Recommendations for the Regeneration and Maintenance of the Tuart Forest in the Yalgorup National Park

Consultant's Report

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Introduction

The tuart (*E. gomphocephala*) forest in the Yalgorup National Park and the adjacent private property has recently been the subject of severe insect attack that has caused serious crown deterioration and some mortality. The primary agent of the crown deterioration is the Tuart borer (*Phoracantha impavida*). More severely damaged and dead trees usually show evidence of attack by Bullseye borer (*Phoracantha acanthocera*) as well. The outbreak was originally noticed in 1997. The affected trees recovered from that attack and developed new epicormic shoots. More severe damage occurred again in 1998 and 1999. The outbreak is confined to areas near Lake Clifton, including the Yalgorup National Park, adjacent State Forest and private property.

The affected area was aerially sketch mapped in 1999 and revealed varying degrees of impact. The most severely attacked areas contain significant patches with more than 90% mortality of tuart. A sample flight of multi-spectral video imagery at a scale of 1:5,000 (2m pixel size) clearly shows the impact at the individual tree scale. The initial aerial sketch mapping in February 1999 indicated that approximately two thirds of the tuart in the park was affected, but a repeat survey in November 1999 showed a substantial increase in the area affected (Mitchell[1] pers. comm.). The most severely affected area is west of Martin's Tank Lake and Lake Yalgorup.

Several theories have been proposed for the stimulus of the outbreak, including lowered water table, air pollution, an unusual frost in 1997, long periods without fire and drought stress caused by overstocking with the peppermint understorey.

This report does not consider the causes of the outbreak but has been commissioned by the Department of Conservation and Land Management to make recommendations for the regeneration of tuart forest where mortality is occurring as a consequence of it. The concern for these areas has been heightened because of the apparent lack of regeneration in the tuart forest under normal circumstances and the probability of a more rapid decline in tuart populations if the seed source is further depleted as a result of mortality due to insect attack.

This report examines what is known about the original (pre- European) condition of the tuart forest; the management practices that are believed to have maintained it in that condition; the changes that have occurred since European settlement; recommendations for regeneration and restoration of the original structure and the management practices needed to maintain the capacity of tuart to regenerate and sustain itself.

[1] David Mitchell, Regional Ecologist, Department of Conservation and Land Management, Kensington.

Tuart in relation to vegetation complex.

Tuart occurs as both a forest and a woodland throughout its range including that within the Yalgorup National Park. In its present condition it typically has a dense second storey of peppermint (*Agonis flexuosa*) and/or banksia spp (*B. attenuata, B. grandis*), and with a ground layer of shrubs and grasses.

The vegetation complexes with which it is associated occur as narrow bands running north-south and include the:

- Yoongarillup complex - on shallow yellow and brown sands over marine limestone - associated with an understorey of peppermint.
- Cottosloe complex (Central and South) - on shallow aeolian sands over limestone with outcrops of limestone - associated with closed heath on the outcrops and *B. attenuata, B. menziesii* understorey in the mosaic of woodland. This complex occurs no further south than the proposed southern extension of the park.
- Karrakatta complex (Central and South) - on deep yellow aeolian sands over limestone - associated with jarrah (*E. marginata*), marri (*C. calophylla*) and an understorey of *B. grandis*
- Vasse complex – on poorly drained plains with variable undifferentiated estuarine and marine sands. This constitutes only a small portion of the area (Heddle *et al* 1980).

The tuart forest at Ludlow, from which most management experience is derived, occurs on the Yoongarillup and Karrakatta complexes.

The pre-European condition of the tuart forest

There were no botanical surveys of the tuart or any other forests until many years after European settlement. For a description of the condition of these forest it is therefore necessary to rely on the general descriptions given by the earliest explorers and settlers before conditions had changed under the influence of settlement.

Hallam (1975) gives the most comprehensive summary of forest conditions in the South West based on the observations of early settlers and pioneers. In this summary, frequent references are made to the open, grassy nature of the woodlands on the coastal plain and in woodlands to the east of the jarrah forest. Specific references concerning the condition of the tuart forest are made by early settlers and travellers in the vicinity of the Vasse, Leschenault Inlet and Lake Preston. All of them describe the tuart forest as open with widely spaced trees and a grassy understorey. Lieutenant Preston in 1831 says of the country south of the Vasse Estuary *"The country passed over this morning was beautiful, much resembling a fine park in England, with excellent timber, five or six to the acre."* (Cross 1980:125). (John Bussell's description of the area near the Vasse River in 1831, and often attributed to the tuart forest - *"The country here was so clear that a farmer could hardly grudge the fine spreading trees of red and white gum and peppermint the small portion of ground they occupied only to ornament."* (Cross 1980: 192) - is more likely to be a description of marri/ flooded gum (*E. rudis*) plains in that area. Bussell's description of white gum, its soil requirements and locality (Cross 1980:196) fits that of *E. rudis* rather than tuart.)

Lieutenant Bunbury in 1836 described the area between the Preston and the Capel Rivers as *"...an undulating Tooart country of considerable extent, with plenty of grass.."* (Bunbury and Morrell 1930:90).

The following descriptions relate to areas closer to Yalgorup. On a journey from Pinjarra to the Vasse in December 1836, Lieutenant Bunbury described the land near Lake Preston as follows. *"We came now into more open country with a good deal of grass growing on a light soil under very large White Gums, called by the natives 'Tooarts' - the soil evidently fertile, though sandy, and free from the sharp scrub that had annoyed us during the forenoon, tearing our trousers and legs. It was quite refreshing to get into this fine country through which the travelling was quite easy."* (Bunbury and Morrell 1930: 71) On this course his first sight of tuart would have been that on the Karrakatta complex, then through the Cottosloe to the Yoongarillup complex. Then, "*Along the* [eastern] *edge of this great lagoon* [Lake Preston] *is found a good deal of food for cattle and horses.... Here I saw for the first time the peppermint tree growing to a large size..... Soon got into a more open flat country lightly timbered with Tooarts, with abundant grass and not many bushes ...* " (Bunbury and Morrell 1930:73). Lieutenant Preston in 1831 describes the land on a line between Leschenault Inlet and Cape Bouvard via Lake Preston thus: *"The hills passed over on the sea coast, afforded good pasture for sheep, particularly between the Murray and Port Leschenault."* (Cross 1980:131). While this description does not necessarily imply grass, it certainly implies at least low scrub or heath rather than dense thickets.

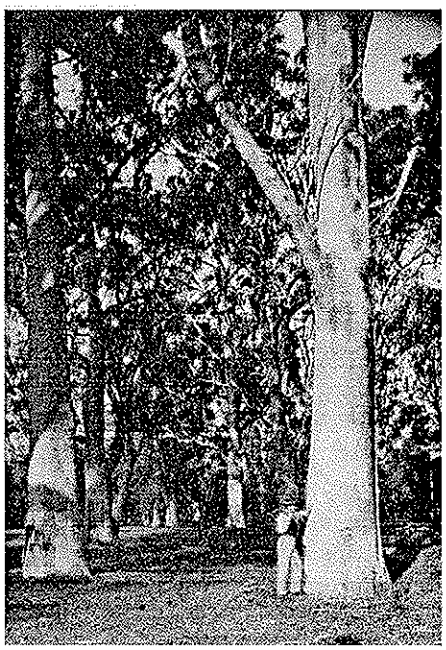

Figure 1. *"Here we have a splendid view of a more than typical portion of the tuart forests.... Although the site of this view is so neat and park-like, it is true to nature, and has not been improved artificially in any way." Ednie- Brown 1896.*

These descriptions of the open grassy nature of the tuart forest near Ludlow were also reported sixty years later by Ednie-Brown (1896). (See the caption of Figure 1). In 1911 Wilson (Gabbedy 1988:20) described this limestone country in similar fashion *"..with tuarts dotted in parklike fashion, and occasional brakes of peppermints...and a rich carpet of annual grasses.."*

Tuart savannah is probably not a description that applied to those parts of the tuart (on parts of the Cottosloe complex) that now have a dense *Xanthorrhoea* / heath understorey. They have probably remained relatively unchanged except for the changes directly related to time since burning.

While there is no local experimental evidence of the management practices required to maintain the savannahs there is considerable historical and anecdotal evidence to support the contention that aboriginal burning practices maintained them in this condition. Historical evidence from early explorers in all states of Australia suggests that large parts of Australia that are now forests were, at the time of European settlement, open savannah. These reports are equally consistent in their description of the frequent burning of these grasslands by aborigines for the purpose of access, hunting or attracting game (Hallam 1975, Ryan 1994). It was the ready-made existence of these grasslands that facilitated the early grazing ventures of Europeans in WA as in the rest of Australia (Moore 1978). The role of aboriginal burning practices, including the maintenance of grasslands is reviewed by Nicholson (1981), Pyne (1991) and Bowman (1998). The

essence of the maintenance of these grasslands appears to be a fire frequency that is short enough to kill emerging woody seedlings and not so hot as to stimulate the germination of deeply buried seed such as acacias. Grasses are encouraged thereby facilitating even more frequent burning.

Lieutenant Bunbury described aboriginal burning practices and their effect in 1831: "*...periodical extensive bush fires which, by destroying every two or three years the dead leaves, plants, sticks, fallen timber etc prevent most effectively the accumulation of any decayed vegetable deposit.....By these fires.... the country is kept comparatively free from under wood and other obstructions, having the character of an open forest through most of which one can ride freely; otherwise, in all probability, it would soon become impenetrably thick...and it would change the nature of the country, depriving it of the grazing and pastoral advantages it now possesses.*" (Bunbury and Morrell 1930:105-106)

Hallam (1975) gives a detailed description of the various objectives of aboriginal burning. The contention that burning was carried out at any time of the year that burning was possible tends to be supported by Bunbury's observation near Leschenault Inlet that.... "[the aborigines] ..*carry under it* [their cloak] *the firestick, which is as constant a companion as the spears.*" (Bunbury and Morrell 1930:85). Most burning was apparently carried out in summer according to early reports of fires (Hallam 1975, Burrows *et al* 1995) and it is logical to assume that summer fires would have been responsible for the bulk of the total area burned. This was also the experience of Lieutenant Bunbury: "*This is the worst season of the year to be travelling, being the last month of summer;.... the natives have burnt with fire much of the country...*" (Bunbury and Morrell 1930:179). Presumably grasslands could have been burnt at any time after they had cured and unlike other fuel types, annual burns would have been possible, though there is no evidence that areas were regularly burnt at this frequency.

Preliminary sampling of grass trees in the Yalgorup National Park to determine fire frequency, using the technique described by Ward (1996) suggests that fire frequency was 2.5 to 3 times per decade until the 1850's (Ward[2] pers. comm.)

The effects of aboriginal burning practices is demonstrated by its absence. Its cessation in eastern Australia had the effect predicted by Bunbury. Major Mitchell in 1848 (quoted in Ryan 1993) said that "*...the omission of annual periodical burning by natives, of the grass and young saplings, has already produced in the open forest lands near Sydney, thick forests of young trees, where, formally, a man might gallop without impediment, and see whole miles before him. Kangaroo are no longer to be seen there; and grass is choked by underwood; neither are there natives to burn the grass.....*".

The mechanism for this change is described by Howitt (1890): "*It* [regeneration] *dates from the very day the first hardy pioneers drove their flocks and herds ..... into the rich pastures of Gippsland. Before this time the gramminivorous marsupials had been so few in comparative number, that they could not materially affect the annual crop of grass which covered the country, and which was more or less burnt off by the aborigines, either accidentally or intentionally, when travelling, or for the purpose of hunting game.These annual fires tended to keep the forests open, and to prevent the open country from being overgrown, for they not only consumed much of the standing or fallen timber, but in great measure destroyed the seedlings which had sprung up since former conflagrations...*

The increasing number of sheep and cattle in Gippsland...lessened the annual crop of grass, and it

[2] Dave Ward, Senior Research Scientist, Department of Conservation and Land Management, Kensington.

was to the interests of settlers to lessen and keep within bounds bush fires which might otherwise be very destructive to their improvements.

The results were twofold. Young seedlings now had a chance of life, and a severe check was removed from insect pests.....After some years of occupation, whole tracts of country become covered with forests of young saplings.... it is difficult to ride over parts which one can see by the few scattered old giants were at one time open grassy country..... the ranges are in many parts quite overgrown with forests not more than twenty years old.

Bush fires, which swept the country more or less annually, kept down the enormous multiplication of insects life, destroying myriads of grasshoppers and caterpillars, which now devastate parts of the Gippsland district, spoiling the oat crops, and eating the grass down to the ground...

Changes to the condition of the tuart forest since European settlement

Increasing peppermint understorey, reducing tuart regeneration

By 2000 the tuart savannahs have all but disappeared from public land and the tuart forest is now typically described as having a more or less dense understorey of peppermint or banksia. This change in condition has been reported for at least 80 years. In 1923 Gardner described the southern portion of the tuart forest as a savannah forest but he also reported that the density of peppermint interfered somewhat with the growth [regeneration] of tuart. The Forests Department's annual report of 1921 was more specific: "*Fires, however, have caused such dense thickets of peppermint coppice that there is little likelihood of young Tuarts in any number ever managing to struggle through such dense growth of shoots and some steps must be taken to greatly reduce the density of peppermints in certain patches.*" (Anon 1921). Concerns have been expressed about the density of the peppermint understorey and the lack of tuart regeneration to the present time (Anon 1976, Portlock *et al* 1995:40). While there is no doubt that changes have occurred in the understorey the timing and causes of the change are the subject of some conjecture, with changes to fire regimes and grazing being primarily implicated.

While most of the data and observations concerning tuart relate to the Ludlow forest because it was the first areas of tuart forest to be reserved and managed, it is not unreasonable to assume that similar patterns applied to the Yalgorup tuart forest especially those on the same vegetation complexes.

An apparent inadequacy of tuart regeneration was expressed as a concern at an early date when Forest Ranger Brockman put the view to the Royal Commission of 1903 that grazing and lack of ashbed was the cause of poor tuart regeneration (Anon 1921). The view was also expressed (Anon 1921) that regeneration had practically ceased 50 years ago (ie from about 1870). This statement is at least partly supported by data derived from a complete enumeration of 1193 ha of tuart forest at Ludlow in 1921 (see Figure 2, derived from data in Anon 1921). This shows a relative paucity of trees less than 30 cm diameter. This is quite different to the expected distribution of stem numbers versus diameter class in a stable forest situation, which follows a negative exponential form (the de Liocourt distribution). While a de Liocourt distribution would not be expected in a 'woodland', which acquires its character from a relative lack of younger trees, one would expect a somewhat 'flatter' distribution of trees in the younger age classes if age distribution is to remain relatively

stable. Based on available growth data, the 1921 distribution suggests a reduction (though not cessation) of regeneration from about 1860. There are no more recent data available but, with the exception of some specific areas of regeneration activity carried out from the mid 1970's, one would expect that the situation is now more exaggerated than it was at that time. The long absence of fire at Ludlow has also probably resulted in the survival of older trees for longer than normal.

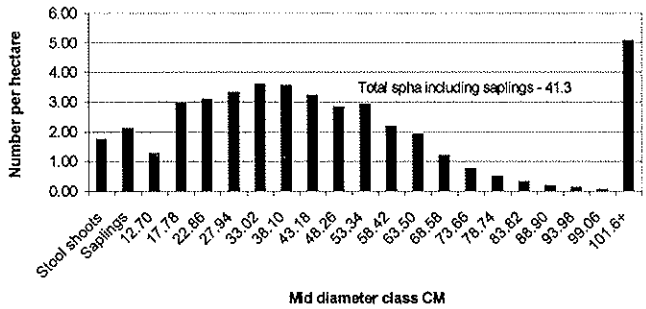

Figure 2. *Diameter distribution of the Ludlow tuart forest in 1921, based on a complete enumeration of 1193 ha.*

The apparent dearth of regeneration may also be a function of overstorey (tuart) competition. If the stands are already fully stocked with larger trees and with few gaps in the tuart canopy, then there is neither the need nor the ability to establish more regeneration. The 1921 data suggests that at least on average the forest (standing at about 15 m^2 / ha) was not understocked. Though the effects of tuart competition are not specifically highlighted in early reports, they were tacitly recognised in the 1912 prescription, along with understorey competition: *"..the problem of re-afforesting this reserve is a comparatively simple one. All that is necessary is to assist Nature by destroying the over matured useless trees, removing the inferior ones such as peppermints, banksia etc. and cleaning up and burning off all of the debris. At the present time there are two traction engines busily engaged...."* (Richardson 1912).

What was less clear was the cause of the increase in peppermint understorey.

Kessel (1923) in the annual report of the Forests Department said: "*Fires resulting in excessive coppicing of the peppermint have resulted in dense thickets of this species with a root formation in places resembling the so-called mallee roots.*" Later (Kessel 1930) he said: "*Excessive grazing and frequent burning of the Tuart forest have created abnormal conditions which render the regeneration of the species extremely difficult. The understorey of Peppermint (Agonis flexuosa) which coppices very vigorously after fire, has spread until parts of the forest are covered with dense thickets.*" The apparent contradiction in the statement about frequent fire and that of aboriginal burning is discussed later.

The implication of grazing in the lack of regeneration is based on the observation that cattle and sheep will graze tuart at times (Anon 1921) and a report by Brockman (1921) that seedlings were only apparent in compartments that had grazing excluded for the previous five years. The role if any of grazing on the spread of peppermint is not clear. Under intensive year-round grazing cattle appear to prevent the establishment of peppermint but cattle do not normally graze peppermint in less confined conditions (Muir[3] pers. comm.)

The descendants of early settlers in the Capel area suggested that peppermint became widespread in the tuart forest after severe floods in the mid 1860's (Rowe[4] pers. comm.). However this would not explain its equal dominance in areas of higher land not subjected to flooding. It might however add further evidence concerning the timing of the increase.

[3] Jim Muir, farmer and former south coast grazier.
[4] Dave Rowe, Forester in the Busselton district from 1971 to 1985.

The available information suggests that changes in the pattern of regeneration of tuart began in about the middle of the 19th century and that the peppermint understorey may have begun to increase in density from about the same period, at least at Ludlow. It does not necessarily mean, however, that peppermint has been the principal cause of the regeneration problem throughout all of that time. A progression of peppermint density over this time is illustrated by the following: Ednie-Brown described the open nature of the forest as *"..more than typical.."* in 1896 (Figure 1) and Wilson mentioned *"..occasional breaks of peppermint.."* in 1911 (Gabbedy 1988). However, at least in some areas, peppermint removal was required for successful regeneration (Richardson 1912). In 1903 Brockman considered grazing and lack of hot fire as the major impediment to tuart regeneration but later (Brockman 1921) he had added *"..suppression by peppermint.."* to the list. By 1921 dense thickets covered *"..parts of the forest.."* (Anon 1921) and by 2000 most of the Ludlow forest could be described as having a more or less continuous understorey of peppermint.

Changes to management practice

Coinciding with these changes to forest condition were major changes to management practices.

The decline in the influence of aboriginal burning began about the 1850's. This coincided with a break-up of aboriginal society in these areas as a consequence of increasing settlement and a severe reduction in their population as a result of introduced disease. It also followed the introduction of Bushfires Ordinance of 1847 that provided for severe penalties for lighting fires, including penalties for aborigines. The combined effect was a reduced fire frequency, but in consequence an increase in the number of severe fires.

Grazing in the Ludlow forest began about the 1840's, with more intensive grazing from 1918, when grazing was seen as a primary means of reducing grass cover and hence the risk of fire. The forest was then accorded full fire protection from that time, a strategy that has been relatively successful from a fire protection viewpoint. However there are areas in the Ludlow tuart forest that have been grazed and ungrazed for the last forty years. While there may be a measurable difference in peppermint density between the two treatments, any such difference is irrelevant since both areas have peppermint density that exceeds that which will allow tuart to regenerate.

Grazing in the Yalgorup area began in the 1860's and continued for the next 100 years. At least in the more recent years of grazing in Yalgorup, burning was used as a tool of pasture management, burning on a two to three year cycle in March. Cattle were grazed in winter in these areas. (Marchetti[5] pers. comm.). Based on the evidence of Ward's samples of fire frequency, burning frequency had been about 3 time per decade till about 1850, reducing to twice per decade by 1900 after which it returned to about 2.5 times a decade till about 1950. It declined again until it became National Park in 1968, after which burning became very infrequent and confined to small parts of the Park. Today there are substantial areas in the park that have not been burned for 20 to 40 years. In areas that were burnt as part of the grazing management it is difficult to differentiate the impact of fire from that of grazing. There are no records of when peppermint became dominant in the understorey but it is possible that it became more prominent with the less frequent and more severe fires of the 1950's and 1960's and developed further in the period of protection since it became National Park. This could probably be confirmed by ring counting of peppermint, though it would not be possible to differentiate between the time since seedling establishment and coppice development.

[5] Elaine Marchetti, former leaseholder, Lake Clifton.

The mechanism for change

The following hypothesis is presented as a probable explanation for the increase in the density of the peppermint understorey.

- Frequent low intensity burning of the grassy understorey by aborigines promoted grass and burnt off the seedlings of peppermint that germinated in the grass, before they were old enough to withstand a fire. Tuart would regenerate only on the ashbed caused by the burning away of the occasional tuart tree that fell over from time to time. If there was a sufficient gap in the tuart canopy these seedlings would develop rapidly and could withstand a mild fire after about two years (Anon 1976, Rowe pers. comm.). Undoubtedly some tuart seedlings were also burnt in these fires, hence the open structure, but sufficient survived for satisfactory recruitment. If there was excessive competition from the tuart overstorey then the seedlings would be suppressed and remain vulnerable to these fires, thus maintaining the open structure of the forest.

- It is possible that an increase in peppermint occurred via three different pathways. The first is that heavy grazing reduced the quantity and continuity of the grassy fuel so that fires were not intense or frequent enough to kill regenerating peppermint seedlings. The density of seedlings would gradually increase and having established a rootstock become relatively immune to fire.

- A second pathway can occur with a reduction in frequent, low intensity fire (which occurred from about the same time) leading to a period of more irregular and severe fire in some areas. Severe fire in these grassy forests is known to promote the regeneration of a thicket of woody understorey, particularly acacias and peppermint (Kessel 1923), and if ashbed is created from fallen trees, then regeneration of tuart (or other eucalypts) is also generally assured. Evidence for this can be seen in the 1996 fire in Yalgorup. Similar evidence exists in what was a peppermint/yate savannah on the south coast between the Donnelly River and Blackpoint which had been maintained in that condition by aboriginal burning and subsequent frequent burning by graziers. A single severe fire event in 1988 produced a thicket of acacia and peppermint which is evident today (Figure 3). Subsequent frequent, low intensity fires will reduce the density of acacias and other woody shrubs over time and will eventually encourage grass especially if associated with grazing. However, future fire regimes or grazing would have little effect on peppermint thickets which will remain as a new and long term feature of the forest structure. Once widespread it is capable of gradual accretion without fire, and with increased vigour with severe fire. By this means it is possible that a peppermint thicket could become established by a single fire event, and it may require an entire rotation to redress. (A similar situation has been reported by Hopkins and Robinson (1981) in a dry woodland in inland W.A.)

- The third pathway is an absence of fire (with or without grazing) that allows the peppermint seedlings to become established and develop a root stock (Figure 4). Once this occurs it will be effectively immune to fire of any frequency or intensity since it will be capable of coppicing if the above ground parts of the tree are damaged. As a tolerant species, recruitment will continue under quite high levels of competition.

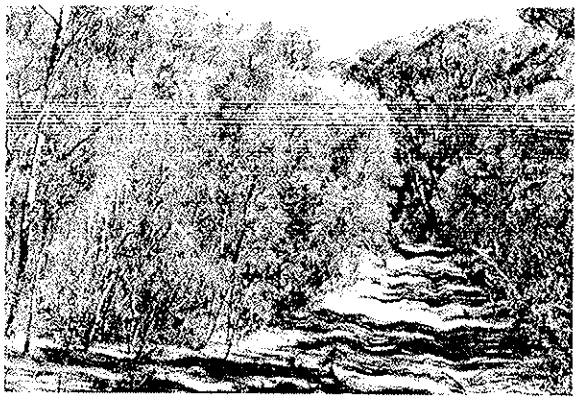

Figure 3. *A dense thicket of peppermint developed in this peppermint/yate savannah after a single severe fire event twelve years previously – between the Donnelly River and Black Point.*

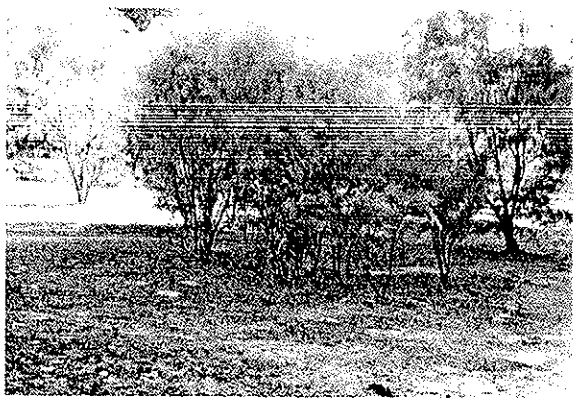

Figure 4. *Seedling peppermint becoming established on an unbunt, ungrazed paddock.*

The apparent contradictions in the impact of fire and grazing on the regeneration and survival of tuart and peppermint could be explained by the above. This is particularly so when it is considered that many of the descriptions and operations described in previous times did not necessarily apply uniformly and are likely to have been patchy or irregular. All of the above mechanisms will have applied at different times and at different places and several will have applied sequentially on the same site.

Figure 5. *Tuart is not able to regenerate beneath a dense understorey of peppermint of this kind. This area has been ungrazed and unburnt for 40 years.*

The establishment of a dense understorey of peppermint impacts on tuart in several ways. It increases competition for moisture and nutrient, affecting the vigour of the standing trees. Although there is no data on the effect of competition in the tuart forest, increased leaf density has been observed in tuart following the removal of competing peppermint (Rowe pers. comm.). When associated with long periods without burning, it could be expected that there would also be an adverse impact on nutrient cycling, though no data is currently available. Once a thicket of peppermint has become established then the primary limitation on the establishment of tuart becomes peppermint competition; and the absence of competition from mature tuart, the creation of ashbed or the removal of grazing are then largely irrelevant to regeneration success. (Figure 5)

The presence of a dense peppermint understorey fundamentally changes the way in which tuart is able to regenerate. The pre-European situation of small gap regeneration following the death of an individual tree is replaced by a stand replacement strategy, with an associated shift from

unevenaged stands to a more or less even aged structure. This occurs because only a severe fire event will temporarily remove competing peppermint to facilitate tuart regeneration – a fire of this intensity will also kill many of the existing tuart as evidenced by the recent severe fire in Yalgorup mentioned above.

Requirements for tuart regeneration

The successful natural regeneration of tuart depends on the coincidence of several factors. If any one of these is absent then regeneration will not become established. These factors are:

- ***The availability of seed.***
  Tuart, like many eucalypts, does not produce seed every year and it has been observed in the Ludlow forest that good seed crops occur about every six years (Broadbent[6] pers. comm.). While some seed will be available in most years, seed supply will dramatically effect regeneration success in any one year. Tuart seed supply is also seriously impacted by the Tuart Bud Weevil (*Haplonyx tibialis*) the presence of which can be detected by a small exit hole in the bud. It may cause the loss of almost an entire seed crop in some years.

- ***Receptive seed bed.***
  Natural tuart regeneration is heavily dependent on ashbed. While the ashbed effect is well known in eucalypts (Hatch 1960), tuart dependence is more extreme than most and in that respect is similar to wandoo (*E. wandoo*). Mortality of germinants off-ashbed is almost 100% and those that do survive for a short time soon succumb to competition from grass or other shrub species. Survival on ashbed is good and an early growth rate of 1 to 2 metres per year can be expected. Apart from its value in increased nutrient availability, the intense heat beneath ashbeds sterilises the soil providing a competition free environment for the early stages of seedling development. Ashbed is generally only receptive to seed for one season after which time it is colonised by moss and then grasses making it unsuitable for seedling germination. For an ashbed to be useful it must also be within the zone of seed cast from a parent tree (usually up to twice tree height). While this would not usually be an issue in a forest situation it may be a factor in more open woodland especially where parent trees have died without accompanying regeneration events such as in the current insect outbreak. While a severe fire tends to produce better ashbed conditions, especially from tree crowns, tuart logs do not require severe fire to burn away and these will produce small but effective ashbeds.

- ***Space to develop.***
  Seedlings that survive on the ashbeds will only develop into saplings and trees if they have sufficient space to develop without undue competition. Competition from surrounding trees occurs in the form of root competition (for moisture and nutrients) and crown competition (for light and physical space). In the pre-European condition, established tuart provided the main source of post establishment competition and stand density was probably maintained by the site limitations for moisture, with light and physical space being less limiting. Under a dense canopy of peppermint, competition for moisture, light and space are extreme, to the point where tuart seedlings cannot become established even when other conditions are favourable.

[6] Charlie Broadbent, Senior Operations Officer, Department of Conservation and Land Management, Busselton.

- ***Protection of the seedlings during their critical early stages.***
  All seedlings are susceptible to fire in their early stages but there is evidence that tuart will withstand mild fire by the time it has reached 2m (about 2 years) and will coppice from its lignotuber from this age if damaged by more severe fire (Anon 1976, Rowe pers. comm.). Young tuart are susceptible to grazing until they have developed a lignotuber (Anon 1921) and they are also susceptible to insect attack. *Phoracantha recurva* has been reported to attack seedlings on the edge of ashbeds but not the more vigorous ones in the centre (Anon 1927) and that more vigorous regeneration had recovered from borer attack (Brockway 1963). (If the species was correctly identified as *P. recurva* it suggests that the 'seedlings' referred to in the 1927 report must have been at least of sapling size, otherwise some other insect is likely to be implicated. Farr[7] pers. comm.)

The importance of some or all of these factors has been recognised for many years though the emphasis on the causes of poor regeneration varied from time to time. For example the importance of ashbed was emphasised by Brockman in 1903 (Anon 1921), competition (Richardson 1912, Anon 1921, Kessel 1930, Brockway quoted in Beard 1967), seed supply (Lane-Poole 1921, Kessel 1923) and damage to seedlings by grazing (Brockman 1921).

Despite examples of successful regeneration (Richardson 1912), achieving regeneration remained a problem apparently because one or more of the requirements mentioned above were absent at various times. A regeneration trial in 1971 was reported by Keene and Cracknell (1972), in which they adopted a similar prescription, relying mainly on the ashbed created by the peppermint understorey which had been pushed and heaped in gaps in the tuart canopy. The heaps were burnt in May and seed came from natural seedfall. Stock was excluded and successful regeneration followed. This was the basis for future regeneration operations that have been consistently successful. They attributed earlier failures to the fact that regeneration had been attempted beneath the peppermint understorey. However there were probably other factors as well, including: inadequate ashbed; cutting off peppermint rather than pulling (Richardson 1912) or pushing them (Keene and Cracknell 1972) which prevented coppice development; and inadequate canopy gaps in the tuart. White[8] (pers. comm.) attributed regeneration failures in the 1950's to the excessive competition in small gaps in the tuart and the peppermint canopy.

Following the successful trials in 1971, prescriptions for tuart regeneration have been included in all Ludlow forest management plans since 1976. Early prescriptions recommended a minimum gap size of 0.5 ha but this was later increased to 1 ha, but in operational programs during the 1980's the majority of peppermints were pushed down in areas up to 20 ha. To overcome the vagaries of natural seed availability, spot sowing or planting of ashbeds was used instead of natural seed fall. Successful regeneration was established over substantial areas using this operational technique (Figures 6 and 7). During this period an area in James' Paddock, prepared for burning, was burnt by wildfire in mid summer. This regeneration was even more successful with minimum damage to the retained trees. The regeneration prescription of 1988 (CALM 1988) restricted the removal of tuart, and confined the peppermint push-down to natural gaps in the tuart canopy but to a preferred minimum gap size of 1 ha.

[7] Janet Farr, Forest Entomologist, Department of Conservation and Land Management, Manjimup.
[8] Barney White, Divisional Forest Officer at Busselton during the 1950s.

Successful operational techniques for the regeneration of tuart are therefore well established and can be adapted to the tuart forest in Yalgorup.

Figure 6. *Regeneration established in winter 1985 in North paddock Ludlow. Some peppermint has become established on ash beds along with the tuart.*

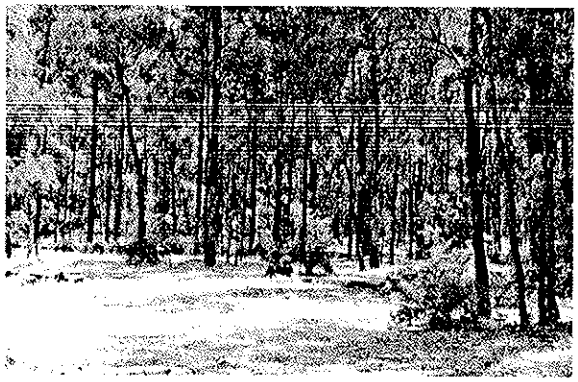

Figure 7. *Tuart regeneration in James' Paddock, Ludlow as a result of a wildfire in an area prepared for regeneration.*

Options for the maintenance of tuart in the Yalgorup National Park

The stimulus for the interest in regenerating tuart in the Park stems from the mortality that is being witnessed as a result of a severe outbreak of insect attack. However the issue has a broader context in that past events and present management regimes have created a situation where the tuart forest is structurally and functionally different to what it was before European settlement and it no longer has the capacity to regenerate itself other than by a severe disturbance or even a stand-replacing event. These recommendations are therefore made with the view to their application beyond just those areas that are severely impacted by insect attack.

The present management plan for the Yalgorup Park (Portlock *et al* 1995) has a stated objective "*to promote the long-term stability of Tuart stands in the Park.*" It recognises the possibility that past practices may have caused changes that require intervention to prevent decline and it recognises the need for fire management strategies to maintain particular vegetation conditions. It also states that care is needed to ensure "*..that any techniques used* [to prevent decline] *...do not cause damage to the understorey or affect fauna species associated with it, such as the Ring-tailed Possum.*"

The primary cause of the inability of tuart to regenerate is the dense understorey (primarily peppermint but also banksia in some areas) that has developed throughout the forest. In some areas the capacity to regenerate naturally is further impaired by severe mortality, and hence a reduced seed supply, as a result of insect outbreak. There is ample evidence to demonstrate that major disturbance of the peppermint understorey is necessary if tuart is to be regenerated. If any semblance of the pre-European condition is to be maintained then it would also be necessary to implement management practices that prevent the peppermint from again becoming dominant. While this would not threaten the existence of peppermint it would potentially impact on the habitat of species such as the Ring-tailed possum unless its dependence on this habitat is reduced by effective fox control. If not then compromise between these two conservation objectives will need to be developed.

The fire management strategies indicated in the plan comprise the use of fire for fuel reduction in buffers, for vegetation management and in scientific reference areas. In practice this has translated into large areas of long-unburnt vegetation, with relatively small areas subjected to irregular fuel reduction burning. These fire management regimes appear to be incompatible with the long-term stability of the tuart.

In areas that contain a dense understorey of peppermint:

- If the protection strategy is successful, and severe fire is excluded from these stands, then the peppermint will remain undisturbed and tuart will not regenerate. If that situation continues for long enough then the standing tuart will decline from old age (if not from other causes such as insect attack) and tuart will gradually disappear from the site. Peppermint will continue to replace itself without disturbance. This situation will apply to areas that are either unburnt or that undergo normal prescribed burning.

- If the protection strategy does fail (as it eventually will at different times) and the resulting wild fire is sufficiently intense to temporarily remove the peppermint, then tuart will regenerate provided a seed source exists. However a fire of this intensity will also kill a high proportion of the standing tuart. Peppermint will re-establish as a thicket and create a continuation of the condition that led to the problem. Therefore while the species will be maintained, the structure and the regeneration strategy will be dramatically different to its pre-European condition.

An alternative to this approach is to intervene and mechanically remove the peppermint understorey progressively over substantial areas of the forest and regenerate a new cohort of tuart in a way that will not seriously disturb the standing tuart. There appears to be two options for its fire management thereafter, depending on whether one wishes to maintain a savannah similar to its pre-European condition or to allow it to re-establish its present understorey. The management options after the establishment of regeneration are:

- To maintain a high frequency, low intensity fire regime with the intention of preventing the re-establishment of the peppermint understorey and promoting a savannah structure. A regular commitment to such a regime (probably a two-year cycle of summer burning) would be required to kill emerging seedlings of peppermint and prevent a build-up of fuel which would allow the opportunity for a fire of sufficient intensity to create a thicket of peppermint regeneration. Tuart would maintain the capacity to regenerate on the ashbeds of trees that fall or are burnt down from time to time. This option would increase diversity at the landscape level by maintaining a representation of a savannah forest or woodland as near as possible to its pre-European condition. It may be possible to further enhance this condition by promoting or establishing a greater representation of native grasses at the time of regeneration. These communities and structures represent an example of the outcome of a once widespread aboriginal management practice that has disappeared from the south west and is now rare throughout southern Australia (Specht 1991, Lunt 1991).

- To maintain a moderate frequency or a no-fire regime with the intention of allowing the understorey to return. This would decrease potential landscape diversity but can be designed to increase localised diversity. The peppermint understorey would again become dominant and intervention would be required whenever a new cohort of tuart regeneration was required.

Recommended prescription for regeneration and subsequent fire management

Objective

- To create a cohort of tuart regeneration:
  - in areas suffering or likely to suffer mortality as a consequence of the current insect outbreak, and
  - in areas exhibiting understocking of tuart and an absence of natural regeneration.
- To maintain a representation of tuart forest with both a savannah and a shrub understorey.

Selection of areas for regeneration treatment

Observation of insect damage suggests a somewhat tenuous relationship between severity and vegetation complex with more severe impact occurring on the Cottosloe complex. However, vegetation complexes do not delineate specific vegetation types on which different treatment appears to be appropriate. In broad terms these separate into:

- Areas with little peppermint, but with a relatively dense understorey of heath, woody shrubs and *Xanthorrhoea,* and:
- Areas with a dense peppermint understorey, some banksia and a relatively light ground storey of grass and woody shrubs. Within this type different treatments are recommended for:
  - Areas to be maintained as a tuart savannah, and
  - Areas to be allowed to revert to a dense peppermint understorey after regeneration.

In the absence of any maps that represent these broad types, or of detailed maps of insect damage or tuart stocking it is strongly recommended that new aerial photography be obtained for the tuart area of the Park. These photos could be used to identify the severity of insect damage, identify the type and condition of the understorey, identify tuart stocking levels and plan the operations of understorey removal at the appropriate level of detail. The most suitable aerial photos for this purpose would be colour diapositives at a scale of 1:10,000 taken with a 300 mm lens i.e. using the same equipment and film as that used for the dieback photography program. Shadowless (preferred) or full sun photographs would be acceptable. If this photography was included as part of the Government photography program (programmed in September each year) then the cost should be of the order of $5,000 to $8,000. These photographs are taken in Autumn each year.

The priority, program and the location of areas for regeneration treatment will need to be based on a consideration of severity of insect attack, practical fire management constraints for both regeneration work and subsequent fire management, aesthetics, location of flora and fauna that is sensitive to disturbance and land tenure (initial treatment programs may be easier to develop on areas which are still State Forest). It is beyond the scope of this report to develop such a program.

Treatment of areas for regeneration

Areas with little peppermint, but with a relatively dense understorey of heath, woody shrubs and *Xanthorrhoea*

- In areas that have remained long unburnt and which contain high populations of *Xanthorrhoea* – selectively burn *Xanthorrhoea* thatches in winter under conditions where the remaining area will not burn.
- Fell dead tuart ensuring that at least 30% of the original stocking remains, dead or alive, to provide for the retention of 'old tree habitat'. Felling will only be an option for the next year or two after which time it is likely to be too dangerous to fall these dead trees.
- Carry out floral cycle sampling to determine whether a seed crop is imminent. Where feasible, program operations so that the regeneration burn coincides with a mature seed crop. However this should not cause the regeneration burn to be delayed beyond one year.
- Undertake rabbit control where there is evidence of their presence.
- Burn the area at moderate intensity with the intention of creating ashbed from the crowns and boles of the tuart that have been felled or which burn down in the fire.
- In areas that have been recently burnt, it may be necessary to do some heaping of tops with a bulldozer to ensure good ashbed formation.
- Immediately prior to the regeneration burn check the retained live trees for the presence of mature seed capsules. Shoot down sufficient samples to confirm the presence or absence of damage by Tuart Bud Weevil (*Haplonyx tibialis*). In winter of the following year, plant ashbeds at an approximate spacing of 2m x 2m. Planting is not necessary on ashbeds within one tree height of a tree with a viable seed crop. (See a later section for recommendations of seed and seedling supply.)
- Survey ashbeds at the end of the following summer to determine regeneration success. Monitor for evidence of browsing by rabbits or native species.
- Follow-up fire regime – burn on a cycle appropriate for strategic protection or assigned vegetation management. The protection period that is required before tuart regeneration is able to withstand fire in the presence of a shrub understorey is unknown but it is likely to be in the order of ten years. The timing of the first burn after regeneration should be reviewed closer to the time that it might be done.

Areas with a dense peppermint understorey, some banksia and a relatively light ground storey of grass and woody shrubs – <u>to be maintained as a tuart savannah</u>

- Undertake rabbit control where there is evidence of their presence.
- Broadcast burn the area proposed for regeneration operations to reduce the fuel load to facilitate the later burning of heaps.
- Push peppermint understorey (in the following spring or early summer) into heaps in gaps in the tuart canopy ensuring that heaps are at least ten metres from any retained tuart. Push away from any patches of existing regeneration. In areas of low tuart stocking, retain only occasional large well-formed peppermint for aesthetic reasons. In areas of variable tuart stocking ensure that gaps are completely clear of peppermint, but retain patches of peppermint beneath areas of dense stocking of tuart if they cannot be pushed into openings. Restrict areas of intensive treatment to about 10 ha and retain 50 m breaks of retained peppermint between such areas for aesthetic reasons.

- Fell or push dead tuart ensuring that at least 30% of the original stocking remains, dead or alive, to provide for the retention of 'old tree habitat'. This will only be an option for the next year or two after which time it is likely to be too dangerous to fall these dead trees.
- Burn heaps (in late autumn or early winter following the push-down) to create ashbed.
- Immediately prior to the regeneration burn check the retained live tuart trees for the presence of mature seed capsules (depending on the timing and intensity of the earlier broadcast burn, any seed that was present may have already been shed). Shoot down sufficient samples to confirm the presence or absence of damage by Tuart Bud Weevil (*Haplonyx tibialis*). Within a few weeks of the burn (not later than the end of July), plant ashbeds, including those from any burnt down trees, at an approximate spacing of 2m x 2m. Planting is not necessary on ashbeds within 1 tree height of a tree with a viable seed crop. (See a later section for recommendations of seed and seedling supply.)
- Survey ashbeds at the end of the following summer to determine regeneration success. Monitor for evidence of browsing by rabbits or native species.
- Follow-up fire regime – burn on a cycle aimed at promoting grass and burning off seedlings of woody vegetation - this is likely to be in the order of a 2 to 3 year cycle and involve summer/autumn burns to achieve the required intensity. The timing and intensity of the first burn needs to carefully evaluated and conducted. The objective is to kill emerging peppermint and other woody seedlings but not kill tuart seedlings.
- Follow-up treatment. Depending on the regeneration of peppermint that follows the regeneration burn, a once-off peppermint control operation may be needed. This would take the form of felling peppermint saplings and poisoning the stumps to prevent coppice.
- Peppermint and exotic regeneration and survival should be monitored to provide a basis for adapting the fire regime if necessary.

Areas with a dense peppermint understorey, some banksia and a relatively light ground storey of grass and woody shrubs – <u>to be allowed to revert to a dense peppermint understorey after regeneration</u>

- Undertake rabbit control where there is evidence of their presence.
- Broadcast burn the area proposed for regeneration operations to reduce the fuel load to facilitate the later burning of heaps.
- Push peppermint understorey (preferably in spring or early summer) into heaps in gaps in the tuart canopy ensuring that heaps are at least ten metres from any retained tuart. Push away from any patches of existing regeneration. Push peppermint in patches of at least 0.5 ha (but preferably 1 ha) centred on gaps in the tuart canopy. Push peppermint beneath all canopy gaps in excess of 0.5 ha (70 m diameter). Retain patches of peppermint beneath areas of full stocking of tuart.
- Fell or push dead tuart ensuring that at least 30% of the original stocking remains, dead or alive, to provide for the retention of 'old tree habitat'. This will only be an option for the next year or two after which time it is likely to be too dangerous to fall these dead trees.
- Burn heaps (in late autumn or early winter following the push-down) to create ashbed.
- Immediately prior to the regeneration burn check the retained live tuart trees for the presence of mature seed capsules (depending on the timing and intensity of the earlier broadcast burn, any seed that was present may have already been shed). Shoot down sufficient samples to confirm the presence or absence of damage by Tuart Bud Weevil (*Haplonyx tibialis*). Within a few weeks of the burn (not later than the end of July), plant ashbeds, including those from any burnt down trees, at an approximate spacing of 2m x 2m. Planting is not necessary on ashbeds within

one tree height of a tree with a viable seed crop. (See a later section for recommendations of seed and seedling supply.)

- Survey ashbeds at the end of the following summer to determine regeneration success. Monitor for evidence of browsing by rabbits or native species.
- Follow-up fire regime – burn on a cycle appropriate for strategic protection or assigned vegetation management. Peppermint understorey would be expected to encroach over time necessitating further mechanical intervention whenever tuart regeneration is required.

Seed and planting stock

For the reasons mentioned earlier, tuart seed is relatively scarce and there are no felling operations of any consequence to facilitate collection. Tuart seed for the most part will have to be collected by shooting. This is an extremely onerous task even in years of good seed crops, if large quantities are required. Since seed supply of tuart is always likely to be limited, planting is recommended over seeding since seed requirements are about $1/20^{th}$ of that required for broadcast seeding.

At the present time the CALM Seed Centre has sufficient stocks of seed of Lake Preston origin to plant about 100 ha of ashbed at 2m x 2m spacing. This is a substantial gross area. A seed crop is expected next year if it not too badly affected by Bud Weevil.

The magnitude of the problem at Yalgorup suggests that an ongoing regeneration program will be required for some years. In view of this it is recommended that a seed orchard of Yalgorup seed be established as soon as possible. The present seed stock has a sufficiently broad but localised genetic base for that purpose. A small orchard based on a simple scheme of rotational destructive collection would be a great deal more efficient that wild collection by shooting. Seed orchard conditions would facilitate a preventive treatment for Tuart Bud Weevil and treatment to stimulate early flowering. An adequate seed supply would make it feasible to reduce plant spacing to say 1.5m x 1.5 m or replace planting with broadcast or spot sowing.

Conclusion

The available evidence suggests that the condition of the tuart forest has changed dramatically from its pre-European condition, primarily as a consequence of past and present fire management practices. These changes have led to a situation where tuart is unable to regenerate itself except by major disturbance, a fundamentally different strategy to that which existed before these changes occurred. This problem has taken on an urgency because of a recent severe insect attack that has caused severe crown deterioration and some mortality of tuart. The range of ages of trees that have been killed in the present attack suggests that this is the most severe outbreak that has occurred in for at least the last 150 years. Whether these dramatically altered conditions and regimes have contributed to the outbreak is presently unknown. Because of the nature of outbreaks of this kind, it will difficult to prove a connection by experimental methods on a small part of the landscape.

The effects observed here have parallels in other places where changes to indigenous burning practices have brought about major changes to the pre-European condition, bringing with it undesirable impacts. Examples include: the encroachment of rainforest understorey and associated dieback of high altitude grassy *E. delegatensis* forest (Ellis 1981), increasing tree density in once open, grassy *Pinus ponderosa* in the USA, with associated health problems (Covington and Moore 1994), and the threat to species in the Tasmanian tussock grass plains (Brown 1996) and in the wet

sclerophyll grassy forest of north Queensland (Harrington and Sanderson 1994). In the first two of these situations at least, reversion to previous practices is insufficient to restore the previous conditions and additional mechanical intervention is required, as it is in the tuart forest.

Lowland grassy woodlands are among the most threatened ecosystems in Australia (Specht 1981) and the south west of Western Australia is no exception. The principal reason for this is that these natural pastures were among the earliest areas of land to be settled and developed as farmland. However, the other potential threat to their survival in reserves is the general application of fire regimes that are inimical to their maintenance. The tuart savannah is one such community. In the past the application of a regime of more frequent fire has been opposed in some quarters because of concerns that it will facilitate weed invasion. While this is a valid concern, it needs to be re-evaluated in the light of the alternative loss of an important forest association and landscape feature. The WA National Parks Association and Reserves Association has previously made representations to re-create the original condition of the Ludlow tuart forest as have aboriginal elders in the area. (WANPARA 1994, Black 1997)

The methodology for establishing regeneration of tuart in these circumstances is well established and has been carried out previously in the Ludlow National Park. There is of course no guarantee that regeneration established in Yalgorup will not be attacked by Tuart borer while the present adverse conditions prevail. To carry out the necessary activity to regenerate the tuart will require the present restriction on disturbance of understorey to be lifted. While there are obvious sensitivities about the use of bulldozers for vegetation management in National Parks, there are no practical alternatives to restoring the conditions necessary to regenerate and maintain tuart.

A pre-requisite for the broader application of the regeneration treatment is the explicit enunciation of vegetation management objectives for the Yalgorup Park, in terms of landscape and localised diversity, the maintenance of specific conditions or seral stages, and the application of different fire regimes. Specifically whether, and to what extent, tuart savannah will be re-established and maintained. This needs to be resolved before the range of management options can be implemented.

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