River Red Gum dieback investigation, Malcolm Creek, Craigieburn

Clifton C[1], Treadwell, S[2], van den Hove R[3]

1. Jacobs Group (Australia) Pty Ltd, 50 Mitchell St Bendigo, Victoria, 3550. craig.clifton@jacobs.com
2. Jacobs Group (Australia) Pty Ltd, 452 Flinders St, Melbourne, Victoria, 3000. simon.treadwell@jacobs.com
3. Melbourne Water, 990 Latrobe St Docklands, Victoria, 3008. ryan.vandenhove@melbournewater.com.au

Key Points

- Canopy condition in mature River Red Gum trees, located along Malcolm Creek Craigieburn, began to deteriorate in about 2014. Since then, about 15% of the trees have died or have very advanced dieback symptoms.
- Recently dead trees and those with the most severe dieback symptoms are all located in or immediately adjacent to the channel of Malcolm Creek, in areas which are most exposed to changes in water regime that have followed urban development in the catchment.
- Changes in water regime associated with urban development appear to be the primary driver of dieback in the mature River Red Gum trees, with insect and possum defoliation exacerbating the effects of these changes.
- Changed management of stormwater flows from urban areas to create longer low and no flow periods, together with mixed species revegetation to improve biological controls of lerp insect populations, may be required to build the resilience of remaining mature River Red Gum trees.

Abstract

Dieback is a well-known phenomenon in eucalypts, with multiple biotic and physical factors implicated. The investigation of dieback in mature River Red Gum (Eucalyptus camaldulensis) trees along Malcolm Creek, Craigieburn was designed to assess the effects of several potential causal factors, including changed water regime from urban development, repeated cycles of defoliation; climatic conditions which may influence defoliating insect populations; and senescence processes in the trees.

A detailed assessment was undertaken along a 1.2 km section of Malcolm Creek. Dieback was found to be severe in about 15% of trees at the time of the assessment, in January 2018. All of the most severely-affected trees were located along the bed of Malcolm Creek. The primary determinant of the dieback in the mature trees appears to be the prolonged waterlogging now being experienced by those growing in or adjacent to Malcolm Creek. This factor, favourable climate and limited biological controls for lerps may also have predisposed the trees to repeated cycles of defoliation.

Rectifying the prolonged waterlogging of the trees by changing stormwater drainage and management appears to be the key to improving the resilience of mature River Red Gum trees.

Keywords

Dieback, River Red Gum, stormwater management, lerps, climate.

Introduction

Many mature Eucalyptus camaldulensis (River Red Gum; RRG) trees located along Malcolm Creek, Craigieburn, are currently in poor health. Their canopies are sparse, unevenly-distributed and have large numbers of small, dead branches. The foliage of these trees has been significantly affected by sap-sucking lerp insects (Psyllid family, most likely Cardiaspina albitextura). Repeated cycles of damage and defoliation by

these insects (and possums) may be contributing to dieback symptoms and the recent death of some mature trees.

Numerous RRG trees have naturally regenerated along Malcolm Creek over the past decade, but at higher elevations than most dieback-affected trees. While the crowns of some of these trees have been affected by lerps, they generally appear to be in better condition than nearby mature trees.

Melbourne Water is the waterway management authority with responsibility for Malcolm Creek. They also regulate the design and development of stormwater drainage from new residential and commercial areas. Melbourne Water commissioned this investigation to understand stresses and conditions that may be affecting the health of mature RRG trees along Malcolm Creek and to provide advice on any interventions or works which may assist in these trees' recovery from dieback.

Crown dieback in eucalypts

Dieback is a well-known phenomenon in eucalypts. A variety of factors have been reported to be associated with this condition (Clifton, 1988), including:

- Excess or deficient water supply
- Damage by defoliating insects
- Soil salinity
- Changes in exposure to wind, radiation and temperature
- Lightning and/or fire damage
- Parasitic flowering plants, such as mistletoe
- Grazing by possums and damage by birds such as cockatoos, corellas and galahs
- Fungal and bacterial diseases of foliage and tree roots

Collett (2000) found that RRG trees appear to be particularly prone to attack by lerp insects. Lerp populations appear to increase to outbreak levels when several interacting environmental factors favour their rapid growth, development and generational-turnover. These factors may include: the presence of abundant immature succulent foliage; leaf nutrient levels being sufficiently high to encourage the growth of individual organisms; warmer than average seasonal temperatures to accelerate generational turnover; adequate soil water supplies for the host foliage to be fully turgid and hence assisting the sucking action of the nymphs and adults; and low population levels of indigenous lerp-specific predators and/or parasitoids. Other studies (e.g. White, 1971) found that lerp outbreaks in stands of RRG may follow a succession of dry summers, combined with wet winters, which caused tree roots to be waterlogged.

Investigation methods

Study area

The investigation was conducted within an approximately 1.2 km section of the waterway reserve along Malcolm Creek, Craigieburn (Figure 1) in January 2018. While most of the mature trees in this vicinity are in the near-stream environment, some are located on the margins of the reserve, up to 80 m from the creek. Mature trees are thought to have been retained from when the area was first developed for agriculture, presumably in the mid-1800s.

The waterway reserve was established when land to the north of Malcolm Creek was developed for urban uses in the early 2000s. This led to the removal of livestock grazing pressure and, consequently, large numbers of RRG trees have regenerated; typically at higher elevations than most mature trees.

Progression of dieback

The progression of dieback along this section of Malcolm Creek was assessed using satellite imagery available (for 2002-2017) via Google Earth. Higher quality Google Earth imager from among those available for this period have sufficient resolution to enable an assessment to be made of the canopy condition of all mature trees present (Table 1).

Crown condition assessment

Crown condition in mature RRG trees along Malcolm Creek was assessed using the approach Clifton (1988) adapted for this species from a method developed for other eucalypts by Grimes (1978). The assessment considers four criteria:

- Crown size: the depth and width of the crown and its distribution around the trunk. Trees experiencing dieback often display characteristics of the overmature state of crown development: this is characterised by the failure of the primary crown branches and their partial replacement by branches arising from dormant buds in the trunk.
- Crown density: the density and distribution of clumps of foliage that make up the crown.
- Dead branches: the loss of major branches is included as a component of the crown size factor. This criterion relates to the degree of small branch and branchlet death.
- Crown epicormic growth: a normal, healthy crown has its foliage concentrated at the ends of the branches. Growth occurring along the branch and in an upright position is normally of epicormic origin (Grimes, 1978). Healthy crowns may contain a small proportion of epicormic growth. Higher proportions of epicormic shoots indicate recent defoliation or that branch failure has exposed part of the crown to more open conditions. This factor considers the proportion of the crown which is of epicormic origin, as well as its age and distribution through the crown.

Each crown condition criterion was assessed on a five-point scale using descriptors developed by Clifton (1988).

The crown size assessment has potential to indicate the extent to which age-related senescence processes may have contributed to the observed dieback. If crown size scores for trees with advanced dieback symptoms are found to be consistently low (indicating that the physical structure of the tree crown has broken down), it is likely that senescence is contributing materially to the tree decline. If the crowns of trees with dieback are otherwise structurally intact, it is unlikely that the trees are in their overmature growth stage and thus senescence is unlikely to be contributing to their decline.

The severity of damage caused by lerps was assessed qualitatively during the crown condition assessment. However, the results of this one-off assessment were of limited interpretive value, because the timing and extent of recovery from defoliation appeared to vary between trees. This meant that trees with newly regenerated crowns at the time of the investigation would be assessed to have low levels of psyllid damage, even if they had been fully defoliated a few months previously.

Relative elevation of the tree trunk

The elevation of the base of each of the trees included in crown condition assessment was assessed relative to water levels in Malcolm Creek (on 16/1/2018) and grouped into four classes (as per Table 2). Classes 1 and 2 comprise trees that are located in the channel of or directly adjacent to Malcolm Creek. They are the most exposed to changes in water regime. Trees in class 3 are located in the near stream environment, with their

bases elevated up to 1 m above the water level. While they may experience flooding periodically, their root zones would not be continuously wet. Trees in class 4 (base >1 m above water level) would only rarely (or never) be exposed to flooding and would most likely be unaffected by changes in the creek's flow regime.

Climate conditions

Literature on eucalypt dieback and insect defoliation suggests a potential role for climate. Warmer than average conditions and excessively dry and/or wet conditions may provide an environment in which lerp populations build up to the extent that trees experience a single major defoliation event or repeated cycles of defoliation and regrowth (Collett, 2000).

Climate data from the Melbourne Airport meteorological station (#086282; ~12 km to the south-west) was analysed to characterise recent climate for the Malcolm Creek catchment and trees at the study site. The analysis considered rainfall and temperature over the period 2000-2017.

Results and discussion

Progression of dieback

Historical satellite imagery of the study site provides insights into the onset of dieback among the mature RRG trees (Table 1). Dieback symptoms can be observed in trees along Malcolm Creek as early as 2006. The decline in crown condition seems to have increased in severity from about 2014 and was well-advanced in the most recent imagery (from 2017).

Table 1. Observed progression of crown dieback in River Red Gum trees located along Malcolm Creek

Year	Image quality	Observation
2002	Fair	No dieback symptoms discernible. No residential development on north side of Malcolm Creek
2005	Fair	No dieback symptoms discernible. Several stormwater detention ponds constructed.
2006	Good	Dieback symptoms present in a small number of trees.
2009	Very good	Dieback symptoms present in a larger number of trees than observed in 2006. Detention basin on Malcolm Creek (west of Windrock Avenue) has replaced a former farm dam on the same site.
2010	Good	Dead tree near western end of Malcolm Creek study site. No dieback symptoms discernible elsewhere.
2012	Fair	No dieback symptoms discernible.
2013	Good	No dieback symptoms discernible.
2014	Good	Dieback symptoms evident in <10 trees along Malcolm Creek.
2015	Good	Dieback symptoms evident in 5-10% of trees along Malcolm Creek.
2016	Good	Dieback symptoms evident in 5-10% of trees along Malcolm Creek.
2017	Very good	Several dead trees present. Numerous trees with dieback symptoms (15-20%).

Crown condition and relative elevation

The crown condition assessment included 87 mature trees, five of which had died in the 1-2 years prior to the assessment in 2018.

The overall crown condition score is typically the sum of scores for the four individual condition criteria: crown size, crown density, dead branches and epicormic growth (Clifton, 1988). However, after reviewing the results, it was decided not to include crown size in the overall condition score. While there was some variation in crown size ratings, there was no consistent pattern of trees with poor crown condition experiencing a breakdown in canopy structure. In many cases, trees with advanced dieback symptoms had

relatively intact crowns and relatively high crown size scores (the average crown size score for the 87 trees within the study area was 4.0 [out of 5]).

Based on the sum of assessment scores for the remaining three criteria, the overall crown condition score was divided into four health classes ranging from I Very unhealthy to IV Very healthy (see Figure 1). Average scores for the three criteria were approximately 3 (of 5), indicating that the mature RRG trees overall were in fair condition.

Fourteen trees were included in the poorest crown health class (I), including the five dead trees (Figure 1). All of the dead and very unhealthy trees were located within the channel of Malcolm Creek (relative elevation class 1). Two thirds of the unhealthy (class II) trees also had this same level of exposure to flows along Malcolm Creek. The RRG trees located away from the creek were mostly in healthy or very healthy condition (Table 2; Figure 1).

Table 2. Results of the assessment of crown condition and relative tree trunk elevation

Relative elevation class	Number of trees in each health class				
	I Very unhealthy	II Unhealthy	III Healthy	IV Very healthy	Average health class
1 Trunk at water level	14	19	12	0	2.0
2 Trunk partly at water level	0	5	13	0	2.7
3 Trunk ≤ 1 m above water level	0	1	2	0	2.7
4 Trunk > 1 m above water level	0	3	14	4	3.0

Figure 1. Location of trees included in this investigation, their overall crown health and relative elevation classes (ESRI background imagery).

Malcolm Creek is an ephemeral stream and the mature trees growing along it were likely to have developed in a water regime with short duration flooding, longer periods of low flow and elevated water tables and extended periods of no flow and lower water tables. Urban development, with increased and more frequent flows from stormwater and longer flow durations due to development of a detention basin upstream of the

study area, may be shortening the period of no flow and extending the duration of periods with elevated water tables. Waterlogging may be directly contributing to the decline of the trees and may also predispose them to damage by lerps (by ensuring leaves are generally turgid).

RRG regrowth along this section of Malcolm Creek is almost entirely absent from the immediate proximity of the creek (i.e. relative elevation classes 1 and 2). While regrowth trees experience some lerp damage, they are not experiencing dieback as are the mature trees located in or adjacent to the creek. Their generally higher elevation (relative elevation class is typically 3 or 4) may allow them to avoid prolonged waterlogging and perhaps reduce the favourability of their foliage as a feed source for the sap-sucking lerps.

Climate analysis

Temperature

Literature reviewed by Collett (2000) suggests that warmer than average temperatures may contribute to a build-up in lerp populations to the point where defoliation events occur. Maximum temperatures have exceeded the long-term average in almost 70% of months between 2000 and 2017. Daily maximum temperature has been consistently above the long-term average since about 2006. This is consistent with Australian and international observations regarding changing climate conditions. The analysis suggests that warming conditions could be influencing lerp populations and related defoliation of the RRG trees. Given projections for continued increases in temperature (e.g. CSIRO and BoM, 2015) as a result of climate change, this suggests that lerps may pose an on-going threat to the health of these trees.

Rainfall

Sequences of dry summers and wet winters have been implicated in lerp outbreaks leading to defoliation events in eucalypts, including E. camaldulensis (e.g. White, 1971). As winter is relatively dry in this part of Melbourne, the analysis considered rainfall in the warm-drier season (December-May) and cool-wetter season (June-November). There are two periods in the recent record with relatively dry warm seasons followed by relatively wet cool seasons, which could account for at least some of the development in dieback observed since about 2014

- 2013 warm and cool seasons: with warm season rainfall 75 mm below the long-term average and cool season rainfall 83 mm above average;
- 2016 warm and cool seasons: with warm season rainfall 49 mm below the long-term average and cool season rainfall 96 mm above average.

While seasonal rainfall since 2016 has not been consistent with the pattern that may give rise to lerp population increases, these two years approximately coincide with changes in crown condition which are evident in historical imagery. The lack of historical data on lerp populations or the level of damage to foliage means that it is not possible to directly confirm any influence of rainfall patterns.

Defoliation by possums

Defoliation by brushtail possums (Trichosurus vulpecula) may also contribute to the decline in crown health of at least some of the RRG trees along Malcolm Creek. An investigation by Yugovic (2016) concluded that excessive grazing by possums was the primary influence on tree health, with defoliation by lerps being a secondary cause. He attributed the better health of trees located away from Malcolm Creek to the possums' reluctance (because of potential predation by foxes or cats) to cross open ground to graze on these trees.

Likely determinants of dieback of River Red Gum trees along Malcom Creek

The evidence gathered in this investigation suggests that dieback symptoms in RRG trees along Malcolm Creek are influenced by multiple factors, including:

- Altered flow regime along Malcolm Creek: the environment experienced by mature trees located within or adjacent to Malcolm Creek appears to have become wetter as a result of urban development in the catchment over recent decades. Extended periods of waterlogging resulting from changes in Malcolm Creek's flow regime may directly contribute to the decline of these trees. Waterlogging leads to the depletion of oxygen in the soil, which in turn impairs the capacity of tree roots to take up water and nutrients. These stresses may also predispose the trees to defoliation by lerps.

- Defoliation by lerp insects: mature trees along Malcolm Creek are clearly under pressure from defoliation by lerps. Repeated cycles of defoliation are known to be associated with dieback in eucalypts and the death of individual or groups of trees.

- Defoliation by possums: although possums (or damage attributable to them) were not directly observed in this investigation, they may also be a cause of defoliation in at least some of the trees along Malcolm Creek. Possums' assumed reluctance to cross open ground to graze on trees more remote from the creek may help to explain why those trees are in better condition, but does not explain why trees at higher elevation, but near the creek, are also generally in better condition than those within or adjacent to Malcolm Creek.

- Climate change and variability: warmer weather conditions and two periods with relatively dry warm seasons followed by relatively wet cool seasons may have been conducive to a build-up in lerp populations and the defoliation which follows this.

No evidence of dryland salinity was observed along Malcolm Creek and this is unlikely to have been a contributing factor to the decline in tree health. It also does not appear that the dieback is simply an expression of age or senescence in the mature trees.

Potential management interventions

In response to staff and community concerns about the condition of the mature RRG trees in the reserve along Malcolm Creek, Hume City Council implemented several measures to reduce the defoliation burden. Tree guards have been installed on several trees to prevent access and grazing by possums. Insecticide has been injected into some trees to kill sap-sucking and any other defoliating insects. These measures may enable or at least encourage the recovery of affected trees, but do not address what is considered to be the main underlying cause of the dieback, the changed water regime in Malcolm Creek.

Melbourne Water are proposing to undertake mixed plantings of Indigenous species to diversify the environment along Malcolm Creek. This should improve habitat values and diversify food sources for insectivorous birds and (potentially) parasitoid wasps and may help to contain lerp populations and defoliation. This form of integrated pest management may take some time to become effective and will most likely be too late for some of the most severely affected trees.

Urban development within Malcolm Creek catchment is already well-advanced and without intervention in stormwater management systems, there is little prospect of altering what appears to be the key determinant in the RRG dieback observed along the creek. There are several opportunities to address stormwater flows along Malcolm Creek in ways that reduce waterlogging. The operation of the upstream detention basin (located to the west of the study area; Figure 1) could be changed to hold smaller dry season flows and

extend periods of low or no flow. Stormwater harvesting could also be introduced to reduce inflows to the basin and/or to Malcolm Creek. These changes would prevent (or at least reduce) flows from small rainfall events from entering the creek and could also allow more frequent or a longer period of drying along its lower reaches.

By reducing waterlogging of trees located within or immediately adjacent to the creek, such changes could assist those which are the most severely affected by dieback.

RRG trees with advanced dieback symptoms are (anecdotally) widespread along waterways in newer development areas located across the north of Melbourne. A similar investigation to this one at Taylors Creek, Keilor, also found that trees with the most advanced dieback symptoms were also located within or directly adjacent to the creek (Jacobs, 2018). Changed flow regime with urban development and stormwater management appeared also to be implicated in this incidence of dieback.

Conclusions

Evidence gathered in this investigations suggests that the primary cause of dieback in mature RRG trees is waterlogging of the mature trees as a result of changes to their hydrological regime. Repeated cycles of defoliation by lerps and possums most likely contribute to the decline in the trees and may be influenced by trends in climate and changes in water regime following urban development. Intervening to reduce the incidence or duration of waterlogging of mature trees within or adjacent to the channel of the creek would appear to be critical to their longer-term survival. It may also be essential in strengthening the resilience of similar stands of River Red Gum in urban creeks across Melbourne's north.

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