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FIRE NOTE

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TREE DECLINE IN THE ABSENCE OF FIRE

RESEARCH IS LOOKING AT THE LINK BETWEEN DIEBACK IN EUCALYPT FORESTS AND FIRE REGIMES

Eucalypts are arguably the defining feature of Australia's flora. There are more than 800 species of eucalypts and their range in Australia extends from sub-alpine areas, through wet and dry coastal forests, to temperate woodlands and the arid inland. There are only about 12 species of eucalypt that occur naturally outside Australia, and only two species are not found in Australia.

There is general scientific agreement that the eucalypts evolved from previously widespread rainforest associations, in response to dramatic environmental changes associated with continental drift, declining soil fertility and a drying climate.

Forests and woodlands are naturally fragmented – water features, rock outcroppings, and shrubby areas can all be part of the forested environment. Different forest types and different successional stages generally can also occur within the greater forest boundary.

Indigenous people used forests and disturbed them for various purposes, particularly through the use of fire. Since the arrival of Europeans in the Australian environment it has been estimated that there has been a reduction of around 37% in the area covered by forests and woodlands. Up until the 1980s land with a potential for agriculture was often cleared, resulting in many remnant forests and a reduction in the earlier more extensive range of forest types.

Australia's remaining forests can also change in character over time, particularly as a consequence of changed fire regimes, the extraction of the range of products and services that forests can provide, and through the introduction of weed species, feral animals, pests and pathogens.

EUCALYPT DECLINE

Eucalypt decline or 'dieback' has been observed since the late 1970s across extensive areas of temperate eucalypt forest. Forest types as diverse as the Tuart woodlands of Western Australia., the coastal forests of New South Wales and the high altitude *Eucalyptus delegatensis* forests of Tasmania are affected.

While variations occur in the characteristics of dieback across forests and locations, there is a significant degree of commonality. In individual tree crowns dieback commences with loss of foliage, followed by dieback of small branches in conjunction with re-sprouting from epicormic buds. With time, epicormic derived foliage comes to dominate, the tree crown becomes very thin and many dead branches are evident. Crown and tree death complete the process. Tree decline varies over time, with increases in intensity in some years followed by a period

SUMMARY OF RESEARCH

Eucalypt decline in the absence of fire, Bushfire CRC Project B7, is lead by Neil Davidson (project leader) and Dugald Close (project manager) of the University of Tasmania.

The researchers are working with the Forest Fire Management Group, the Department of Environment and Conservation (WA), the Tuart Health Research Group (Murdoch University), Forests NSW, Forestry Tasmania, the Department of Environment and Heritage (SA), the Department of Sustainability and Environment (Vic), the Department of Arts, Environment and Heritage (Tasmania) and the Tasmanian Fire Service.

This project will guide the development of policies on the frequency of fire required to maintain overstorey eucalypt health in a given forest type. The outcome will be a guide that can be used by forest managers to determine when a forest should be burnt to maintain its health. The guide will be targeted for use by fire managers working in susceptible forest types.

of regrowth, but overall there is a pattern of gradual deterioration. The intensity of dieback sometimes increases with the occurrence of drought although drought is rarely considered to be the primary cause of decline.

The general aim of forest conservation, across most forest tenures, is to ensure that forest ecosystems and the natural processes that sustain them remain intact, for their own sake and for the benefit and enjoyment of future generations.

As research continues to improve our understanding of forests, it is increasingly recognised that disturbance has been a main driver of evolutionary significance across the Australian landscape. Since European settlement new forms of disturbance have been added to the environment on a sometimes unprecedented scale. A number of researchers now believe that the various agents of disturbance may have greater ecological effects than those of any particular agent. It is now considered (for example, see Florence, 2005) that eucalypts can be sensitive to a wide range of factors including;

- various site conditions predisposing eucalypts to environmental stress;
- excessive demand on site resources associated with changes in stand structure;
- an increase in the frequency of occurrence of weeds;
- changes in soil microflora and increased rates of nutrient mineralisation;
- a more persistent shrub understorey;
- greater soil wetness and reduced soil aeration; and
- the activity of pathogenic or antagonistic soil organisms.

Jurskis (2005) suggests that "Competitors, parasites and diseases of eucalypts proliferate" and that stressed trees and their associated physiological changes favour the myriad of antagonists. He suggests that "Koalas, possums, bellbirds, noisy miners, borers, Christmas beetles, leaf beetles, leaf skeletonisers, lerps, loopers, moths, sawflies, and stick insects" have variously been recorded as proliferating in declining eucalypt stands, but that the outbreak of pests and predators is a symptom rather than a cause of eucalypt decline.

Some of the better known examples of eucalypt decline include those associated with Phytophthora (a soil borne pathogen, which is technically classified as a water mould), Armillaria (a pathogenic fungus) and psyllids (sap-sucking insects that feed on a wide variety of eucalypts).

EUCALYPT DECLINE AND FIRE REGIMES

As an ecological factor, fire has operated over geological time-scales to profoundly influence the richness, composition and distribution of most of Australia's ecosystems. Much of Australia's biota has evolved in this fire-prone environment and is adapted to, and largely dependent on fire and the attendant variety of fire regimes for its continued existence and development. Importantly however, there are some species and community types which are very sensitive to fire (such as the rainforests of south-eastern and northern Australia).

Complexity can characterise the ecological effects of fire, with a large range of factors potentially being involved - those intrinsic to the ecosystem and its constituent species (e.g. landform, topography and the species' life history attributes) and those extrinsic (e.g. season, climatic variability and episodic events like droughts and floods). Such factors may exacerbate or outweigh changes attributable to fire, so that post-fire succession does not return ecosystems to their pre-fire condition. Indeed, in any given landscape unburnt

UNDERSTANDING THE TERMS

In 1995, in a new milestone in Eucalyptus taxonomy, two botanists proposed 'splitting' the genus with their description of a new genus, Corymbia. This new genus comprised the ghost gums and the bloodwoods. The remainder of the genus Eucalyptus remained untreated at this level in a formal taxonomic sense.

This 'split' remains contentious with, for example, the Australian National Herbarium, among others, taking a more conservative approach. Under this approach the 800 or so species of Eucalyptus remain divided into 13 subgenera, two of which are the ghost gums (subgenus Blakella) and the bloodwoods (subgenus Corymbia). These two subgenera constitute the more recently proposed single genus Corymbia.

Epicormic buds – a characteristic of many species of eucalypt. They allow a tree to sprout new shoots along its branches and trunk in response to tree crown damage by agents such as fire, drought and wind. The small, normally dormant buds, allow the tree to survive until the crown recovers.

Fire regimes – the season, intensity, frequency and scale of fire in a given area over a period of time.

Forests - Australia's State of the Forests Report (2003) defines a forest as; An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.

Prescribed burning – the controlled application of fire, under specific environmental conditions, to a predetermined area and at a time, intensity and rate of spread required to achieve planned management objectives.

Vital attributes – the key life history features that determine how a species lives and reproduces. With respect to fire, these attributes govern how a species responds to fire and/or persists within a particular fire regime. For plants the vital attribute groups are method of persistence, conditions required for establishment and relative longevity. For fauna, shelter, food and breeding requirements largely determine a species' response to fire and to post-fire successional patterns.

Ectomycorrhizal fungi - fungi that live symbiotically on plant roots and provide the tree with water and nutrients in return for carbohydrate.

LEFT: TUART STATE FOREST, WESTERN AUSTRALIA, FREQUENTLY BURNT AREA WITH AN OPEN UNDERSTOREY AND A HEALTHY EUCALYPT OVERSTOREY.

ABOVE: NEARBY, IN AN INFREQUENTLY BURNT PART OF THE YALGORUP NATIONAL PARK, A DEVELOPED UNDERSTOREY AND A DEAD EUCALYPT OVERSTOREY IS CLEARLY VISIBLE.

areas may change in species abundance and composition as much as areas that are burnt. As such, notions of a 'steady state' or a pre-European settlement forest or woodland condition are often meaningless. Instead, biologists and land managers are increasingly grouping species in a given area in terms of their 'vital attributes', and developing predictive models of species responses and successional patterns to various fire regimes.

Over the years there has been much debate regarding the nature of Australia's fire regimes prior to the arrival of Europeans. While sediment cores, dendrochronological studies and general historical records have proved helpful in some locations there is uncertainty about how well most of these methods record the occurrence of low-intensity fires. Again, considerable debate revolves around the nature of fire regimes (particularly in southern Australia) since 1788, the situation being characterised since the early 20th century, by more frequent high intensity fires associated with an increasing emphasis on suppression, and a diminishing use of low intensity fire. Consequently, research has recently started to focus on possible links between changed fire regimes and the increasing phenomenon of eucalypt decline.

Parallel to the debate about changes in fire regimes has been one about changes to vegetation and its associated fauna. Controversy particularly centres on the amount of burning conducted by Aboriginal people, and the relationship between that activity and the extent of grasslands, as opposed to scrubby understoreys in many forest areas. There is however, a reasonable level of agreement that there have been significant vegetation changes in many areas as a result of changed fire regimes over the last 200 years. The 'Pilliga scrub', in central western New South Wales, the denser forests on the Murray River floodplain, and the scrubby foothill forests of Victoria's East Gippsland are all cited as examples of a preoccupation, over the last 150 years, with fire suppression.

Links between changed fire regimes and adverse impacts on forest health are not uniquely Australian in nature. In the southwest of the United States for example, widespread forest mortality has been observed in ponderosa pine *(Pinus ponderosa)* in recent years. While the primary cause of tree death was initially thought to be due to infestations of bark beetles, research has now revealed a somewhat more complex picture. The beetles typically attack physiologically stressed trees. Links are being made between the occurrence of overly dense stands (with individual trees having to compete for available moisture, light and soil), poor tree health and beetle infestation. In turn, a focus on the exclusion of fire in the forests, over the last 100 plus years, is seen as a major contributor to the overstocked stands.

EUCALYPT DECLINE AND THE BUSHFIRE CRC RESEARCH PROJECT

Early in 2006 the Bushfire CRC, following a request from a number of park and forest agencies around Australia, commenced a collaborative research project to investigate links between fire regimes and eucalypt ecosystem health.

This project is the first national study of tree decline caused by reduced frequency or absence of fire. In New South Wales, Victoria, Western Australia and Tasmania there are significant areas where there is evidence linking eucalypt decline to changes in fire management - from historically low intensity fire regimes to more recent approaches effectively leading to fire exclusion.

The project is concentrating on testing the following hypotheses:

- Exclusion of fire from regrowth forests is leading to dense understorey and litter development, which changes soil and microclimatic conditions;
- The decline in competitive ability of eucalypt roots in altered surface soil conditions, below a dense understorey, is associated with elevated nitrogen status and altered microbial communities (particularly ectomycorrhizal associations);
- Declining root vigour induces stress as water demand increases with increasing transpirational capacity of the forest. Resulting changes in physiology and nutrition increase the susceptibility of trees to pathogens and pests;
- Any adverse factor such as drought, fungal infection or other pest attack reinforces the physiological changes and contributes to the trees' irretrievable decline. Unhealthy trees become more susceptible to drought stress than corresponding understoreys that are favoured by fire exclusion.

Research sites consisting of adjacent stands in the same forest with contrasting fire histories (long unburnt, and frequently burnt) have been established in Western Australia (in *Eucalyptus gomphocephala* woodland), New South Wales (in the Eden Burn Study) and in Tasmania (N.E. and N.W. *E. delegatensis* forest and *E. amygdalin*a forests).

THE FUTURE

At both the national and international level the understanding of forest fire ecology regularly suffers from limited data, the time-frames that the processes under consideration operate, and the complexities of the interactions between fire regimes and forest ecosystem components. The impact of global warming is now further complicating the study of these relationships.

Until recently, most relevant research tended to be more of the 'one-off' kind that focussed on the ecosystem consequences of single fires (usually high intensity wildfires) or one or two low intensity 'prescribed' fires in relatively quick succession (less than 15 years).

In southern Australia, and indeed in most fire-prone areas of the world, community expectations over the past century or so has meant that most efforts in fire management have focussed on fire suppression and/or fire exclusion. Over the last 10 to 15 years however, park and forest managers have increasingly come to recognise that the presence, frequency or absence of fire is a vital consideration in the maintenance of the health of many ecosystems.

In Australia, several longer term fire ecology studies continue. Arguably, the most significant of these has been underway in the lower reaches of the Great Dividing Range, in west-central Victoria since 1984. This comprehensive study is examining the impact of the repeated use of low-intensity prescribed burning on a range of ecosystem components. One of the more significant outputs from the study to date has been the demonstration that short-term fire effects research can be misleading, given the longevity of forest ecosystems.

The current Bushfire CRC project (Project B7) is designed to make a major contribution to the understanding of the relationship between fire regimes and overstorey eucalypt health, both in the specific ecosystems being studied, and more generally.

More details relating to the project can be found at: **www.bushfirecrc.com**

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