

Historical perspectives on mosaic burning in Western Australia's southwest forests

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ABSTRACT: In 1961 intense bushfires devastated parts of the southwest of Western Australia, most notoriously the small town of Dwellingup. These events motivated the predecessor organization to the state government Department of Conservation and Land Management (CALM), to extend their fire management strategy which now involves prescribed, low intensity mosaic burning to remove litter build up from the forest floor and to assist in maintaining and promoting biodiversity. The objectives of researching and writing this paper were to compare the different beliefs and values that have impacted on fire and forest management in the southwest of Western Australia; to clarify the lineage of ideas and practices underlying prescribed burning policy; to explore Indigenous burning with respect to CALM's prescribed burning practices; and to assess the effectiveness of CALM's mosaic burning for preservation of biodiversity in the southwest forests.

1 INTRODUCTION - THE VALUE-LADEN NATURE OF FIRE

In the process of conducting research for this paper a range of experts were consulted for their views on the effectiveness of prescribed burning as an environmental management tool. The array of responses were testimony to the highly value-laden nature of fire and ecology, clearly supporting the argument that fire cannot be considered in separation from its social, cultural, political and historical context, rather that these values are intrinsic to how it is understood and perpetuated. The history of burning by Aboriginal people prior to European invasion has been central to understandings of the ecology and biodiversity of the Australian landscape for more than a decade (Bowman 1998; Ward 1997; Abbot and Burrows 2003; Gill 1986; Pyne 1991, Flannery 1997), including debates about the extent and impact of this burning. Perhaps less studied in relation to these issues is the culture of burning amongst European settlers, the clash of land and fire uses by Aboriginal and European people, and for the purposes of this paper, the policies that developed around fire in the twentieth century in the southwest region, particularly with regards to forests (Ward, 1998; Griffiths, 2002). In our investigations of the histories of 'mosaic burning' we were struck by the numerous understandings of this term, and thus its clarification from across disciplines and cultures was a primary objective. This paper also reveals the significance of the historical conception of fire in the Australian landscape to current research directives and investigates the means by which the success of forest preservation through fire policy and practice is appraised, with particular reference to the biodiversity of the southwest. The region has many spatial representations and is a diverse landscape. Different scales and practices of burning have

been carried out across various forests, including northern and southern jarrah (*Eucalyptus marginata*), karri (*Eucalyptus diversicolor*), and tuart (*Eucalyptus gomphocephala*). This study refers to the boundaries of the Nyungar people's land rather than to any specific forest formations (Tindale 1974; Bindon and Walley 1992).

2 MANY KNOWLEDGES

An important contribution to the clarification of burning practices in the southwest forest is the consideration of many different perspectives. In this paper the knowledges of Aboriginal and European landholders, government scientists and bureaucrats are discussed in relation to fire history. When considering Aboriginal fire practices in the southwest our approach was based in the belief that this is a living knowledge, supported by evidence that Nyungar fire practices have been carried out in the region up to the present day. Glen Kelly has argued that

... [i]n all cases, when a Nyungar's perspective is given, it is based on a traditional lifestyle and knowledge, ... [and] upon the cessation of Nyungar land management practices, dramatic changes occur to the land. Up until 20 or 30 years ago, Nyungar land management practices, which involved frequent cool fires over much of the country, were maintained to a large extent by the cattlemen of the south coast. They used skills shared with them at the time of settlement, when a major part of the rural work force was Nyungar people. (Kelly 1998 p.52)

Noel Nannup, who we consulted regarding Nyungar burning practices, has been successful in translating his knowledge across cultural and disciplinary boundaries, working as a National Parks ranger and establishing the Indigenous Heritage Unit at the Department of Conservation and Land Management (CALM). Noel provided a unique and important perspective on fire derived from his personal history and invaluable cultural knowledge. He spoke of *Karla Mia Djugabra*, or Firestick Dreaming, which is a significant element of the Nyungar understanding of land, water, sky, fire and people. Marissa Maher and Delvene Cornwall from the Indigenous Heritage Unit at CALM also alerted us to the significance of fire and burning practices for Nyungar women and this is an area of knowledge that requires further investigation. The spatial and spiritual complexity that characterized Nyungar society prior to European invasion is important when considering the movements of fire at that time. Dreaming trails, which cross the landscape, were most probably burnt annually with a high degree of random frequency burning between the trails, in accordance with tribal events, food requirements and the response of different vegetation and animals. As families left an area they were responsible for burning in order to ensure plentiful supplies and traversable land in the following season. Firing was used on a smaller scale, particularly in riparian areas, to attract animals to the new shoots. Practices may have varied in different areas of the southwest, however the Nyungar word for fire, *Karla*, appears to have been fairly uniform and could indicate the integration of knowledge and practices throughout the region. Noel Nannup described these practices as creating a landscape pattern similar to a patchwork quilt, or mosaic; another description was of fingers of burnt trails across the landscape. In this schema, fire is central to the interdependent relationship of people and their ecology; it is a sacred element that invokes the holistic life-cycle. Nyungar knowledge of plant and animal species and other fire related subjects, including at the landscape scale, is a significant and important source for future direction in human-environment relationships in the southwest.

Spatial complexity also features in other perspectives and histories of fire, forest and society. Colonization and the introduction of a European model political economy in the southwest region contributed to immense change, leading to what is currently conceived as a fragmented landscape, another form of mosaic. The region now has vast areas of cleared land for agriculture, areas affected by salinity, national parks and reserves, waterways, riparian and heath lands, urban and industrial development, and varying scale patches of remnant vegetation. Initially, fire was utilized by European settlers to remove cleared vegetation and promote pasture growth. Woody fuel was

often left as a result of logging, vital to the fledgling colony, and fire was used to 'clean-up' in order to avoid wildfire.

Despite the changes that occurred in the southwest landscape over the first century of settlement, at the 1961 Royal Commission into the southwest fires Commissioner G. J. Rodger declared that Australian forests were still in a 'virgin state', in contrast with European forests which were considered to pose less fire risk because of more intensive and prolonged use. In his summing up Rodger stated that '[m]any witnesses referred to the "good old days" when the forest was burnt and kept burnt. Actually, the position appears to have been that, while the forest may have been frequently burnt in the early days of settlement, it was not kept burnt. On the contrary, many of the fires which occurred from time to time resulted from deliberate action by man to destroy the fire hazard of logging debris left lying in the forest. The burnings generated intense heat and resulted in the destruction of all regrowth and in serious damage to the remaining trees' (Rodger 1961 p.51). The debris left by early unregulated felling of the forest contributed to more intense conflagrations, with the second-growth trees and scrub also prone to fire (Hallam 1975). The Commissioner found that the 'settler's burning off fires [were] not only the greatest single cause of bushfire but ... also responsible for the largest area burnt over' and that '[c]ontrol burning of a forest is an operation which must be practiced as an art if it is to be carried out without obvious damage to the stand ...' (Rodger 1961 p.51). There is some evidence then that in conjunction with developments in the timber and agriculture industries, individual landowners carried out protective burning as an attempt to avoid wildfire and keep the forest 'clean'. Such unregulated practice ran counter to developing ideas amongst some government bureaucrats about the need for a controlled, civilized and minimally burnt forest. There were also clashes between Nyungar and forestry practices, as Sylvia Hallam has suggested; the object of Nyungar burning was not the same as that of the European forest management which succeeded early felling, 'native groups had valued grazing, not timber'(Hallam 1975).

There were variations on the 'art' of controlled burning by foresters over time. Charles Lane-Poole, Conservator of Forests from 1916 to 1922, supported a total fire exclusion policy with the goal of achieving a point of balance at which forests would no longer burn. Lane-Poole's well-known democratic leanings towards forest preservation were bound with his strategy to also make them more profitable. In a report prepared for the British Empire Forestry Conference in London, Lane-Poole declared that '[t]he control of fire alone will have a tremendous effect on the general growth of the timber density of the stocking. With proper forest management and sound silvicultural treatment there is no reason why there should not be built up on the wreckage of the once splendid forests of Western Australia tended forests which will yield for all time 100 cubic feet of timber acre per year' (Lane-Poole 1920). S. L. Kessell, Lane-Poole's successor, came to favor principles of controlled burning, believing that it would 'play a large part in forest protection, as well as in silvicultural practice' for many years (Kessell 1928 p.17). Some time later, it was reported at the sixth British Commonwealth Forestry Conference that during the war and post-war period (1939-1949) severe fire damage was experienced in at least a million acres of the far south; fires were blamed on the lack of staff and 'lack of normal rate development.' (Stoate 1952 p.11). During the war period official policy had suppressed burning on the grounds that fires might provide guidance to Japanese night bombers (Ward 1997, p.13). Financial resources were sought to establish 'at least 10,000 miles of additional roads and tracks ... which, with the attendant fire staff and organization, could bring this area under management and reduce the serious annual losses' (Stoate 1952 p.11). In 1950 a Forest Research Station was established at Dwellingup, jointly funded by the State and Commonwealth governments, (the Forests Department had set up a fire weather station there in 1934).

G. J. Rodger's conclusions at the 1961 Royal Commission countered the popular opinion that the Forests Department was not carrying out controlled burning in the Dwellingup forest. Some areas had been reserved from burning for scientific research, however Rodger claimed that most of the Dwellingup Division had been subject to controlled burning in recent years. He called for greater co-operation between the Forests Department and local Bushfire Brigades along with better communications infrastructure, effectively absolving and supporting the controlled burning

programme. His findings and the recommendation that the Forests Department should extend their programme has continued to feature in the argument for the importance of controlled burning practice in the southwest of Western Australia.

3 FIRE HISTORY AND FOREST MANAGEMENT

Over the last few decades there has been an increasing literature that addresses the history of environmental management in the Australian setting. Historians such as Geoffrey Bolton and William Lines have defined the human-environment relationship in post-invasion society as characterized by conquest, deriving from European concepts of nature/culture duality. More recently Andrea Gaynor and Patricia Crawford have both written about the importance of social, political and economic history to such issues as salinity and forest clearance in Western Australia. The history of preservation and conservation is a significant part of the land management story of the past 200 years. The influential work of Libby Robin, Eric Rolls, Tim Bonyhady and Tom Griffiths regarding preservation and environmental movements in Australia draws connections between these concerns and developing national and regional identities. Rolls' and Griffiths' work in particular has addressed the importance of forests in the national psyche, the 'politics of understanding regrowth', the 'culture of burning in Aboriginal and settler society and its implications for management and biodiversity' (Griffiths 2002 p.375). Griffiths argues that 'from the 1970s, with a growing appreciation of the Aboriginal practice of firestick farming, light regular burning of national park and wilderness landscapes acquired a new, *historical* significance' (Griffiths 2002 p.383). Accordingly, when Stephen Pyne wrote of the intrinsic nature of fire to the Australian bush, he couched the prescribed burning program within terms of a shared natural and cultural heritage, asserting that '[t]he perceived pervasiveness of Aboriginal fire helped inspire an Australian system of fire-protection – unique in the world – that emerged during the 1950s ... The torch was passed, not extinguished (Pyne 1991 p.135). The system to which Pyne refers originated in Western Australia, as acknowledged by A. G. McArthur. He wrote that '[f]rom a modest beginning in Western Australia during the early 1950's, area prescribed burning has extended throughout Australia as a cheap practical means of reducing the danger of conflagrations. The practice has extended into a wide variety of plant associations and climatic conditions, and has achieved the status of a skilful art' (McArthur 1966 p.10).

McArthur was the technical advisor to Rodger during the 1961 Royal Commission. He became director of the Forest Research Institute in Canberra during the 1970s, and was a proponent of prescribed burning. His major publication on the subject was based on his own research and the practice of the Forests Department in Western Australia (Pyne 1991). In his research, McArthur looked to the historical records of explorers and early settlers to find the fire history of the nation. His conclusions were that Aboriginal burning was widespread at the time of European settlement, that with the 'drastic decrease in the Aboriginal population and extension of agricultural settlement, especially sheep grazing, the incidence of fires appears to have decreased for a period' and that the 'incidence of destructive fires increased as land settlement extended into forested land...' (McArthur 1970, p.21). Referencing the work of Charles Gardner, McArthur described Australia as 'the most arid continent on earth' with a highly endemic flora and fauna adapted to living in an environment dominated by periodic fire (McArthur 1970 p.3). He believed that area prescribed burning maintained benefits above more complex and expensive technology in the prevention of wildfire. McArthur referenced the work of American fire behaviour expert, Clive M. Countryman, as proof of the 'cutting edge' status of the Australian controlled burning program. Countryman had previously declared that he was 'not sure what the answer to the Southern California fire problem [was]', but that he did not believe the fires would be stopped by 'sheer weights of sophisticated equipment' (McArthur 1970 p.22). McArthur emphasized that European civilization and technology had restrained the development of the Australian continent for 'a century or more', and that Anglo Australians had struggled to develop the appropriate means for the management of fire for almost 200 years (McArthur 1970 p.6). Through the historical landscape of fire, McArthur

envisaged a method of economical and adaptable environmental management that was grounded in science and relevant to the nations of the new world. His advocacy of prescribed burning drew on a background in forestry, however his findings were an important part of a more general shift in the historical understanding of forests and fire in the Australian landscape (Jones 1969; Hallam 1975). Forest management policy continues to respond to this historical conception of fire, along with the more recent concerns of declining rainfall and increased fuel loads.

4 RISE OF AN ECOLOGICAL CONSCIOUSNESS

Libby Robin has discussed the social and environmental importance of the 'rise of an ecological consciousness' in Australia during the 1970s and onwards. In Western Australia, CALM has marked the increasing value attached to the environment by the public as a significant factor in their approach to and the limitations on their fire practice. In fact the Department is itself testament to an increased politicization of the environment, formed in the 1980s under the auspices of the Burke Labor government. Burning to maintain and promote biodiversity is now listed alongside the protection of life and property as the major pressures and attainments of CALM's programme. (CALM website www.calm.wa.gov.au/forest_facts/fire_forest.html accessed 01/11/04). CALM's policy has been informed by ongoing scientific research, including that of David Ward, Malcolm Gill, Ian Abbott and Neil Burrows. David Ward in particular has drawn on the historical record of fire and the southwest forest to support his research directives. Ward has contributed to the investigation of local fire history in jarrah, karri and tuart forests, combining the use of historical and anthropological research with the marks on the stems of balga (*Xanthorrhoea preissii*), as natural texts which divulge information about the frequency of fire over hundreds of years (Ward et al. 2001). Ward made a number of recommendations from his research, which drew on a comparison between the frequent burning of pre-European Aboriginal society and the growing restrictions on CALM's burning due to public opposition and lack of opportunity and resources. He identified significant historical sources to support the argument of widespread use of fire by Aborigines at the time of early settlement, suggesting that it was the urban dweller that was new to the landscape, rather than the smoke generated by fire. Ward also argued that '[i]f Nyoongar people burnt as frequently as the evidence presented suggests, then it would be more rational to switch the research spotlight away from the effects of frequent burning, and toward the effects of not burning for long periods (Ward 1997 p.20).

In his study of the tuart in the Yalgorup National Park, Ward concluded that the restoration of traditional Nyungar fire regimes was the most likely answer to the problem of the diminishing forest, if pursued carefully, and that Nyungar owners who have knowledge to contribute should be paid to be involved in the fire management of the park' (Ward 2000). The initiative to implement co-management in the southwest includes the 'Memorandum of Understanding' for the development of cooperative management arrangements for the D'Entrecasteaux and Shannon National Parks, signed by CALM and the Manjimup Aboriginal Corporation in 1988. Neil Burrows, Director of the Science Division at CALM, has more recently supported the idea of co-management schemes across the state based on the 'empirical knowledge accumulated from experience over hundreds of generations' of Aboriginal people. He suggests that

'... [g]iven the importance of country to Aboriginal people, conservation and land management, including fire management, need to go beyond biodiversity. In the words of the Ngaanyatjarra Council, cultural conservation needs to occur to assist Indigenous land owners to continue caring for country' (Burrows 2003).

The highly fragmented nature of the southwest country does present problems for this kind of approach. The most recent pilot project directed by Burrows in the deep southwest corner of the state, at the Walpole Wilderness Area, is an experiment in fine-grained mosaic 'patch burning'. Rather than drawing significantly on indigenous knowledge it is based on the theorization of

natural systems and patterns of disturbance. Ecological theory which supports the reconstruction of the mosaic pattern fire history of the forest dates back to the 1970s when the association between varying fire frequency, intensity, scale and plant and animal biodiversity had been identified (Western Australia Wildlife Authority 1975). An accurate picture of how the patch burning technique will impact on the forest is difficult to determine, especially at the ecosystem scale. The reserve mentality, whereby fragments of the landscape might be subject to ecological and indigenous burning practices in order to maintain pockets of cultural and natural heritage must be considered within the context of the bioregion which may be subject to increasing development and accompanying clearing. Even when CALM's burning practices are informed by a high degree of local and historical knowledge, it is significant that at the landscape scale the ecosystem continues to undergo change.

Some recent literature in landscape and urban planning challenges the viability of natural reserves to 'mitigate the human impacts on nature caused by industrialisation' (Jongman et al. 2004). This argument highlights the need for quality habitat which allows species to move through and re-colonise the landscape. Islands of habitat that exist on various scales as remnant vegetation, reserves and national parks are part of a general approach to conservation planning which treats 'both biodiversity and human economic systems as static'. The implementation of conservation actions is subject to social and political variables, such as budgets, and tend to be 'unpredictable, both in space and through time'. In the meantime, changes in ecological processes continue to take place, biodiversity may be lost and 'the geography of both human dominated and natural landscapes changes' (Meir et al. 2004). A more transparent and well-informed public debate is required in order to define the values of biodiversity and the processes of ecology at a landscape scale, in conjunction with the values of protection of property and life in relation to burning practices in the forest. This kind of debate will need to have access to and draw from different sources of knowledge and experience, including those of the indigenous, non-indigenous, environmentalist, scientific, agricultural and urban communities.

5 TOWARDS AN ASSESSMENT OF CALM'S CURRENT POLICY AND PRACTICE

CALM is responsible for 23.5 million hectares of land, almost 10% of Western Australia (CALM 2003). It is also responsible for the conservation of Western Australia's biodiversity (CALM 2003). Since July 2003, CALM has been handed a further 90 million hectares of unallocated Crown land and unmanaged reserves, constituting a further 36% of Western Australian land (CALM 2003). In the 2002/2003 bushfire season, CALM attended 549 wildfires which burned 140 000 hectares of the southwest forest regions. 275 of these fires were started by lightning strikes and 126 000 hectares of the total area burnt was on land managed by CALM (CALM 2003). Assessment of the effectiveness of CALM's mosaic fire policy and 40 years of research and implementation must be directed by the objectives of prescribed burning and the scale and indicators by which the assessment is made.

From the CALM literature, there appears to be two distinct operations: the management and the science of fire in the forests of the southwest of Western Australia. They present two different, and perhaps complimentary, perspectives towards the role and impact of fire in the region. CALM literature from the fire management perspective is focused on the mechanics of fire suppression and fuel reduction, when and how to burn as well as how often to burn and areas that should be prevented from burning (McCaw 1993). Habitat management, forest regeneration and environmental values are often listed as secondary reasons to burn (McCaw 1993; Sneeuwjagt 1994) but usually in the context of reducing "the quantity of dead leaves and twigs on the forest floor and therefore starve a future wildfire of much of its fuel" (Underwood and Sneeuwjagt, 1993; Sneeuwjagt and Higgs 1995). It is clear that the objectives for prescribed burning in the southwest forests for fire management are for protection of life, property and assets (Underwood and Sneeuwjagt, 1993). Protection of environmental values or the preservation of biodiversity has often been presented as secondary: "Although the focus of these operations tends to be on those areas

adjacent to the highest values, such as towns and farms, areas vulnerable to serious fire damage such as regrowth forests and pine plantations are also protected” (Underwood and Sneeuwjagt, 1993).

The CALM prescribed burning program for the southwest has a target of between 200 000 and 240 000 hectares per year burnt by low intensity, slow moving fires to reduce fuel build up (Sneeuwjagt and Higgs 2000; CALM 2003). Areas subject to prescribed burning have been burnt routinely at 5 to 10 year intervals for several decades (Burrows et al 2003). Typically firing is carried out in spring when moisture differentials exist over and across the landscape enabling different vegetation types to respond differently to the fire. It is unclear whether this program provides a mosaic within the burnt block. Over the last 10 years, between 60 and 80% of the total area burnt by the prescribed burning program was ignited by aerial incendiaries (Sharp, 2003). Because vegetation burns at different frequencies and different rates, subsequent ignitions of an area are carried out “to burn a mosaic of each major vegetation type as the fuel moisture burns out” (Sneeuwjagt and Higgs 2000). It would appear that multiple ignitions over the same area would rather result in the greatest proportion of the block being burnt out. Burrows et al (2003) indicate that there is a risk of re-ignition of fuel later, leading to burning out of the entire landscape and to possible fire escape. Sneeuwjagt (1994) notes that escape burns do occur, usually due to unpredictable changes in weather conditions. According to Sneeuwjagt (1994) the percentage of these escapes is small, decreasing from 7.5% in 1989/90 to 3% in 1992/93. However, given that these prescribed burns are often conducted adjacent to “areas of the highest values” (Underwood and Sneeuwjagt 1993) the potential detrimental effects of such an escape, no matter how small the risk, could be devastating – such as to wipe out an endangered species. Unplanned wildfires, started by arson or lightning, pose an equal risk.

Over the last several years the State has experienced extended drought conditions and CALM’s prescribed burning target has not been achieved over this time. CALM (2003) predicts that up to 75% of the Department’s lands are vulnerable to severe wildfires and that if the annual target for burning is not increased to 250 000 to 300 000 hectares a year, the increase in heavy fuels will continue to pose a serious hazard. The CALM 2003 report also notes that the costs for the “planning, preparation and implementation of prescribed burning has doubled in the last 5 years” and attributes part of this to the decrease in average burn sizes, the shapes being more irregular, and the increasing demand to exclude areas containing rare and endangered flora and fauna.

The objectives of the prescribed burning practice are indicated by the means through which success is measured. Loss of life and number of fires are the main statistics quoted when supporting the claim of the success of the policy (McCaw 1993, Underwood and Sneeuwjagt 1993, Sneeuwjagt 1994). However, no measurement of the success of the preservation of biodiversity is similarly provided (Wells et al 2004) although is often quoted (Sneeuwjagt 1994; Sneeuwjagt and Higgs 1995; Hodgson 2004). This is no doubt due to the ease and low cost of measuring the former compared to the latter but leaves the argument lacking the necessary supporting evidence. In fact, contrary to these statements, CALM’s Biodiversity Audit of Western Australia’s 53 Biogeographical Subregions (2002) noted that a priority gap in the knowledge included the effect of and response to fire in the jarrah forests, noting that the data was limited to a few communities and taxa. Further, for the jarrah regions and Warren, little to no data is available as to the “regional context on life-history (including population trend) of most species including predators (fox, cat), invertebrates and reptiles. Most reserves don’t have long-term survey data on species presence or absence, even for vertebrates” (CALM, 2002). Information on population ecology and biology for both the flora and fauna in the region is lacking. That being the case, it is difficult to make any claims as to the success or failure of preserving this biodiversity.

As a result, a major question arises as to how to evaluate ecosystem integrity and biodiversity. These need to be assessed first before the impact of fire upon any ecosystem and the biodiversity within can be evaluated. Further, the definition of biodiversity needs to be clarified. If biological biodiversity is taken as that described in the Convention on Biological Diversity (United Nations Environment Programme 1992), it is the “variability among living organisms from all sources ... and the ecological complexes of which they are part; this includes diversity within species, between

species and of ecosystems". However, as the Convention explains an ecosystem is a "dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." Ecosystems consist of dynamic processes as well as the functions of and relationships between components of the ecosystem, therefore measurements of the number of certain species present in a given ecological block at a given point in time may not reveal the underlying dynamics of the ecological state of the system. More information over a longer time frame is required to assess the sustainability of an ecosystem. Ecosystem health methodologies (DellaSalla et al 1995, Yazvekno and Rapport 1996, Hodges and Regens 1996, Vora 1997) offer an alternative approach, explicitly recognising the values and capacity of forests to sustain healthy human communities and may be a more useful method to assess the impact of CALM prescribed burning practices on the southwest forests.

Given the lack of evidence to support the success of prescribed burning for landscape biodiversity, can the effectiveness of CALM's fire practice in relation to this objective be assessed? Many studies have been conducted, by the Science Division at CALM and others, investigating the impact of species richness after a fire and the most appropriate fire regime for various specific species of flora and fauna (York 1999, Burrows and Wardell-Johnson 2003, Robinson and Bougher 2003, Van Heurck and Abbott 2003, Burbidge 2003, Bamford and Roberts 2003, Friend and Wayne 2003, Auld and Scott 2004, Chistensen and Maisey 1987). Studies have also been completed on the effect of fire on other elements of the ecosystem such as organic substrates (Horwitz et al 2003), and nutrient availability (Adams et al 2003). However, all these studies tend to focus on specific parts of the ecosystem rather than the ecosystem response as a whole (Hodgson 2004). Thus, results from these studies should be used carefully when extended to fire management of ecosystems across the south-west as the same species can respond differently to fire depending on fire intensity, fire history, climate and location within the landscape (Burrows and Wardell-Johnson 2003). In addition, a question remains as to the correct control against which disturbances within the studied burnt area should be compared. Ecosystems of the south-west have experienced a major ecological event with dramatic shifts in the fire practices over an evolutionary short time frame. It is not unreasonable to think that these systems are still adapting to the many changes in fire regime. Thus, there is uncertainty as to whether an unburnt patch is the ideal control site to use in study comparisons of species change due to particular fire regimes (e.g. Abbott et al 2003). The fire regime experienced by the control site is unknown as is the ideal fire regime for ecosystem biodiversity requirements. An added unknown is the degree to which species composition of the ecosystem has been changed by European settlement. This system is likely to be responding to a shifting fire practice and regime that has been dramatically changing for over 100 years. Thus the unburnt patch may not be a control but rather another area subject to a different fire regime.

There is still a knowledge gap for ecosystem response to fire and the most suitable fire regimes to preserve biodiversity. Western Australian forests lack long term and broad scale information about previous species composition and sustainable ecosystem components. Without this information, we cannot assess the effectiveness of current or future fire management practices towards preserving biodiversity. The pilot study of Burrows et al (2003) into the effects of fine-grained scale mosaic burning using a detailed monitoring programme for a wide range of both flora and fauna species may go some way to answering the core question: can prescribed burning that produces a mosaic on the vegetation scale (as opposed to the landscape scale) promote biodiversity? Again, the results of this study will be site and time specific and caution should be used when attempting to extend the programme to the rest of the southwest forests. However, it may well be that a rigorous study and monitoring programme will show a conflict between burning for fuel and hazard reduction and burning for biodiversity (Cary 1996). In any case, a rigorous monitoring programme across all of CALM's land is much needed to truly assess the effectiveness of their prescribed burning programme, regardless of the objectives.

6 CONCLUSIONS - WHITHER THE MOSAIC

The word 'mosaic' is used profusely in discussions and presentations of fire management and policy in Western Australia. It is used in different contexts and refers to different scales within these contexts. For example, there is the mosaic produced as a result of indigenous fire practices, driven by a number of social, cultural and economic objectives and practiced at a variety of scales from the species to the landscape level. There is what Neil Burrows calls the fine-grained or intra-patch mosaic, this is at the ecosystem level, between individual plants or small communities of plants. There is the fire unit mosaic created by burning large hectares at different frequencies to create over the landscape patches of different burn history. There is the mosaic that has been created by the fragmentation of our landscape – the southwest – including patches of protected forest, timber industry, wetlands, cleared land, agriculture, areas of dieback, areas of saline-affected ground, mining areas, heathland, and towns. And all of these mosaics change and evolve through time, adding an additional mosaic – sometimes conceived as snapshots of the landscape through time.

Through the historical and scientific investigation of fire it has been revealed that the relationship between fuel reduction prescribed burning and burning for biodiversity is a problematic one. Fuel reduction burning supported the programme to protect life, property and the forest, primarily as a timber source. The rise of ecological concerns and the politicizing of the forest caused the addition of preservation and the promulgation of biodiversity as objectives. Accompanying this were developments in the historical understanding of fire as necessary to endemic species, and the impacts of climate change and increased fuel loads. Without the evidence to support or assess the current claims to protect biodiversity, prescribed burning policy rests to some extent on an historical understanding of fire in the landscape. However, as this paper has identified, burning by Aboriginal people prior to the introduction of European forestry and other industries had different objectives and spatial circumstances. The replication of mosaic burning has been one approach to conserving pockets of forest heritage; we believe that there could be a more holistic approach that would involve a rethinking and redefining of current objectives, making reference to invaluable Indigenous knowledge. It is the way that we manage the land at both the landscape and the ecosystem level that affects the biodiversity and will ultimately determine whether these ecosystems are sustainable in the long term.

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REFERENCES

- Abbott, I. Burbidge, T., Strehlow, K., Mellican, A., and Wills, A. 2003. Logging and burning impacts on cockroaches, crickets and grasshoppers and spiders in Jarrah forest, Western Australia, *Forest Ecology and Management* 174: 383-399.
- Abbott, I. and Burrows, N. (eds) 2003. *Fire in ecosystems of south west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Adams, M.A. Grierson, P.F. and Burrows, C. 2003. Fires, soils and plant nutrition in forests of south-west Western Australia: a focus on spatial and temporal variability. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Auld, T.D. and Scott, J. 2004. Estimating population abundance in plant species with dormant life-stages: Fire and the endangered plant *Grevillea caleyi* R. Br., *Ecological Management and Restoration* 5(2):125-129

- Bamford, M.J. and Roberts, J.D. 2003. The impact of fire on frogs and reptiles in south-west Western Australia. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Bindon, P. and Walley, T. 1992. Hunters and Gatherers. *LANDSCOPE* 8(1): 31-35.
- Bolton, G. 1981. *Spoils and Spoilers: Australians Make their Environment 1788-1980*. Sydney: Allen and Unwin.
- Bonyhady, T. 2000. *The Colonial Earth*. Melbourne: Melbourne University Press.
- Bowman, D. 1998. Tansley Review no. 101: the impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* 140: 385-410.
- Burbidge, A.H. 2003. Birds and fire in the Mediterranean climate of south-west Western Australia. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Burrows, N. 1998. A fire for all reasons, *LANDSCOPE* 13(3): 18-
- Burrows, N. 2003. Using and Sharing Indigenous knowledge. *Australia Burning: Fire Ecology, Policy and Management Issues*: 205-210.
- Burrows, N. and Wardell-Johnson, G. 2003. Fire and plant interactions in forested ecosystems of south-west Western Australia. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Burrows, N., Liddelow, G., Green D., Bain, K., Freebury, G., 2003, *Fire-induced habitat mosaics in South-West Landscapes*, Draft.
- CALM, 2002. *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002*, Perth: CALM.
- CALM, 2003. *Department of Conservation and Land Management Report on 2002/2003 Bushfire Season*, Perth: CALM
- Cary, G. 1996. Conservation conflicts over burning bush in south-eastern Australia, *Biological Conservation* 76: 167-175
- Christensen, P. and Maisey, K. 1987. The use of fire as a management tool in fauna conservation reserves in *Nature Conservation: The Role of Remnants of Native Vegetation*, Perth: CALM.
- Crawford, P. and Crawford, I. 2003 *Contested Country: A History of the Northcliffe area, Western Australia*. Nedlands: UWA Press.
- DellaSalla, D.A. Olson, D.M., Barth, S.E., Crane, S.L. and Primm, S.A. 1995. Forest health: moving beyond rhetoric to restore healthy forest landscapes in the inland Northwest. *Wildlife Society Bulletin* 23: 346-356.
- Flannery, T. 1997. *The future eaters: an ecological history of the Australasian lands and people*, Sydney: New Holland Publishers.
- Friend, G. and Wayne, A. 2003. Relationships between mammals and fire in south-west Western Australian ecosystems: what we know and what we need to know. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Gaynor, A. 2002. Looking Forward Looking Back: Towards an Environmental History of Salinity and Erosion in the Eastern wheatbelt of Western Australia. *Country: Visions of Land and People in Western Australia*: 105-123.
- Gill, A.M. 1986. *Research for the Fire Management of Western Australian State Forests and Conservation Reserves*. Perth: Department of Conservation and Land Management.
- Griffiths, T. 2001. *Forests of Ash: an environmental history*. Melbourne: Cambridge University Press.
- Griffiths, T. 2002. How many trees make a forest? Cultural debates about vegetation change in Australia. *Australian Journal of Botany* 50: 375-389.
- Hallam, S. 1975. *Fire and Hearth: a study of Aboriginal usage and European usurpation in South-Western Australia*. Canberra: Australian Institute of Aboriginal Studies.
- Hodges, D.G. and Regens, J. L. 1996. Methodological issues in valuing forest ecosystem health. *Ecosystem Health* 2(1): 52-55.
- Hodgson, 2004. *Conservation and Land Management's (CALM) fire management policies and practices, A Report to the EPA*. Perth: Government Printer
- Horwitz, P. Judd, S. and Sommer, B. 2003. Fire and organic substrates: soil structure, water quality and biodiversity in far south-west Western Australia. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Jones, R. 1969. Fire-stick farming. *Australian Natural History* 16: 224-228.

- Jongman, R.H.G. Kulvik, M. and Kristiansen, I. 2004. European ecological networks and greenways, *Landscape and Urban Planning* 68: 305-319.
- Kelly, G. 1998. Karla Wongi: Fire Talk. *Landscape* 14(2): 50-53.
- Kessell, S. 1928 *The development of forest practice and management in Western Australia*. Perth: Forests Department.
- Lane-Poole, C. 1920. *Statement Prepared for the British Empire Forestry Conference London*. Perth: Government Printer.
- Lines, W. 1991. *Taming the Great South Land: A history of the conquest of nature in Australia*. North Sydney: Allen and Unwin.
- McArthur, A.G. 1966. Prescribed Burning in Australian Fire Control. *Australian Forestry* 30(1): 4-11.
- McArthur, A.G. 1970. The historical place of fire in the Australian environment. *Symposium papers presented at the second Fire Ecology Symposium*: 1-22.
- McCaw, L. 1993. Wildfires: living with the threat *LANDSCOPE* 9(1): 50-52.
- Meir, E. Andelman, S. and Possingham, H.P. 2004. Does conservation planning matter in a dynamic and uncertain world? *Ecology Letters* 7: 615-622.
- Pyne, S. 1991. *Burning Bush: A Fire History of Australia*. Sydney: Allen and Unwin.
- Robin, L. 1998. *Defending the Little Desert: The Rise of Ecological Consciousness in Australia*. Melbourne: Melbourne University Press.
- Robinson, R.M. and Bougher, N.L. 2003. The response of fungi to fire in Jarrah (*Eucalyptus marginata*) and Karri (*Eucalyptus diversicolor*) forests of south-west Western Australia. *Fire in ecosystems of south-west Western Australia: impacts and management*, Western Australia: Backhuys Publications.
- Rodger, G.J. 1961. *Report of the Royal Commission appointed to enquire into and report upon the bush fires of December, 1960 and January, February and March, 1961 in Western Australia: the measures necessary or desirable to prevent and control such fires and to protect life and property in the future, and the basic requirements for an effective state fire emergency organization*. Perth: Government Printer.
- Rolls, E. 1981. *A Million Wild Acres: 200 years of man and an Australian forest*. Melbourne: Nelson.
- Sharp, C. 2003. *Question on Notice*, Legislative Council, 19th August 2003.
- Sneeuwjagt, R. 1994. Fighting Fire with Fire, *LANDSCOPE* 9(3): 36-38
- Sneeuwjagt, R. and Higgs, N., 1995. Fighting Wildfires: breaking the triangle, *LANDSCOPE* 10(4): 44-48.
- Sneeuwjagt, R. and Higgs, N., 2000. Managing a fiery change. *LANDSCOPE* 15(4): 37
- Stoate, T. 1952. Forest Policy and Management. *Sixth British Commonwealth Forestry Conference Forests Department Bulletin* 61: 10-11.
- Tindale, N. 1974. *Tribal Boundaries in Aboriginal Australia*. Canberra: Australian National University Press.
- Underwood, R. and Sneeuwjagt, R. 1993. Where here's fire there's smoke. *LANDSCOPE* 8(3): 12-16
- United Nations Environment Programme 1992. *Convention on Biodiversity*, Rio de Janeiro.
- Van Heurck, P. and Abbott, I., 2003. Fire and terrestrial invertebrates in south-west Western Australia. *Fire In Ecosystems Of South-West Western Australia: Impacts And Management*. Western Australia: Backhuys Publications.
- Vora, R.S. 1997. Developing programs to monitor ecosystem health and effectiveness of management practices on lakes states national forests USA. *Biological Conservation* 80: 289-302.
- Ward, D. 1997. *Reconstructing The Fire History Of The Jarrah Forest Of South-Western Australia: A Report To Environment Australia Under The Regional Forest Agreement*. Canberra: Environment Australia.
- Ward, D., Lamont, B. and Burrows, C. 2001. Grass trees reveal contrasting fire regimes in eucalypt forest before and after European settlement of southwestern Australia. *Forest Ecology and Management* 150(3): 323-329.
- Wells, G., Hopper, S.D., Dixon, K.W., 2004. Fire regimes and biodiversity conservation: a brief review of the scientific literature with particular emphasis on southwest Australian studies. *Consultants Reports Commissioned as Part of the EPA's Review of CALM's Fire Policies and Management Practices*, Perth:EPA.
- Ward, D. 1998. *Fire, Flogging, Measles And Grass: Nineteenth Century Land Use Conflict In South-Western Australia, An Essay In Human Ecology*. Perth: Department of Conservation and Land Management.
- Ward, D. 2000. *Trouble in the Tuart: A Brief Fire History*. Perth: Department of Conservation and Land Management.
- Western Australian Wildlife Authority, 1975. *Policy: Fire In Nature Reserves*. Perth: Department of Fisheries and Wildlife.

- Yazvenko, S.B. and Rapport, D.J. 1996. A framework for assessing forest ecosystem health. *Ecosystem Health* 2(1): 41-51.
- York, A. 1999. Long-term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of southeastern Australia. *Journal of Insect Conservation*, 3: 191-199.