Seedling survival, growth and health of *Eucalyptus gomphocephala* (Tuart) seedlings in Yalgorup National Park

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Report June 2003

1.0 Executive summary

This report presents the major results from a study of *Eucalyptus gomphocephala* (tuart) seedlings in Yalgorup National Park. The project was initiated in February 2003 to inform the Department of Conservation and Land Management regarding the persistence of the *E. gomphocephala* population in the park. Research conducted over the past five years in Yalgorup National Park and Kings Park will also be incorporated into this report.

The major findings of the study were:

- Naturally recruited *E. gomphocephala* seedlings in Yalgorup National Park, which recruited following a fire in 1996, have a high survival rate of 91%. This is higher than in *E. gomphocephala* seedlings (76%) that naturally recruited in Kings Park also following a fire 1996.
- Seedlings at the Yalgorup National Park study site have grown well over the five-year period since the last monitoring event, averaging over three metres in height in 2003. Seedlings in Kings Park are slightly smaller, most probably due to resprouting in response to recurrent wood boring insect attack.
- The general health level of the Yalgorup National Park seedlings is relatively high compared with those in Kings Park. They are, however, showing signs of wood boring insect attack and the effects of a fungus (*Mycosphaerella cryptica*). The effect of these conditions will require further monitoring.
- At this time, the number of seedlings in Yalgorup National Park that are affected by wood boring insects is similar to that in Kings Park (8-9%).
- Using only the percentage of canopy as an indicator, it seems that the area of Yalgorup National Park that was burnt in 1996 is recovering well.

Recommendations include the continued monitoring of *Eucalyptus gomphocephala* seedlings at Yalgorup National Park on an annual basis to determine the long-term survival and growth of the seedlings and their ability to replace the declining adult population.

2.0 Introduction

The Department of Conservation and Land Management is committed to determining the cause of *Eucalyptus gomphocephala* decline in the Yalgorup National Park region. Given the recent high mortality rates of adult *Eucalyptus gomphocephala* plants, it is vital to understand whether this mortality rate similarly applies to seedlings. There is concern that in this event, the population may not persist in the Yalgorup region given the limited replacement of adult plants. In February 2003, it was proposed that re-surveying of research sites in Yalgorup National Park, initially set up in 1998 (Ruthrof 2001), be undertaken to determine whether the *E. gomphocephala* seedling population was surviving to such an extent as to replace adult plants.

The data collected in Yalgorup National Park was compared with that from the 1998 survey and will indicate whether seedlings are persisting and have the ability to replace the current declining adult population. To determine any site differences, information collected at Yalgorup National Park will also be compared with that of *E. gomphocephala* seedlings in Kings Park. *Eucalyptus gomphocephala* seedlings recruited naturally following a fire in 1996 in Kings Park and have been surveyed annually for the past seven years.

3.0 Materials and methods

Measurements of the naturally recruited *E. gomphocephala* population in Yalgorup National Park were originally made in 1998 (Ruthrof 2001). In 1998, two transects of 100m x 10m (each made up of 10 10m x 10m quadrats) were surveyed within the area burnt in 1996. These transects were re-located and monitored again in April 2003.

Seedling survival and growth following natural recruitment has been determined for *E. gomphocephala* in an area of Kings Park. Ten 5m x 5m quadrats were set up in 1997 in an area of the park that was burnt in 1996 in which natural recruitment of *E. gomphocephala* was evident. In each quadrat 20 randomly chosen seedlings were numbered, tagged and monitored.

3.1 Seedling survival

During the 2003 monitoring event, all seedlings located within the Yalgorup National Park transects were monitored. By determining the number of seedlings in each quadrat and comparing the data to the last survey in 1998, seedling survival was determined.

3.2 Seedling growth

In Yalgorup National Park, seedlings were also measured using a tape measure or clinometer and placed in a height class (0.0-1.9m, 2.0-3.9m, 4.0-5.9m, 6.0-7.9m, 8.0-9.9m, and >10.0m). Similarly, all individuals were measured with a DBHOB (diameter at breast height - 1.3m - over

bark) measuring tape and placed in stem diameter classes (0.0-10.0cm, 11.0-20.0cm, 21.0-40.0cm, 41.0-80.0cm, and >81.0cm).

3.3 Seedling health

Other measurements for each seedling included a general health indication, and a specific health rating relating to wood boring insects. The general level of health was monitored by giving each seedling a rating from 1 to 5; 1 indicating dead and 5 indicating healthy. The specific health rating took into account whether a seedling was affected by wood boring insects and how many wood boring insect lesions each seedling had developed. A wood boring insect lesion is a very obvious, often round, hole in the trunk or branch, with a covering of sawdust (Plate 1).

Plate 1. Wood boring lesion on Eucalyptus gomphocephala seedling (Photo: Dr I. McLean)

3.4 General vegetation recovery

The recovery of the canopy in the section of Yalgorup National Park burnt in 1996 was determined by measuring the canopy cover with a spherical densiometer (Lemmon 1956). A reading was taken at each corner of each of the 10m x 10m quadrats in both transects. By comparing the data from the survey in 1998 to that in 2003, the recovery of canopy vegetation can be estimated.

4.0 Results

4.1 Seedling survival

A total of 667 seedlings were monitored in Yalgorup National Park in 1998, two years following recruitment. In 2003, 609 seedlings remained; a 91% survival rate after five years. The density of seedlings in the Yalgorup National Park transects has not changed significantly over five years (Figure 1). In Kings Park, of the 200 seedlings that were tagged in 1998, 152 remained in 2003; a 76% survival rate over five years.

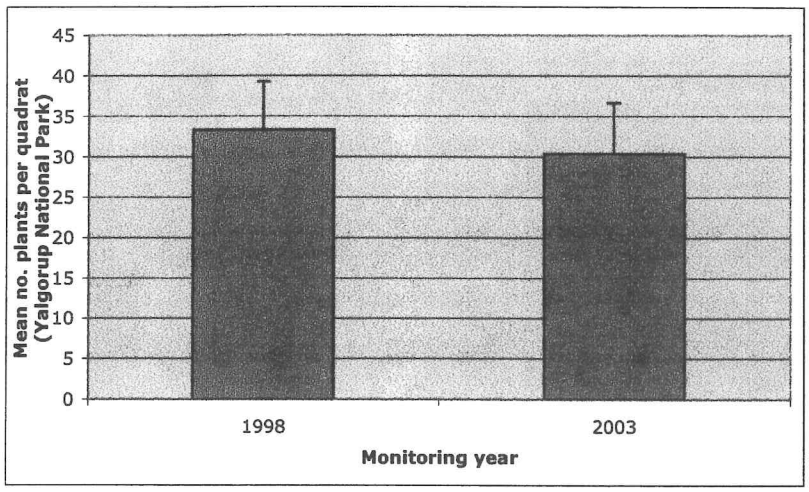

Figure 1. Mean seedling density, ± standard errors in each 10m x 10m quadrat, in the area of Yalgorup National Park that was burnt in 1996, monitored in 1998 and 2003. Values are means of 667 and 614 observations respectively.

4.2 Seedling growth

Seedling height has increased significantly over the past five years at both study sites (Figure 2). Seedlings were slightly taller in Yalgorup National Park in 1998 compared with Kings Park. This pattern was the same in 2003. The maximum height of the seven-year-old seedlings in Yalgorup National Park was 6.2m and the maximum height in Kings Park was 6.9m in April 2003.

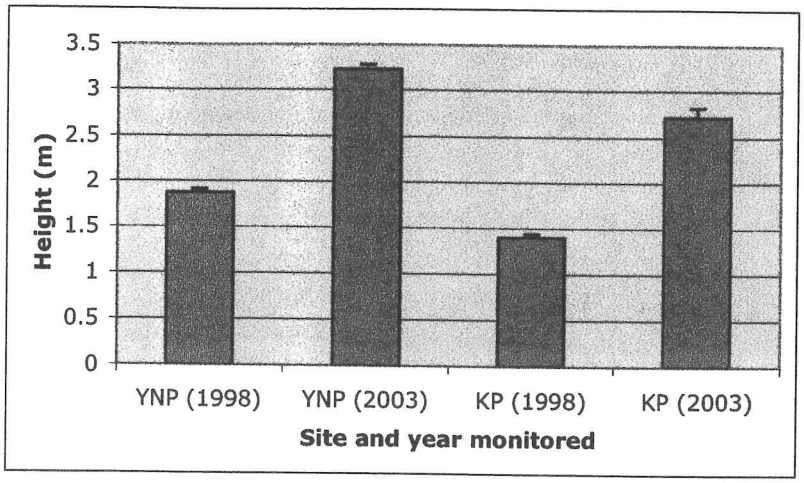

Figure 2. Mean seedling height (m), ± standard errors, in Yalgorup National Park (YNP) and Kings Park (KP) in 1998 and 2003. Values are means of 667 and 614 for YNP and 200 and 152 observations for KP.

The DBHOB of seedlings has increased significantly from 1998 to 2003 (Figure 3) in both Parks. However, the 2003 monitoring indicated that there is little difference between the seedlings of Yalgorup National Park and those in Kings Park. The maximum readings varied, however, with the maximum DBHOB in Yalgorup National Park being 13.3cm and 6.8cm in Kings Park.

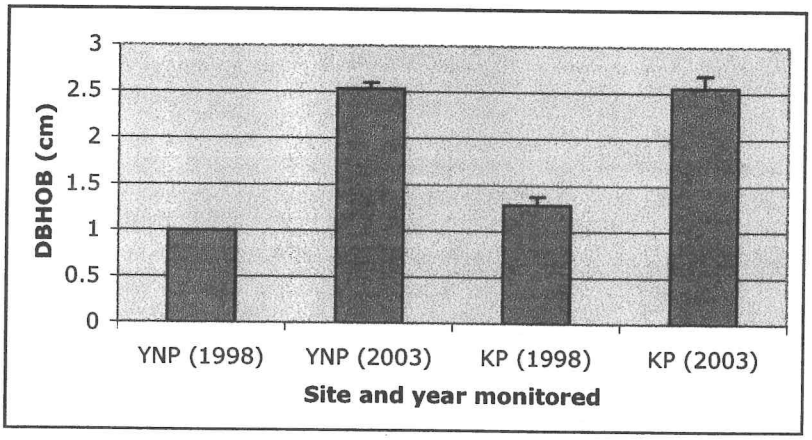

Figure 3. Mean seedling DBHOB (diameter at breast height over bark) (cm), ± standard errors, in Yalgorup National Park (YNP) and Kings Park (KP) in 1998 and 2003. Values are means of 667 and 614 for YNP and 200 and 152 observations for KP for 1998 and 2003 respectively.

A closer look at seedling heights by placing seedling data into size classes showed some interesting patterns. The height class figure indicates that in 2003 there are fewer plants in the smaller classes but more in the 4.0-5.9 class (Figure 4).

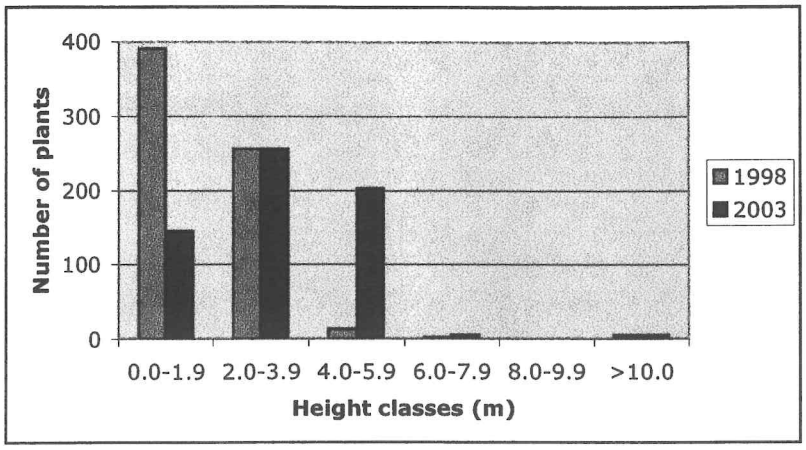

Figure 4. Number of individuals in height classes (m) in Yalgorup National Park in 1998 and 2003.

Seedlings were also placed in DBHOB classes, which showed a slightly different pattern to that of the height data (Figure 5). Here, the seedlings have only just moved into the next size class.

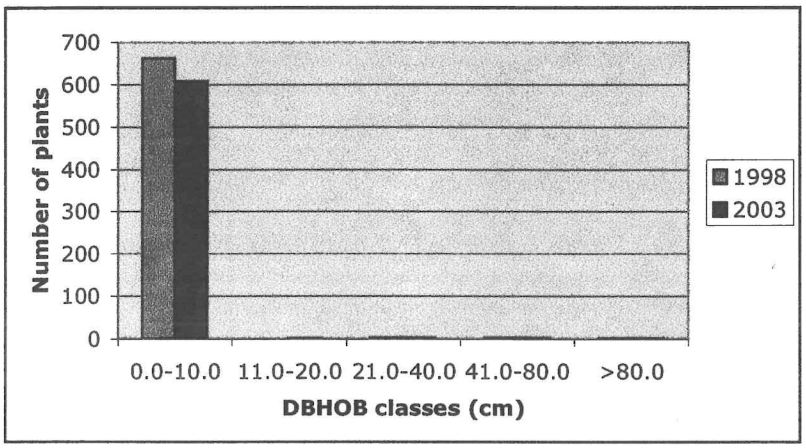

Figure 5. Number of individuals in DBHOB classes (cm) in Yalgorup National Park in 1998 and 2003.

4.3 Seedling health

The general health level of seedlings was significantly different between Yalgorup National Park and Kings Park (Figure 6). Seedlings in Yalgorup National Park were much healthier than those in Kings Park. Kings Park seedlings are being affected by a fungus called *Mycosphaerella cryptica* (Paul Barber, Murdoch University, pers. comm.). Results indicate that approximately 22% of the Kings Park population are being affected by this fungus species. Although the fungus also occurs in Yalgorup National Park (Paul Barber, Murdoch University, pers. comm.), fewer seedlings seem affected than in Kings Park at the time of the monitoring event.

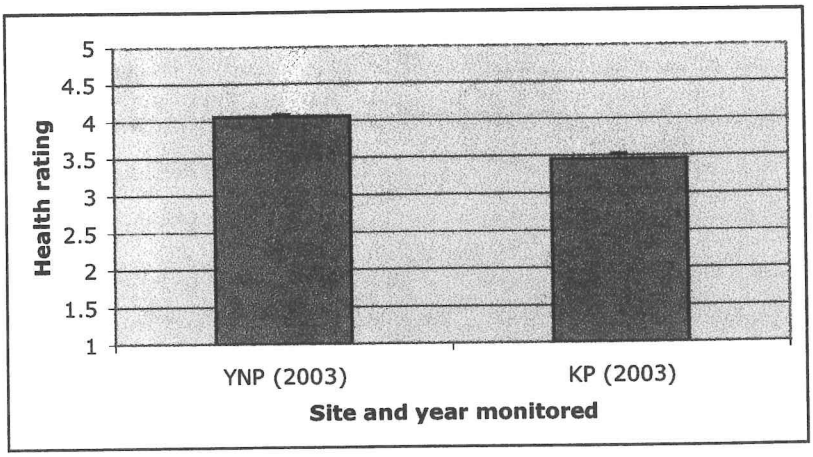

Figure 6. Mean health rating, ± standard errors, of seedlings in Yalgorup National Park (YNP) and Kings Park (KP) in 2003. Values are means of 614 for YNP and 152 for KP seedlings.

The number of seedling affected by wood boring insects was very different in Yalgorup National Park compared with Kings Park (Figure 7) in 1998, where significantly fewer seedlings in Yalgorup National Park were affected by wood boring insects compared with Kings Park. However, in 2003, the pattern is reversed with slightly more seedlings in Yalgorup National Park being affected than in Kings Park. However, the number of seedlings affected is quite low for both parks.

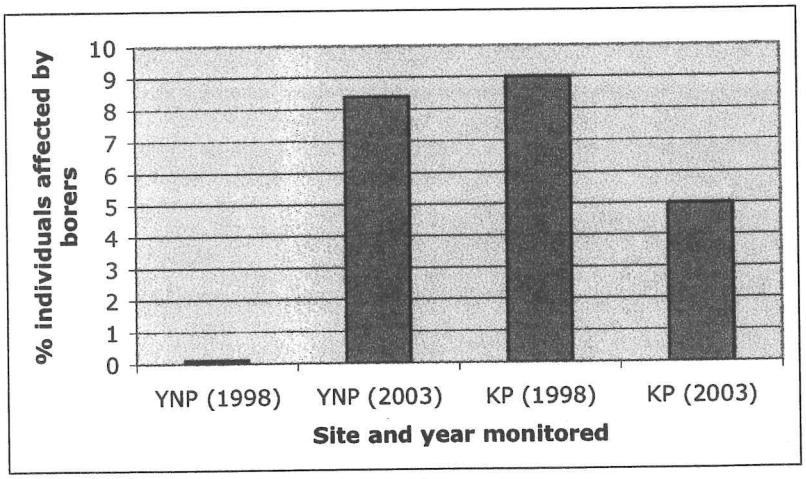

Figure 7. Percentage of seedlings in Yalgorup National Park (YNP) and Kings Park (KP) being affected by wood boring insects in 1998 and 2003. Values are percentages of 667 and 614 for YNP and of 200 and 152 observations for KP for 1998 and 2003 respectively.

4.4 General vegetation recovery

The native vegetation in Yalgorup National Park has recovered well following the fire in 1996. This can be seen by the increase in canopy cover over the past five year period from 1998 to 2003 (Figure 8).

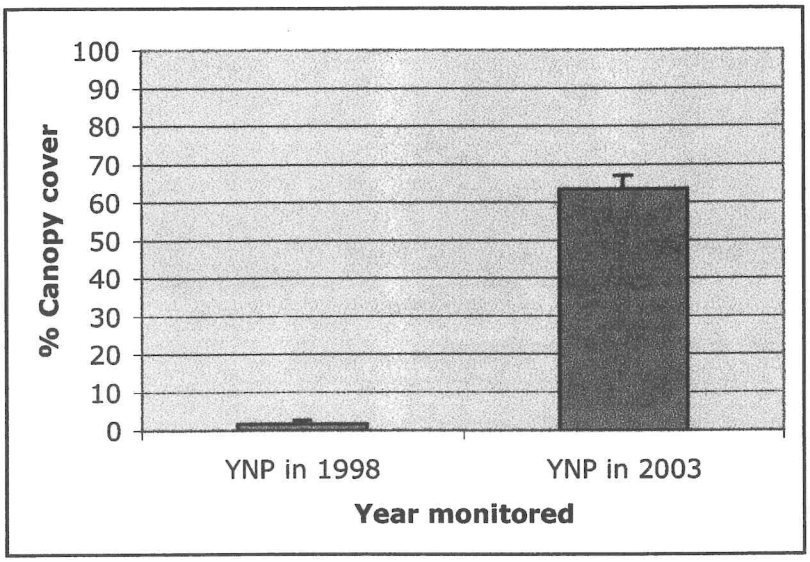

Figure 8. Mean percent canopy cover, ± standard errors, in the area of Yalgorup National Park burnt in 1996, when monitored in 1998 and 2003. Values are means of 80 observations.

5.0 Discussion

5.1 Seedling survival

Mass recruitment of temperate eucalypts has been well documented (Ashton, 1976; Wellington and Noble 1985ab; Yates *et al.* 1994; Ruthrof 2001). It is one of the many characteristics that temperate eucalypts share. Other shared characteristics include the mass release of canopy stored seed following fire, leading to a temporary satiation of seed harvesters and the production of a temporary soil seed reserve (O'Dowd and Gill 1984). These are some of the characteristics that *E. gomphocephala* also shares (Ruthrof 2001).

Following mass recruitment, seedlings must establish and grow to reproductive maturity for the continued survival of the population. Survival of naturally recruited eucalypt seedlings is normally quite low, especially during the first two years following emergence (Jacobs 1955; Wellington and Noble 1985a). High levels of mortality are associated with drought, competition with the surrounding vegetation, high soil temperatures in summer, pathogenic fungi, frost, herbivory, level of litter accumulation, and low light intensities in winter due to overstorey shading (Cunningham 1960; Davies and Myerscough 1991; Stoneman *et al.* 1994). The present study has focused on the mass recruitment and survival of *E. gomphocephala* seedlings in Yalgorup National Park. The study has shown that the level of survival after seven years following recruitment is very high at 91%. The density of seedlings has therefore also not changed significantly over the last five years. This survival rate is slightly higher than that seen in similarly aged seedlings in Kings Park, which have a 76% survival rate. This is perhaps due to the

higher level of recurrent wood boring insect damage that the Kings Park seedlings have experienced.

5.2 Seedling growth

Seedling growth can be affected by the similar factors that affect survival, including drought, competition, high temperatures, pathogens, and herbivory (Bowman and Kirkpatrick 1986; Stoneman *et al.* 1994). Although at first it would seem that survival in the first few years seems more important than growth, from an ecological viewpoint both are vital; faster growth allows seedlings to out-compete other native and non-native species. This may be significant in the Yalgorup National Park context given that a native dominant mid-level canopy species, *Agonis flexuosa* population may be increasing in abundance in the park.

The current study has shown that the *E. gomphocephala* seedlings in Yalgorup National Park are growing well and are at a height slightly greater to that of similarly aged seedlings in Kings Park. However, the DBHOB of seedlings in both parks is very similar. Again, this is most likely due to the fact that many of the Kings Park seedlings resprouted following wood boring insect attack. That is, seedlings of both parks have a similar DBHOB but due to those in Kings Park having to resprout, height is compromised.

From the population structure diagrams, it is obvious that the seedling population is moving into the larger size classes. It is hoped that continued growth without interruption (such as by fire or a disease outbreak) can lead to these seedlings moving further into larger size classes, replacing dead adults.

5.3 Seedling health

Seedling health can be compromised by a number of factors, and affect the ability to survive, grow and reproduce. This latter factor will be vital in the Yalgorup National Park situation in the next decade when the *E. gomphocephala* seedlings will hopefully be healthy enough to reproduce and continue the persistence of the population. The health rating for seedlings in Yalgorup National Park was surprisingly high. On a scale of 1 to 5, with 5 being the healthiest, seedlings in Yalgorup National Park had a mean rating of over 4. In contrast, those in Kings Park had an mean rating of less than 3.5. This relatively low level for Kings Park seedlings is associated with the recovery from recurrent wood boring insect damage, and the effects of the fungus *Mycosphaerella cryptica* (Paul Barber, Murdoch University pers. comm.). The fungus has affected both Yalgorup National Park and Kings Park seedlings over the 2003 winter and will need further monitoring.

The number of seedlings affected by wood boring insects was relatively low in both Yalgorup National Park and Kings Park in April 2003. Seedlings in Kings Park were clearly recovering from previous wood boring insect attack (which peaked in their fifth year when 51% of seedlings were affected). However, in Yalgorup National Park, seedlings were not in the process of recovering and thus it is suggested that over the past five years, these seedlings have had quite low levels of wood boring insect attack. The Yalgorup National Park seedlings are at the same level of insect attack as those in Kings Park in 1998. This will be a concern if the level of attack in Yalgorup National Park increases further.

The interesting pattern regarding borer attack is that the Yalgorup National Park seedlings seemed not as affected by wood boring insects as the adults, which were so affected that mortality in the park was unprecedented (as far as is known). A possible explanation is that seedlings are not affected by changes in water levels and quality as the adults, which have adapted to a certain level and quality of water. Research has been conducted in the US on wood boring insects such as *Phoracantha semipunctata* (the same genus that has been linked with *E. gomphocephala* damage) (Lawrence *et al.* 1995). These studies have shown that wood boring insects tend to attack plants with high water stress. This pattern has also been noted in Australia where high levels of wood borer attack of *Eucalyptus rossii* was linked to fissures caused by drought (Pook *et al.* 1966). More specifically, the variation in resistance of eucalypts to attack by the borer is associated with moisture content of the bark (Lawrence *et al.* 1999). That is, in trees with moist bark, larvae fail to reach the cambium, feeding instead on tissues beneath the bark surface. Trees that seem more resistant to attack by wood borers are those that are most tolerant of drought (Lawrence *et al.* 1999). However, more information is required regarding the factors affecting wood boring insect distribution, abundance, feeding patterns and associated impacts on *E. gomphocephala* populations.

5.4 General vegetation recovery

Although a single fire can have dramatic effects on vegetation structure, it seldom results in the complete loss of a species from a community. Most species have effective survival strategies (Noble and Slatyer 1981); however, adaptations are usually connected to a particular fire regime. Repeated fires, in an ecosystem that has evolved with an intermittent fire regime, can have a significant influence on vegetation by eliminating sensitive species and encouraging the spread of resistance species. The canopy in the study area has recovered quite well, growing from a mean of 1% to 63% canopy cover in five years. The majority of this canopy was made up of *E. gomphocephala* seedlings and resprouting adults. It was interesting to note that, although there are only small pockets of *Agonis flexuosa,* the population is recovering very quickly following the 1996 fire; some plants have already produced fruit. In contrast, none of the *E. gomphocephala*

seedlings are reproductive mature. Since the *E. gomphocephala* seedlings have not as yet become reproductively mature, and the adults have not recovered to reproductive maturity, another fire in this area would be highly detrimental to the *E. gomphocephala* population at this site.

6.0 Conclusions and recommendations

The *Eucalyptus gomphocephala* seedlings in Yalgorup National Park are, at this stage, surviving at high levels and are growing well. They are, however, being affected by wood boring insects and by an outbreak of the fungus *M. cryptica*. It is recommended that these seedlings be re-monitored annually to determine their long-term ability to replace the declining adult population in the park. It is highly recommended that this area of the park be protected from fires until the *E. gomphocephala* seedlings are mature enough to survive a fire event.

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