on board. Pat Hart, during her talk, broached the subject of arson within brigades in a very sensitive way, saying that it should be discussed openly and positively, especially during training.

Media Reporting

Many commented on media reporting. Rick Sneeuwjagt commented that a big fire is an attractive topic to report on, since the media and public likes bad rather than good news. CALM has found the less sensational, more positive stories are often ignored by the media; such as research findings or prevention work. He asked Patrick Cornish of The West Australian how organisations or community groups can get access to the media to ensure the balance is redressed. Patrick suggests grabbing the ear of the press in the following way will help: When approaching a harassed news editor provide pictures and examples, and exercise restraint. One personal call, followed by a fax and 'thank-you for your time' should work better than any other way.

The audience agreed that an embargo on reporting of bush fires, such as occurred with youth suicide, is necessary to reduce arson events. The media should also be encouraged to publicise the penalties for arson and the rewards available for offering information.

A fire volunteer highlighted that the problem of sightseers and media reporting during fires needs to be addressed. It was recommended that the local brigades talk to the police about alleviating the problem. Sightseers were a particular problem at the Lesmurdie fire last summer, partly because the media exaggerated and sensationalised the situation. They obtained information by scanning the emergency channels, something over which the authorities have no control. At some fire events, the media directly hinders fire crews by being in the way. The John Day Report has identified recommendations and mechanisms to deal with some of these problems. The fire authorities have held debriefing sessions, and shall be seeking the cooperation of the media to improve their behaviour.

The media does need to play a role during a fire event, as there is a need to inform the public of what is going on for safety reasons. The police and WAFB employ media liaison officers. One of their roles is to convey information to the media during a big event, and they should also be able to help improve media behaviour.

Cooperation

Many times during the conference members of the conservation movement and fire authorities alike recognised the benefits gained from hearing the other point of view and holding discussions. Very few people are actively involved in both conservation and fire fighting. It was pleasing for those involved in urban bushland conservation to hear the encouraging feedback from members of the fire fighting authorities. It was generally felt that a proactive, rather than a reactive, approach was the best one. Already, fire fighters and community groups (eg at Armadale Settlers' Common and Bungendore Park) are establishing positive contact and it was generally agreed that as a result of

holding the conference more positive contacts will take place.

The conference clearly showed that a major change in community and fire fighting attitudes is needed to protect our unique bushland heritage. The conference provided an encouraging start in this direction.

Where to from here?

Suggestions from conference participants

These suggestions were made by conference participants during discussions at various points throughout the conference. They are grouped by subject, but not by priority. Many are actions that any individual may undertake, others are suggestions for Government or specific agencies.

Slash fire breaks

Advise shire officers and volunteer fire chiefs that:

- Fire risk and the need for control burns may be reduced by removing dry debris in low fuel buffer strips;
- Try slashing instead of ploughing firebreaks, and planting "low fuel" buffer zones (such as pigface and other fleshy plants, deciduous plants, or salty plants);
- Weed intrusion may be prevented by not burning and not disturbing soil. This could further save expensive spray for weed control as weed-infested areas are usually 'high fuel' areas.

Research

Approach the government to carry out a study of the causes and psychological factors involved in arson and wild fires in urban bushland.

Dialogue

Approach the WAFB and the Bush Fires Board to establish a working party to develop fire prevention strategies for urban bushland. Seek funding from the government for this exercise.

Media

Develop a policy on reporting of wildfires and fire hazards and initiate dialogue with the media outlets and journalists' associations. A panel of representatives from here (the conference participants) could monitor the media and make appropriate responses until they (the media) get the message.

Guide book

Publish a guide to preventing fire for groups involved in managing urban bushland.

Follow up

Set up a working party to evaluate the findings of the conference and to implement them.

Community Fireguard programme for WA

At present there are a number of networks of community conservation organisations (eg UBC, Conservation Council of WA, community catchment groups, and DEP's Ecoplan programme). In setting up the Community Fireguard programme in WA, the fire authorities seek to contact local conservation groups and include these people on any fireguard groups. At the conference, Mal Cronstedt, WA Bush Fires Board, offered to take up this suggestion.

Environmental fire officers

Environmental fire officers should be appointed.

Urban Bushland Advisory Service

Call on the government to urgently establish the Urban bushland Advisory Service (as given in the government's Urban Bushland Strategy 1995) which will "assist local authorities and the communities in issues such as management plans, fire prevention, etc". This group should have as a focus promoting an understanding of the values of urban bushland, as identified by the community.

Education and training

- UBC should approach BFB about the possibility of members of volunteer

groups receiving basic fire fighting training with back-packs, rake hoes, etc.

- Community groups should invite local fire fighters to visit and walk over their bushland areas. Suggestions also included bus tour of the region, social gatherings such as barbecues with fire fighters and friends groups participating.
- Train volunteers intensively.
- School education programmes about fire need further initiatives.

Fire management

Small grants schemes for helping community groups incorporate fire management into their management plans. In other words, can WAFB help fund fire plans?

Prepare guidelines and examples of fire management plans for the assistance of urban bushland groups. Ensure they include flora and fauna requirements, control of sightseers, and contact with the media.

Assess fire risk on the basis of each municipal area, or on fire threat areas across boundaries (in accordance with how fire travels or occurs). Ensure all agencies agree to and are involved in developing the fire response plan.

Produce information of weeds and fire for urban bushland groups in a simple format for wide distribution (refer Eddie Van Etten). Contact Rod Safstrom about these ideas.

Farm lands adjacent to bushland

Bush Fires Board examines the issue of perceived threats from bushland (reserves, road verges, remnants on private property) to grazing and agricultural land in light of the actual sources of fire. Fires often actually arise from use of machinery and escapes from controlled burns. What is the possibility of decreasing fuel loads on adjacent farm lands and properties to protect bushland from fire? Examples could be buffer burns adjacent to fire breaks after harvest, and so on.

Fire fighters

WAFB and BFB prepare a flow chart or readily understandable diagram of the relationships among all agencies that have fire control responsibilities.

Arson

Develop a strategy to reduce publicity about bush fires and arson. Lobby for stronger penalties for arson.

Prescribed burning

Encourage manual and herbicide methods of weed control to reduce fuel loads which could result in low fuel buffers around bushland and keep the remnant intact (Local government authorities, community groups, Australian Trust for Conservation Volunteers, Australian Association of Bush Regenerators).

Community attitudes

Perceived threats of fire to bushland need to result in understanding and a commitment to weed control (ie make sure weed control happens as it helps reduce fire risk).

Displays in shopping centres help raise awareness of the problem and actions people can take to reduce fire risk, report arson and so on.

Conference participants

Name	Organisation
Jeni Alford	CALM
Wendy Alpers	Friends of the Forest, Margaret River
Jeff Anderton (s)	Port Kennedy LCDC
Mark Angeloni	"Lowlands"
Ruth Arnel	Parkerville Primary School
Ed Bartosiak	WA Fire Brigades Board
Craig Bowers	Kalamunda Volunteer Bush Fire Brigade
Alan Briggs	CALM
Michael Brooker (s)	CSIRO
Neil Burrows (s)	CALM
Norma Calcutt (c)	Friends of Bold Park Bushland; UBC Executive
Maureen Campbell	Crestwood Bushland Restoration Group
Ben Carr (w)	
Tony Carter (s)	Arson Council of WA
Mike Clarke	Jandakot Volunteer Bushfire Brigade
Diana Corbyn	Murdoch TAFE Campus
Patrick Cornish (s)	West Australian Newspapers
Sallie Coulson	Lowden
Neil Coy	Wildflower Society of WA
Malcolm Cronstedt (s)	Bush Fires Board of WA
Denise Crosbie	
John Day (s)	MLA for Darling Range
John Dell (s)	WA Museum
Bob Dixon	Kings Park and Botanic Garden
Molly Dowdall	Bassendean Preservation Group
Cathy Drake	RTR-FM
Regina Drummond	Friends of Brixton Street
James Duggie (c)	Friends of Shenton Park Bushland
Lyn Dunstan	Ellenbrook Conservation Group
Claire Dyball	City of Fremantle, Parks and Recreation Department
Peter Easton	Student, Curtin University
Jon Elder	Australian Trust for Conservation Volunteers
Gus Fergusson	Wetlands Conservation Society
Judy Fisher	UWA Botany Department
Gordon Friend (s)	CALM
Mary Gray (c)	Wildflower Society of WA; UBC Executive
Ruth Green	Calectasia Study Group
Wendy Griffiths	The Tree Society
Tammy Grimes	Kalamunda Volunteer Bush Fire Brigade
Cheryl Hamence	Blackwood Environment Society; REEP
Jillian Harris	Jillian Harris Consulting, Conference Organiser
Don Hart	Department of Land Administration
Pat Hart (s)	City of Armadale
Judith Harvey	CALM
Diane Harwood	Denmark Bush Community Regenerators
Jerry Healy	Hames Sharley
Anne Homes	Wildflower Society of WA

Angas Hopkins (w)	CALM
Stephen Hopper (s)	Kings Park and Botanic Garden
Wes Horwood	Swan River Trust
Ric How (s)	WA Museum
Robert Hughes	Department of Environmental Protection
Bridget Hyder	Department of Environmental Protection
David James	Friends of Forrestdale
Peter Jenal (s)	Police Arson Squad
Philip Jennings (s)	Conservation Council of WA
David Kaesehagen (s)	Ecoscape Australia; Australian Association of Bush Regenerators
Bronwen Keighery (s)	Consultant Botanist; Wildflower Society of WA
Shona Kennealy	Western Power
Jan King	Aquinas College
Len Knight (w)	Farmer, Harvey
Margaret Langley	CALM
Victoria Laurie	Nature Reserves Preservation Group
Alan Lloyd (s)	Friends of Hepburn and Pinnaroo Bushland
Kevin McAlpine	Department of Environmental Protection
Douglas McArthur	Department of Land Administration
Matt McFadyen	Kalamunda Volunteer Bush Fire Brigade
Michael MacShane	Bayswater Greenwork; UBC Executive
Stephen Magyar	Councillor, City of Wanneroo
Carol Matison	Friends of Mary Carroll Park
Ross Mead	CALM
Allan Millar	Canning River Residents Environmental Protection Association
Doug Monk	Midland College of TAFE
Brian Moyle	Wildflower Society of WA, Perth Branch
Peter Murphy	Lowden
Greg Napier	CALM
David Newsome	Murdoch University
Mark Norton (s)	Student, Edith Cowan University
Margo O'Byrne	Department of Environmental Protection
Diana Papenfus	
Joan Payne	Conservation Council of WA
Coral Pepper	
Patrick Pigott (s)	CALM
Tony Poynton (w)	Cockburn Wetlands Education Centre
Joy Renisch	
Midge Richardson	"Lowlands"
Richard Robertsen (s)	WA Fire Brigades Board
Margaret Robertson (s)	Friends of Ellis Brook Valley
Dave Robinson	Deputy Chief Bush Fire Control Officer, Serpentine/ Jarrahdale
Unice Robinson	Friends of Mary Carroll Park
Margot Ross	Canning River Residents Environmental Protection Association
Katinka Ruthrof	Student, Murdoch University
Rod Safstrom (s)	Australian Trust for Conservation Volunteers; Environs Consulting
Tim Saggers	Landsdale Farm School
Kim Sarti	Bungendore Park Management Committee
Karen Savage	Friends of Mary Carroll Park
Martine Scheltema	Greening Western Australia

Nicole Siemon	Swan River Trust
Keith Smith (s)	WA Native Animal and Bird Hospital
Rick Sneeuwjagt (s)	CALM
Chris Sousa	Armadale West Bush Fire Brigade
Jo Stone	Canning River Regional Park Volunteers
Paddy Strano	City of Cockburn
Cathy Taylor	Friends of Hillview Community Bushland; UBC Executive
Cate Tauss (s)	Friends of Yellagonga Regional Park
Andrew Thomson	City of South Perth Environmental Association; Greens (WA)
Natalie Thorning	Department of Environmental Protection
David Tiggerdine	
Brett Tizard (s)	Armadale Settlers' Common Group
Rob Towers	CALM
Kirsten Tullis (c)	Men of the Trees; UBC Executive
Eddie van Etten (s)	Edith Cowan University
Wayne Van Lieven	City of Gosnells
Donna Van Rijnswoud	Kalamunda Volunteer Bush Fire Brigade
David Wake (s) (c)	Quinns Rocks Environmental Group; UBC Executive
David Ward (w)	CALM
Graeme Williams	WA Fire Brigades Board
Jill Williams	Bayswater Greenwork; UBC Executive
Duncan Wilson	Kalamunda Volunteer Bush Fire Brigade
Boyd Wykes (s)	HMAS Stirling (Environmental Manager)
Marilyn Zakrevsky	Wanneroo and Northern Suburbs Branch Naturalists' Club

(s) — Speaker (w) — Workshop leader (c) — Session Chair

The following people were not delegates, but are co-authors of papers:

Trevor Drummond	Friends of Brixton Street
Greg Keighery	CALM
Keran Keys	Kings Park and Botanic Gardens
Bill Loneragan	University of Western Australia
Bill McArthur	Consultant Botanist
Natalie Reeves	Quinns Rocks Environmental Group
Alex Robertson	CALM
Bruce Ward	CALM
Paul Wycherley	

Conference programme

Day One

8.30 am Registrations

9.00 am Welcome
Mary Gray, President, Urban Bushland Council

9.05 am Official opening
John Day, MLA, Member for Darling Range, Chair Ministerial Committee investigating fire hazard in the Darling Range.

9.10 am Session One: Community perspectives
Chaired by Margaret Robertson, Friends of Ellis Brook Valley
Other presentations by:
David Wake, Quinns Rocks Environmental Group;
Brett Tizard, Armadale Settlers Common;
Cate Tauss, Friends of Yellagonga Regional Park;
Alan Lloyd, Friends of Hepburn-Pinnaroo Bushland;
Jeff Anderton, Port Kennedy Land Conservation District Committee.

10.00 am Morning tea

10.30 am Session Two: Historical and ecological perspectives
Chaired by Kirsten Tullis, Men of the Trees, Urban Bushland Council Executive

A fifty year record of fire management in Kings Park
Bob Dixon*, Keran Keys*, Stephen Hopper*, and Paul Wycherley#
*Kings Park and Botanic Gardens.
Nicholson Road, Subiaco

Fire and human disturbance regimes and impacts on plant communities at Star Swamp
Patrick Pigott and Bill Loneragan, University of Western Australia.

Fire ecology and fire management of Garden Island
Boyd Wykes, HMAS Stirling Garden Island and Bill McArthur, Consultant.

Regeneration and flowering responses of plant species in the jarrah forest plant communities
Neil Burrows, Bruce Ward, and Alex Robertson
Department of Conservation and Land Management.

12.00 pm Lunch

1.00 pm Session Three: Workshops and walks
To be held concurrently. Choose any one.
1) Tony Poynton, Cockburn Wetlands Education Centre, A closer look at Bibra Lake's recent fire history.
2) Len Knight, Farmer and fire-fighter, Keeping fuel loads down.
3) David Ward, CALM, Grass trees and fire history.
4) Angas Hopkins, CALM, Monitoring — essential part of bushland management.
5) Magical mystery tour.

1.45pm Session Four: What happens to the animals?
Chaired by David Wake, Quinns Rocks Environmental Group, Urban Bushland Council Executive

Faunal responses to fire in urban bushland
John Dell and Ric How, WA Museum.

Wildfire and its effects on birds of the Darling Scarp
Michael Brooker, CSIRO.

Fire and fauna
Keith Smith, WA Native Animal and Bird Hospital.

Effects of fire on fauna
Gordon Friend, Department of Conservation and Land Management.

3.15 pm Afternoon tea

3.30 pm Session Five: Managing with/ without fire
Chaired by Norma Calcutt, Friends of Bold Park Bushland, Urban Bushland Council Executive

Management guidelines for urban bushland and fire effects
Bronwen Keighery and Greg Keighery, Botanists.

Fire control: Its integration into bushland management
David Kaesehagen, Australian Association of Bush Regenerators.

The problem of weeds in bushland: implications for fire management
Eddie van Etten, Edith Cowan University.

Fire in the urban-bushland interface
Rick Sneeuwjagt, Department of Conservation and Land Management

5.00 pm End of day one

Day Two

9.30 am Session Six: Approaches to fighting and preventing fire
Chaired by James Duggie, Friends of Shenton Park Bushland

Fire prevention: A Victorian view
Mark Norton, Environmental Management Student,
Edith Cowan University.

Fire management: Cooperation between the Country fire Authority (Victoria) and conservation groups
Rod Safstrom, Australian Trust for Conservation Volunteers.

Fire control Port Kennedy style
Jeff Anderton
Port Kennedy Land Conservation District Committee

Improving liaison and moving forward
Richard Robertsen, WA Fire and Rescue

11 am Morning tea

11.20 am Session Seven: Arson and Publicity
Chaired by Kirsten Tullis, Men of the Trees, Urban Bushland Council Executive

What is the Bush Fires Board doing to reduce the incidence of bush fires?
Mal Cronstedt, Bush Fires Board of WA.

Arson — incidence, causes, consequences and remedies
Tony Carter, Arson Council of WA.

Fire and its effects on arson
Peter Jenal, CIB Arson Squad

"Downtown Dowerin Inferno"
Patrick Cornish, The West Australian.

12.30 pm Lunch

1.30 Session Eight: Looking for answers
Chaired by Mary Gray, Wildflower Society of WA, Urban Bushland Council Executive.

Fire hazard on the Darling Scarp
John Day, MLA for Darling Range.

Future directions in fighting fire
Pat Hart, Community fire fighter.

Approaches to preventing bush fires
Philip Jennings, Conservation Council of WA.

2.30 Session Nine: So where to now?
Chaired by Mary Gray, Wildflower Society of WA, Urban Bushland Council Executive.

A final plenary session to take us forward.

3pm Close of conference.

Note: For joint papers, the person presenting the paper at the conference is the one underlined in the programme.