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fact sheet

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Making the most of scant environmental flows:

Maintaining the river red gum and black box woodlands of the Lower Murray Valley

This fact sheet written by Dr Anne Jensen presents findings from a Land & Water Australia PhD study undertaken on the Lower Murray Valley floodplain in South Australia. Primary study sites covered the region from Morgan in the west to Chowilla on the New South Wales border.

The majestic river red gum and black box woodlands of the Lower Murray Valley are in serious decline, literally dying for a drink. The floodplain is drying out, through lack of over bank flows onto the floodplain to replenish soil moisture reserves and freshwater lenses in water tables. The last useful over bank flows were in 1996. The current severe drought has made conditions much more critical. By 2004, more than 75% of river red gums and black box trees were stressed, dying or dead. Apart from above average rainfall in 2005, the situation is even worse in 2009, as there has been below average annual rainfall since 2004 and no river flows to alleviate the water stress on these iconic woodlands.

Murray Valley floodplain woodlands, which stretch for more than 700 km from the Barmah-Millewa Forest downstream to Mannum, were naturally sustained by over bank flows every two to three years, when water flooded out of the main river channel and along flood runners into wetlands and

Highland irrigation at Bookpurnong (right) is displacing saline groundwater to the floodplain (centre pool). This saline water rises into the root zone of river red gum and black box woodlands adjacent to the River Murray at Clarks Floodplain (grey vegetation centre left).

across the floodplain. Over-allocation of water resources in the Murray-Darling Basin and river regulation (particularly downstream of Mildura) has removed these small floods and severely restricted the duration and frequency of larger flows, thus leading to drier floodplain conditions and reduced water availability for floodplain trees and shrubs.

This project aimed to provide scientific knowledge to support environmental flow allocations for floodplain vegetation along the River Murray floodplain. It investigated the relationships between water availability and recruitment in river red gums, black box and lignum. Field and laboratory investigations were undertaken to determine the availability of viable seed and requirements for soil moisture to trigger germination and sustain seedlings. The investigations included the source and availability of viable seeds, timing of peak seed availability, critical levels of soil moisture content to support survival of seedlings, the role of rainfall, and the potential disruption of recruitment by external factors such as stock grazing. Outcomes from the study will have application in environmental flow management for determining the best timing and volumes required to achieve the most effective outcomes in maintaining river red gum, black box and lignum communities on the Lower Murray Valley floodplain.

Anne Jensen checks a seed trap at Twin Creeks during a watering event.

Seed traps at Werta Wert Lagoon on the Chowilla Floodplain, set to catch seed rain generated by the prevailing south-westerly winds.

This healthy mature red gum at Banrock Station in 2005 shed over 28,000 seeds m^{-2} in February 2005.

Three years later, the same tree at Banrock Station showed a thinning canopy and shed only 995 seeds m^{-2} in February 2008, following drying of the adjacent Banrock Lagoon and below average rainfall. However, after filling of the Banrock Lagoon in winter-spring of 2008, this tree starting releasing significant quantities of seed in July, peaking at over 27,000 seeds m^{-2} released in September 2008.

Project results and significance

Contrary to popular assumption, the seeds of eucalypts and lignum are not stored in the soil. Seeds for germination are held in aerial seed banks of mature closed fruit (serotiny). The two eucalypts release light seed rain for most of the year, with a peak fall in summer. This timing for peak seed rain would normally coincide with the greatest chance of sufficient soil moisture to support seedlings through their first summer, under natural flow conditions. Lignum flowers and releases seed in a very short period after heavy rain, thus giving the best chance for sufficient soil moisture to support successful germination.

Healthy eucalypts produce very high quantities of seed, with numbers measured in excess of 990,000 seeds per river red gum annually and 420,000 seeds per black box tree. Each species has distinct local patterns of bud development, flowering, fruit development and growth of new leaves. For the Lower Murray Valley, both red gum and black box exhibit a flush of new leaf growth each summer, with distinctive bright green clusters of leaves at the tips of branches. Old leaves and bark are shed at the same time.

Eucalypt buds are generally formed in January–February. However, the well-formed buds are then retained on the tree until flowering in the following summer. During the year, some buds are shed, with larger numbers shed in dry periods to reduce use of physiological resources by the trees. Similarly, fruit are formed from January–February and are retained on the tree for 1–2 years, with crops reduced by shedding fruit when conditions are not favourable. Small amounts of seed are released throughout the year when fruit or branches are damaged or break off, but most of the fruit stay closed until the valves of the fruit open over 1–2 months in summer, releasing the seed.

Most red gums in the Lower Murray Valley flower in December, but individual trees tend to flower every second year. About half the trees are on the opposite annual cycle, so the result is that about half of the red gums flower each year. This strategy spreads reproductive activity to maximise the chance of successful germination, ensuring high volumes of seed rain when adequate soil moisture is likely to be available.

Most black box trees flower every year, with more trees flowering every summer but some trees flowering every winter. This strategy allows black box trees, which grow at higher elevations which are less frequently flooded, to respond when either rain or flood events create adequate soil moisture to support germination.

Lignum appears to be more responsive to rain than flood for flowering and setting seed, with heavy seed production and release over a short period in late spring after significant rains.

Stressed eucalypts were found to be producing much less seed, as much as 10 times less than healthy trees. At sites which have been watered in The Living Murray program, stressed trees started to show a modest response in seeds released after their second watering, but the volumes of seed released remained low and almost continuous, compared with the definite summer peak of high volume seed release in healthy trees.

Floods do not trigger germination of eucalypt and lignum seeds in the soil, since the seeds are not held in soil seed banks. Instead, floods provide moisture for germination and survival of seeds released from aerial seed banks on the trees. Seed rain can land on water surfaces and be blown to the water's edge (a process called *hydrochory*), or can land on soil made moist by rainfall. Germination can be triggered initially by rainfall and then supported by moisture provided by subsequent flooding.

While floods are often described as the drivers of River Murray floodplain ecosystems, it turns out that soil moisture is the critical factor in germination and survival of seedlings. Floods can replenish freshwater lenses in water tables and soil moisture reserves, but eucalypt seeds will drown if they float in water for longer than 10 days. They need to reach the water's edge and strand onto moist soil to grow successfully. This process creates the characteristic strandlines of even-aged saplings after floods.

Lignum assumes a dormant state during dry periods, with no leaves or flowers, and mostly brown or yellow stems.

Twin Creeks red gum woodland on Chowilla Floodplain was extremely stressed in 2004, with thin canopies and brown leaves, as the sandy soils at this location cannot retain water as well as clay soils.

In spring 2005, the same lignum shrub blossomed profusely, produced leaves, extensive green stem growth and a dense seed crop after above average rainfall on the Chowilla Floodplain.

Watering at Twin Creeks in late 2004 gave instantaneous results, with green growth appearing within two weeks as water spread rapidly through the sandy soils.

In contrast to red gum and black box seeds, lignum seeds continue to float after germination and can survive for at least 28 days on the water surface while developing shoots and roots. However, over a period of 30 months, no successful lignum recruitment was observed in the field either at watered sites or after above average rainfall. This disturbing result indicates that lignum communities are not being sustained in the Lower Murray Valley under current conditions.

Management Options

Environmental flows are being recommended to restore and maintain the health of the floodplain ecosystem. Water is needed to encourage germination and support survival of seedlings to reproductive age, particularly in river red gums, black box and lignum. With limited water available for environmental flows, these results can be used to target use for best effect, aiming to support germinating seedlings through their first summer.

River red gum seedlings (with red stems) germinated in tens of thousands after watering at Coppermine waterhole on the Chowilla Floodplain in 2005, but did not survive subsequent hot summer conditions, even though grazing stock were fenced out.

Healthy river red gum seeds germinate within 5 days, given adequate moisture and day temperatures of 30°C. Viable seedlings can then be counted and separated from non-viable seeds, chaff and other fine debris caught in trap samples.

The magic number for soil moisture is ›10%, with 10–25% providing ideal conditions for seedlings to thrive. If soil moisture falls below 10%, seedlings quickly wilt and die.

Any flow or rain events which have the potential to increase soil moisture on the floodplain should be the trigger for piggy-back environmental flows to extend the period of soil moisture. Rain events ›5 mm are sufficient to trigger germination, even in winter, and soil moisture levels should be maintained at 10–25% in the top 10 cm of soil through the first summer after germination.

December is the most likely month for value-adding environmental flows, given current flow patterns and rainfall patterns. This also coincides with the natural pattern of flooding which peaked generally in November-December before river regulation.

In the absence of floods and restrictions on available environmental water, irrigation technology could be used, to apply a water regime of just 5 mm per week or 10 mm per fortnight to keep existing seedlings alive through their first summer. At target sites, the top 5-10 cm of soil should be kept in the range 10-25% for the first summer, until rain (or flood) events can provide an alternative source of moisture.

Conclusion

The floodplain vegetation communities of the Lower Murray Valley are under severe water stress, which can only be alleviated by a sequence of repeated over bank flows reaching the floodplain, to restore soil moisture reserve and recharge groundwater lenses.

Precision watering using irrigation techniques offers an alternative interim measure for local application in the absence of over bank flows, to keep seedlings and saplings alive until the next over bank flows. This project has provided key indicators for maintenance of critical soil moisture levels and for timing of environmental flows, to achieve the best possible outcome from the scant volumes available to maintain river health during times of severe water stress. It has also highlighted the importance of providing water allocations for environmental health, to replenish soil moisture and freshwater lenses in water tables during high flow events.

Clarks Floodplain red gum forest, downstream of Berri in the South Australian Riverland, was lush and healthy in 2000 but in serious decline by 2004, as a result of saline groundwater intruding into the root zones of the trees.

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Thesis

Anne Jensen, 2008 The roles of seed banks and soil moisture in recruitment of semi-arid floodplain plants: the River Murray, Australia, PhD thesis, School of Earth and Environmental Sciences, The University of Adelaide. http://digital.library.adelaide.edu.au/dspace/handle/2440/49169

Other publications arising

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Publications in preparation

6. Jensen, A.E., Walker, K.F., & Paton, D.C. (2008c). The floodplain seed bank of a regulated lowland river: composition and responses to wetting treatments for the River Murray floodplain, Australia. In prep.
7. Jensen, A.E., Walker, K.F., & Paton, D.C. (2008d). Soil Moisture for Seedling Survival: a key factor in woodland decline on the Lower Murray, Australia. In prep.

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