SYMPOSIUM ON THE BIOLOGY OF NATIVE AUSTRALIAN PLANTS,
UNIVERSITY OF WESTERN AUSTRALIA, PERTH. AUGUST, 1979

FIRE AND THE REGENERATION OF KARRI

P.C. Kimber and C.J. Schuster
Forests Department of Western Australia

ABSTRACT

Karri has been observed to regenerate in the absence of fire only where ground disturbance, resulting in the baring of mineral soil, but avoiding soil compaction, has taken place.

Regeneration fails to take place beneath a virgin stand, even when in a state of decline where gaps have formed in the upper canopy, unless fire removes the litter layer, and kills the understorey of shrubs and small trees. Regeneration is found in virgin stands that have been subjected to wildfires, but persistent regeneration larger than small saplings only survives in gaps created by deaths in the overstorey.

Regeneration in undisturbed virgin stands is probably inhibited by competition from the overstorey and shrub layer. This competition is removed by fire under natural forest conditions.

Fires originating from lightning strikes are a regular feature in the karri forest, have been shown to be randomly distributed. There is thus a high probability that the entire forest will have been fired by lightning over the past few centuries.

The reluctance of karri to regenerate in the absence of fire, and the high probability of fire occurring within the forest, points to fire as a regenerating agent in the absence of perturbation by man.

INTRODUCTION

Karri (*Eucalyptus diversicolor* FVM) is a large tree species confined to a limited area of the extreme southwest of Western Australia. The forest is similar in structure to the mountain ash (*E. regnans*) forests of Eastern Australia (see, for example, Ashton, 1979), and karri has many characteristics in common with mountain ash. These include a non-lignotuberous habit, seedlings that are strongly light demanding and with very rapid early growth, and the inability to regenerate successfully except following a major site disturbance.

Significant natural disturbances to the karri forest include wildfires which almost invariably have been followed by the appearance of seedling regeneration. However, persistent regeneration, resulting in a new stand of trees, appears only to be associated with mortality (of single trees, or groups of trees) in the original forest as a result of the fire.

Our objectives in this paper are to present some evidence of the inability of karri to regenerate naturally in the absence of major perturbation, to investigate the possible reasons for this, and to support the hypothesis that fire is the natural agent promoting successful regeneration.

SEEDLING OCCURRENCE IN ESTABLISHED FORESTS

We have conducted surveys of karri seedling regeneration in established karri forest at various periods following prescribed burning. The assessment was made using 1 m^2 quadrats located at 10 metre intervals on randomly located transects. The presence or absence of karri seedlings and saplings was noted for each quadrat. The results of the survey appear in Table 1.

TABLE 1

Karri regeneration related to prescribed burning

Period since last fire (years)	Percentage of quadrats with karri regeneration	Number of quadrats
45	0	120
25	0	120
6	0.83	120
2	6.67	120
1	40.00	50

An association between prescribed burning (which temporarily removes the litter and shrub layers of the forest), and the presence of regeneration is apparent in Table 1. However, the rapid reduction in regeneration between one and six years since the last fire suggests that the seedlings which became established following the relatively mild fire did not persist. The complete absence of karri seedlings and saplings in stands burnt 25 and 45 years previously suggests that seedfalls in the years following the fire were unsuccessful in establishing seedlings. In this regard karri follows the pattern of the wetter eucalypt forests throughout Australia where, with no fire and in the absence of disturbance by man, regeneration is practically non-existent (Mount 1969).

SOME FACTORS AFFECTING REGENERATION SUCCESS

Natural seedfall of karri takes place over the two summers following the ripening of the seed capsules. However, the capsules open very rapidly following a fire and all the seed is shed within 6 weeks (Christensen 1971).

Germination takes place with the onset of cooler weather and winter rains; the peak period of germination is late April to early May. (Christensen and Schuster 1979).

Whatever form the seedfall takes (natural and protracted, or induced by fire and rapid), a significant proportion of the fallen seed will lie inactive on the ground for some weeks before germinating, and will be subject to predation and other adverse factors. Cunningham (1960) itemised seed losses and destruction in E. regnans in the following order of importance: insects (mainly seed harvesting ants), loss of viability due to high soil temperatures, and fungal attack.

Losses of E. regnans seed from the ground in a 7 day summer period are shown in Table 2.

TABLE 2

Seed losses (E. regnans) over 7 days, November 1955
(After Cunningham 1960)

	Situation	
Treatment	Bare soil	Undisturbed ground vegetation
Sprayed with dieldrin	3%	33%
Not sprayed	27%	57%

The substantial reduction in seed loss achieved by the dieldrin spray indicates that insects are likely to be responsible. The differences in losses between seed lying on bare ground, and that lying beneath undisturbed ground vegetation are interesting. Presumably the ground vegetation harbours larger insect populations and its removal (by fire or disturbance) is of value in conserving seed.

Christensen and Schuster (1979b) have reported similar studies in karri demonstrating a threefold increase in the survival of seed to the germination stage as a result of sparying the seed with insecticide.

At the germination and small seedling stage eucalypt litter and topsoil have been shown to inhibit germination or seedling growth in some wet forest species. Effects of this nature have been recorded in E. regnans (Ashton 1962). E. obliqua (Attiwill 1962), and E. pilularis (Florence and Crocker 1962). Our own recent work with karri has demonstrated that leachates from freshly fallen karri leaves inhibit karri germination to a level of 10% of total available seed, when compared to a seed viability level approaching 95%.

Seedling survival of some wetter forest type eucalypts has been shown to be dependent on soil disturbance, and on light intensity and associated factors. Cunningham (1960) reported the survival of E. regnans seedlings during their first two years of life to be 3 to 5 times greater on disturbed soil than on undisturbed soil. Recent work on the artificial seedling of karri (Annells 1979) has confirmed a similar trend, and has further shown the importance of ashbeds as a substrate for successful seedling establishment (see Table 3).

TABLE 3

Karri seedling stocking by seedbed type
2 years after seeding
(Annels 1979)

Location (Forest block)	Seedbed type (Percentage Stocking (Note 1))		
	Undisturbed, Unburnt	Disturbed	Ashbed
Andrew	33.4	66.7	79.4
Shannon	25.0	62.9	77.6
Warren	8.0	62.5	82.6
Shannon	27.3	68.8	53.0
Warren	13.3	59.3	80.8
Shannon	43.6	57.7	73.3
Means	25.1	63.0	74.5

Note 1: Percentage stocking = percentage of 4 m^2 quadrats containing one or more karri seedlings.

The effect of light intensity on karri seedling growth has not been studied. However, Ashton (1956), determined from glass-house studies that E. regnans seedlings grown in 28 percent of full sunlight were not markedly different from those grown in 70 percent. Less than 11 percent of full sunlight resulted in spindly, etiolated seedlings. Ashton also recorded that infection of the seedlings by soil-borne fungi increased under low light intensity.

In the field situation Cunningham (1960) found E. regnans seedling losses to be heavy with less than 10 percent full sunlight, and very few seedlings survived below 5 percent. Light intensities of below 10 percent occurred beneath residual ground vegetation. Removal of the ground vegetation with retention of the tree canopy gave a reading of 30 percent of full sunlight.

Hence the ground vegetation appears responsible for the reduction of light intensity to a level unfavourable to seedling survival.

The forgoing data apply to seedlings up to two years old. Development beyond this age is certainly affected by competition from the overstorey. Measurements of a typical regeneration group in a selection cut karri forest are shown in Figure 1, and demonstrate two points. Firstly, no regeneration had become established within 8 to 10 metres of the residual overstorey trees, and secondly there is a marked profile of increasing regeneration height with increasing distance from the residual large trees. This suggests a significant competition factor from these trees.

In summary, successful regeneration of wet area eucalypts, including karri, appears to be dependent on the removal of the litter and the shrub layer for short term establishment, and a reduction, at least, in the upper tree canopy to ensure the continuing development of the sapling.

THE ROLE OF FIRE

Fire is perhaps the one natural phenomenon that will remove litter, understorey and overstorey simultaneously, and it may therefore be regarded as a primary factor in aiding karri regeneration.

Two other influences favourable to seedling establishment also follow an intense wildfire, such as is necessary to achieve the level of disturbance for satisfactory regeneration.

The first of these is the development of ashbeds where nutrients and other soil factors favourable to seedling growth are improved (Loneragan and Loneragan, 1964), and where seedling establishment is most successful (Annels 1979). The second influence, which is perhaps associated with ashbeds, is the

physical change in the burnt soil surface. A fine mineral tilth develops which is soft and friable, and into which seeds sink up to a centimetre on falling to the ground, thus protecting them from insolation and seed-robbing insects (Mount 1969).

NATURAL FIRE IN THE KARRI FOREST

If the hypothesis that fire is essential to natural karri regeneration is to be supported, then the occurrence of fire in historical times must be proven to account for the existence of the forest in its present form.

Churchill (1960) concluded from carbon dating charcoal deposits in the karri area that the forest had been associated with fire for at least 7000 years.

Hallam (1975) states that the peripheries of the karri forest were regularly burnt, deliberately and accidentally, by aborigines. Some of these fires would certainly have penetrated deep into the forest, driven by the hot easterly and northerly summer winds.

An equally certain source of fire is lightning. Underwood (1978) analysed 20 years of records of lightning fires in the karri forest attended by Forests Department personnel. The average number of lightning-caused fires was 4 a year, ranging from none to 24. These fires occurred mainly in the period January to March, coinciding with the period of maximum flammability of the forest, and they were randomly distributed through the forest area.

It is therefore probable that the forest was burnt at not infrequent intervals prior to European colonisation.

LITERATURE REFERENCES

ANNELS, A.R. 1979

Broadcast seeding of karri. Res. Paper (in press) Forests Dept., Perth.

ASHTON, D.H. 1956

Studies on the autecology of E. regnans. Ph.D thesis, Botany Dept., Univ. Melbourne.

ASHTON, D.H. 1962

Some aspects of root competition in E. regnans. Paper to 3rd Conf. I.F.A., Melbourne.

ATTIWILL, P.M. 1962

The effect of heat pre-treatment of soil on the growth of E. obliqua seedlings. Paper to 3rd Conf. I.F.A., Melbourne.

CHRISTENSEN, P.S. 1971

Stimulation of seedfall in karri. Aust. For. 35(3): 182-190.

CHRISTENSEN, P.S. & SCHUSTER, C. - 1979 a

Research paper in preparation.

CHRISTENSEN, P.S. & SCHUSTER, C. - 1979 b

Some factors affecting the germination of karri. Res. Paper 50. Forests Dept., Perth.

CHURCHILL, D.M. 1960

The distribution and pre-history of E. diversicolor, E. marginata, and E. calophylla in relation to rainfall. Aust. Journal Bot. 16: 125-151.

CUNNINGHAM, T.M. 1960

The natural regeneration of Eucalyptus regnans. Bull. No. 1 School of Forestry, Uni. Melbourne.

FLORENCE, R.G., & CROCKER, R.L. 1962

Analysis of blackbutt (Eucalyptus pilularis Sm.) seedling growth in a blackbutt forest soil. Ecology 43(4):67-679.

HALLAM, S.J. 1975

Fire and Hearth, a study of Aboriginal usage and European usurpation in southwest Australia. Aust. Inst. Aboriginal Studies, Canberra.

LONERAGAN, O.W. & LONERAGAN, J.F. 1964

Ashbeds and nutrients in the growth of seedlings of karri (Eucalyptus diversicolor F.V.M.) J. Roy. Soc. W.A. 47(3):75-80.

MOUNT, A.B. 1969

Eucalypt ecology as related to fire. Proc. No. 9, Tall Timbers Fire Ecol. Conf. Tallahasse, Fla. U.S.A.

UNDERWOOD, R.J. 1978

Natural fire periodicity in the karri forest. Res. Pap. No. 41, Forests Dept., Perth.