SOME ENVIRONMENTAL EFFECTS OF DRY CONDITION FIRES ON THE JARRAH FOREST

1983

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1. INTRODUCTION

It is not always adequate to describe forest fires as 'cool' or 'hot' or 'fast' or 'slow' when describing the effects of fires on soils and vegetation. There are five primary factors which must be specified before the possible environmental effects of fire can be fully considered. These are:

(i) the interval between fires (frequency)

(ii) fire intensity (kW/m) and residence time (seconds)

(iii) fuel bed characteristics (moisture content, quantity and structure)

(iv) vegetation life cycle and soil characteristics

(v) season of the fire.

As our knowledge of fire behaviour and fire effects increases, so too will the role of fire as a management tool increase. In the past 30 years or so, fire has been used primarily to manage forest fuels. These fires could be described as low intensity ($<$350 kW/m) frequent (5-7 years), cool (spring or late autumn) burns. The aim of such fires is to remove a considerable portion of the litter bed fuel in a controlled manner and without damaging the overstorey trees. Such fires are most often carried out in September to December or in April/May. The most important factor ensuring a successful fuel reduction burn is probably fuel moisture content. Generally, burns are kept to low intensities when fuels are 12 - 18% o.d.w. and the Soil Dryness Index is $<$600.

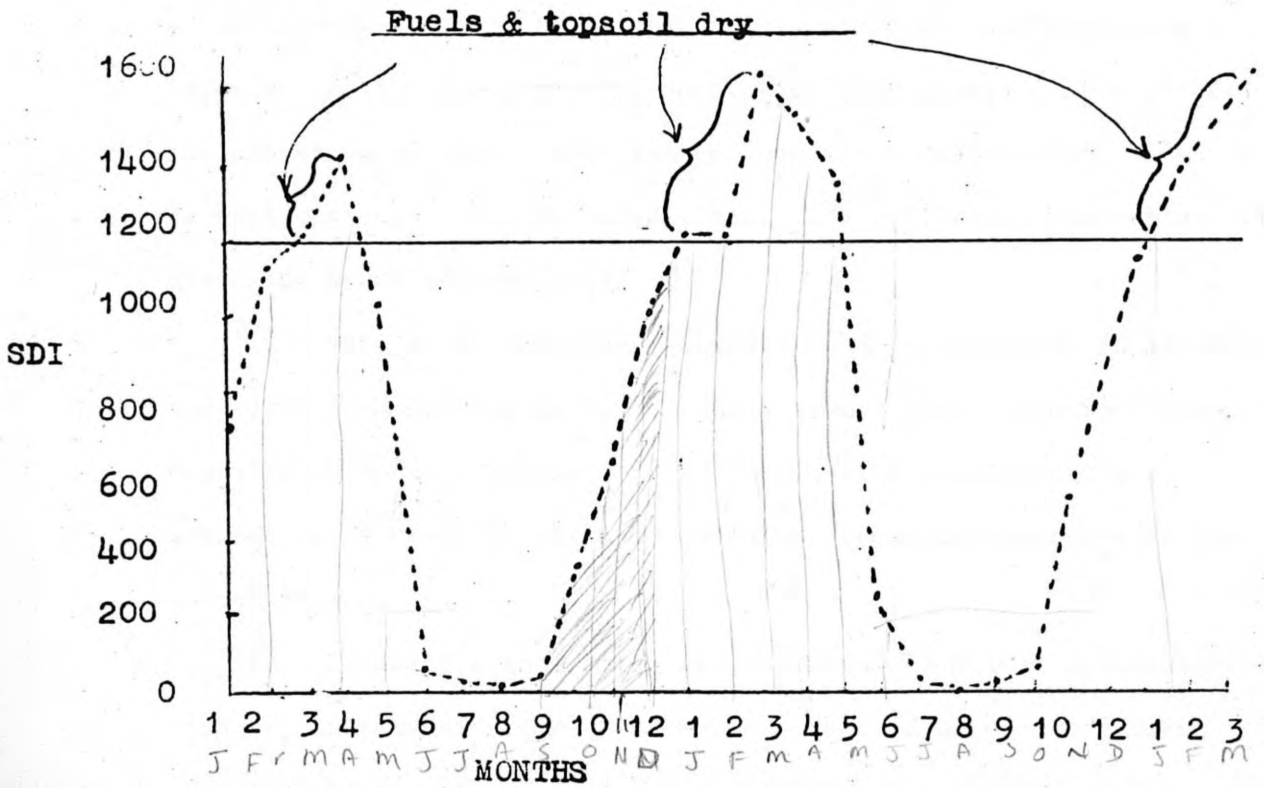
Recent research has shown that fire may be used to achieve other management objectives such as dieback and other disease control (Shea) and in fauna habitat management (Christensen).

While there is a lot to learn, it is recognized that fires burning under dry (summer) conditions, do effect the forest environment differently to fires burning under cool, moist conditions. While we do not have all the answers, and probably never will, there are a number of basic interactions between fire and the forest environment which are moderately well understood. I will discuss what is meant by the term 'dry' condition burns and then discuss some of the enviromental effects which have been observed and recorded from wildfires and experimental burns. I will then present some of the results of two fire studies carried under dry conditions. It is stressed that these observations are from single fire events and neither discriminates between fire intensity nor fire frequency.

2. WHAT ARE 'DRY' CONDITION BURNS?

In a few words, summer or early autumn burns. This does not necessarily mean the calander summer, but the dry period associated with the Mediterranean type climate experienced in the south-west. This is well illustrated by the Soil Dryness Index in figure 1. A measure of soil moisture content is also provided. Soil dryness not only reflects the dryness or droughting of both living and dead vegetation (fuels) but it also affects their dryness.

Fig.1. Soil Dryness INDEX



The definite seasonal peaks and troughs in figure 1. correspond to wet and dry conditions. Most hazard reduction burning is carried out under cool moist conditions (as marked). Under these conditions, the topsoil and heavy fuels (logs) and deep litter profiles are wet and only the fine, surface fuels are dry enougn to burn.

Dry condition or summer fires are those which burn when topsoil, logs, deep litter fuels, fine fuels and the entire forest complex is dry and flammable. A feature of our Mediterranean climate is that dryness or wetness is very seasonal, i.e. cool - wet winter, warm - moist springs, hot - dry summer, warm - moist autumn. The vegetation life cycles (growth, flowering, seeding etc.) are partly dictated by these sequence of events. Combined with the different physical effects of fires on soil, vegetation and season of burn, fire regimes can have significant environmental effects.

3. DRY SCLEROPHYLL (JARRAH) FOREST

From observations, the regeneration of many jarrah forest species depends on lignotuberous seedlings. The conditions which lead to the establishment of these seedlings, unlike the hard-seeded species (Acacias etc.) is less clearly understood. Observation of wildfires and experimental fires under summer conditions suggest that this is best achieved under dry conditions. The following observations have been made which support this;

(i) The jarrah forest is generally made up of trees of mixed age and size, each corresponding to a past summer (dry condition) fire. However, it doesn't follow that <u>each</u> such fire initiates a new generation of trees as fires may occur at frequent intervals in the jarrah forest.

(ii) Seedling regeneration and survival is mostly associated with higher intensity fires which are a feature of dry or summer fires. The intensity of the fire, quantity fuel removed and the timing of the fire contribute to seedling development.

(iii) Very healthy and fast growing seedlings occur where the soil has been sufficiently heated. This is achieved by the complete combustion of fuels (down to mineral earth) and dry soils, a feature of summer fires. The quantity of fuel burnt rather than fire intensity is the overiding factor.

(iv) Seedling survival is enhanced if the fire has covered a large area - large enough to minimise the impact of grazing by kangaroos etc. Before white settlement, such fires would most likely have occurred in summer or early autumns (dry condition). It is doubtful whether the aborigines were able to fire large contiguous areas under moist conditions as we can now achieve with aerial ignition.

(v) Seedlings which regenerate after a dry condition fire may continue to grow if conditions are suitable or may become semi-dormant until some later disturbance.

(vi) Dry condition fires consume considerably more ground fuels including twigs and logs. These heat the soil to a considerable depth. This erroneously termed "ash bed" effect is confined to conditions where a considerable quantity of fuel is consumed (down to mineral earth).

(vii) Hard seeded species (such as Acacias etc.) require the seed coat to be cracked before the seed can imbibe moisture and regenerate. Seeds stored in the soil are "heat treated" and the seed coat cracked by dry condition fires. As mentioned, these fires consume more fuel (so more energy is dissipated into the soil) and heat is more readily conducted through the dry soil.

(viii) Following dry condition fires, seeds buried in the soil may not germinate immediately unless there is a considerable shower of rain. When seeds do germinate, it will be nearer the onset of winter so drought deaths are likely to be less.

(ix) Dry condition fires stimulate a massive and synchronised seedfall. Such a massive seedfall increases the probability of seedling survival and seeds are in a position to take maximum advantage of the "ash bed".

(x) Between dry condition fires; there is little or no regeneration of tree species or understorey species, even though seed is released each year. A mineral seed-bed (and not litter or charred leaf) is necessary for optimum germination and rapid growth. Rootstock species with soft seeds not protected in woody capsules (Podocarpaceae, Restionaceae, Liliaceae, Orchidaceae, Ranunculaceae, Rutaceae etc.) usually rely on being able to quickly re-sprout, flower and discharge massive amounts of seed onto a hospitable seed-bed prepared by dry condition fires. The "ash bed" effect diminishes after the fire, but probably lasts for 2-3 years. This is probably the time in which seedlings of these species become established. Unlike the hard seeded species and those species in which the seed is protected in a woody capsule, the soft seeds on the bush are killed by fire and there is no soil stored seed. Considerably more research is necessary to determine the life cycle and particularly, seed morphology and function of understorey species (i.e.: the "silvicultural" requirements of the various understorey species).

(xi) Accumulated organic matter (profile litter beds) can cover the entire soil surface in about 3 years. Experiments have shown that seedling root systems of eucalypts and many other species develop poorly in litter. This could be due to the physical barrier presented, low nutrient availability or the adverse effect of leachates.

(xii) Some seeds require full exposure to light to germinate and develop successfully. This is probably more important in the karri forest. Temporary reduction of the light impeding overstorey is achieved by dry condition fires.

(xiii) Many seedlings succumb to fungal attack in their first winter, especially in shaded conditions and deep (duff) litter beds.

(xiv) Seed and new seedlings are readily removed by insects. Dry condition fires provide a temporary respite - sufficient for seedlings to become established.

(xv) Drought - seedlings germinating in spring or in moist organic substrates, drought off and die when these dry over the ensueing summer.

(xvi) Plant competition - this relates to shading, competition for moisture, nutrients etc. and phytoxic alleleopathy. These factors are temporarily removed by dry condition fires.

(xvii) All seeds found in most of our eucalypt forests are small by world standards. Therefore, seedlings do not have a great propensity to survive on seed stored food. Once germinated, the conditions mentioned above must prevail or the seeedling does not survive. Again, this is most likely following dry (higher intensity, heavy fuel, deep and cleansing) burns during summer/autumn.

(xviii) Post fire flowering and foliage development appears to be faster and greater after summer burns.

(xvix) Dry sclerophyll species display many fire adaptive traits including:

- soil protection of buried buds (rootstocks, rhyzomes, bulbs)
- bark protection
- sprouting from stems (epicormics)
- hard seeds (Acacias)
- woody and protective seed capsules (Banksias, hakeas etc.)
- fire triggered massive seed release (relies on dessication of capsules/fruits)
- immediate post fire flowering (orchids, Xanthoreaceae etc.).

These many observations suggest that infrequent dry condition fires (summer, early autumn) are ecologically desirable. Fire characteristics which contribute to these desirable interactions include i) complete fuel consumption ii) defoliation of scrub and possibly overstorey (full scorch to the overstorey probably achieves the same result) iii) dry soils v) large areas burnt. In the pristine state, such fires probably occurred in the dry sclerophyll forest about every 15 - 40 years and considerably longer in the mesophytic forest (karri). Over this period, fuel build-up would be adequate to prompt the above mentioned interactions.

So much for general observations. The following are results from recent research into the use of dry condition fires to reduce the abundance of Banksia grandis thickets and to stimulate legume regeneration. These studies were undertaken following work by Shea, who suggested that there existed a potential to minimise the impact of dieback on most upland jarrah sites by re-structuring the understorey using higher intensity fire.

4. BANKSIA GRANDIS AND FIRE - RESULTS OF RECENT RESEARCH

(i) Banksia grandis density and basal area can be reduced by moderate - high intensity fire (600 - 1,500 kW/m) where 8 - 10 tonnes/ha of litter fuel is consumed.

(ii) Younger plants ($<$ 5 cm in diam.) were killed back to ground level by these fires, but readily re-shoot from lignotuber. The older plants ($>$ 12 cm dbhob) were found to be ineffective and many of these plants, when girdled by fire, were killed outright.

(iii) Low intensity fire did not have any long term effect on existing Banksia populations.

(iv) Where jarrah forest fuels are maintained at or below 8 t/ha, fires would need to spread at 160+ m/hr to achieve any kill of larger Banksias. There are difficulties prescribing and controlling such fires. Under these light fuels, the effect would be patchy and hence probably ineffective.

(v) A better, more broadscale result, could be achieved by allowing greater fuel accumulation (12 - 14 t/ha) and burning all this fuel at a lower intensity and under milder conditions. However, this is a trade-off with fire protection requirements.

(vi) Having killed a "substantial" proportion of Banksias to ground level, frequent and low intensity fires (every 2 - 3 years) may eradicate the plants after about 10 years or so. In doing so, other desirable species may be equally effected (such as legumes). Frequent, low intensity fires (at 7 year intervals) are unlikely to achieve lasting, broadacre reduction.

(vii) The optimum level of stocking for disease control, awaits definition.

(viii) Side-effects of a regime designed to eradicate or reduce Banksias need to be thoroughly investigated - e.g. damage to timber values, overall ecological impact, cost versus benefits.

(ix) I believe the best way to prevent the formation of dense Banksia thickets is to maintain (through planting or other means) a high stocking of jarrah regrowth following logging operations.

(x) The best way to eradicate Banksias is with P.c.?

(xi) Some form of control may be afforded by a combination of mechanically pushing down Banksias and burning.

5. LEGUMES

(i) Site is an important factor affecting the regeneration of legumes. Any amount of fire is useless if seed is not available.

(ii) Where seed is available (in the soil) the regeneration of legumes is dependent on:

i. soil dryness - dry soils = better heat penetration

ii. total ground fuel quantity burnt. This is a function of fire interval, fuel moisture content and fire intensity.

(iii) After fire, subsequent development of legumes will be affected by many factors including:

i. droughting

ii. grazing

iii. competition from other vegetation and many of the factors discussed earlier.

6. HABITAT MANAGEMENT - PERUP FAUNA PRIORITY AREA

Dry condition fires are important in the regeneration of thickets of heartleaf poison (Gastrolobium bilobum) and Melaleuca viminea which die and degenerate at the age of twenty to thirty years. Frequent and low intensity ($<$ 350 kW/m) spring fires (under moist conditions) can accelerate the degeneration of these thickets, which are essential for the survival of the Tammar wallaby. Heartleaf poison is a hard seed species and its requirements for successful regeneration are similar to that of Acacia pulchella. Melaleuca viminea regenerates best following high ($>$ 1,000 kW/m) intensity summer fires for the combination of conditions outlined earlier.

A blend of cool ($<$ 350 kW/m) spring hazard reduction burns and warm ($>$ 1,000 kW/m) summer or dry condition burns to regenerate collapsing thickets is an optimal fire regime for the Tammar wallaby.

7. CONCLUSION

There is still a great deal to learn about the role of fire in forest management. Unless the alternative is complete destruction of the jarrah overstorey caused by dieback, I don't believe that attempting to "cook" the Banksias out of the system is a viable method of disease control where timber is the primary land use. It is advantageous to stimulate legume regeneration and the regeneration of overstorey and scrub species by dry soil, deep cleansing burns at infrequent intervals.

Given the current state of knowledge, I believe a "healthy" fire regime for mature dry sclerophyll forests managed for timber production is primarily for frequent, cool spring burns to maintain fuel loads < 8 t/ha for 3 - 4 rotations. The 4th or 5th burn should be a moderate intensity (500 - 1,000 kW/m) burnt in summer or early autumn under dry conditions. This simple regime, I believe, provides opportunity for seedling establishment and maintains fuels < 8 t/ha. Obviously, stands containing jarrah saplings and poles should not be burnt for at least 15 years and then under very mild conditions.