Science for Saving Species

Research findings factsheet

Project 1.2.2

Threatened Species Recovery Hub

National Environmental Science Programme

Rabbits, kangaroos and seedling survival in Endangered buloke woodlands: Project update

In brief

Grazing and browsing by herbivores like rabbits and kangaroos can be a serious impediment to restoring degraded ecosystems.

We used a field experiment to investigate survival and browsing damage to seedlings in an Endangered vegetation community, Buloke woodlands. The knowledge gained will also benefit the conservation of other woodland communities where active or natural regeneration is impacted by browsing.

Mere survival is not enough for seedlings exposed to strong browsing pressure. They need to attain a height and bulk where they are no longer vulnerable to herbivores. That is, they must definitively "escape" herbivores in order to reach maturity and ensure future populations. In buloke woodlands, this has been estimated to take around nine years or more.

Buloke woodlands

Buloke woodlands are an Endangered semi-arid woodland ecosystem found in the Riverina and Murray-Darling Depression Bioregions of southern Australia. These woodlands, which are typically co-dominated by buloke (*Allocasuarina luehmannii*) and slender cypress pine (*Callitris gracilis*), were extensively cut from the 1850s to promote pasture for cattle and sheep, and later for cereal crops. Many native plant and animal species became locally extinct, and the remnants suffered from the introduction of weeds and feral herbivores, especially the European rabbit.

Over the past 50 years, the largest remnants were incorporated into protected areas and livestock grazing phased out to encourage natural regeneration. However, there has been no indication over this period that young trees are emerging to replace the ageing stock of mature trees. The survival of an entire Endangered ecological community is the ultimate goal, but buloke was the focus of our experiment. Buloke is a vital structuring species of the community that has failed to regenerate there for more than half a century.

Since livestock were removed from parks and reserves, the key threat that has emerged to the restoration of buloke woodlands is browsing by rabbits and (native) kangaroos. Both species prefer grasses and herbs but will readily browse shrub and tree seedlings, and older plants, when their preferred foods are scarce. Previous studies have shown that even when rabbits are in low numbers they are capable of causing significant damage and mortality to native plants.

Kangaroos are known to cause significant degradation when they are in large numbers, but it is less well-understood what impact they may have on woody perennial species such as buloke when they are in low to moderate numbers. Other studies have found that the browsing by kangaroos presents a lesser threat to ecological systems than that by rabbits.

Parks Victoria allocates significant resources to monitor and control rabbits and kangaroos (and goats) with the aim to restore buloke woodlands.

Our research will help managers understand and predict how, where and when they can most cost-effectively intervene to restore Endangered buloke woodlands.

Buloke woodlands. Image: David Duncan

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What we did

The research examined variations in survival and growth of seedlings under three different levels of browsing protection; across four different buloke habitat types; and with varying levels of rabbit and kangaroo activity.

The Pine Plains management area of Wyperfeld National Park in north-west Victoria contains the largest remnant of Endangered buloke woodland, at around 700 ha. It is highly degraded; these woodlands now have a very reduced understory, with occasional shrubs and a ground layer dominated by native and introduced herbs and grasses.

The research team hand-planted 1275 buloke seedlings at Pine Plains in late Spring 2016. The seedlings had been grown in the nursery for around two years, and were about 31 cm tall on average. Seedlings were watered at the time of planting and after a hot and dry start there was above average rainfall during the study period.

Seedlings were planted at 17 sites across the Pine Plains randomly selected within areas that formerly supported buloke woodland.

A site was considered suitable if a live or dead buloke tree was located within 200 m, but we took care not to plant the seedlings within 13 m of a live tree, as buloke seedlings have previously been shown to suffer when they are planted too close to mature trees.

The 17 sites covered four different landscape types within the woodlands, which are used by kangaroos and rabbits in different ways:

1. *Open grassland:* former woodlands. Although open grasslands provide good foraging they lack shelter, and this habitat type is therefore less attractive to herbivores, presenting less risk to planted seedlings.
2. *Wattle dunes:* open areas near the foot of dunes and near shelter from wattles. Rabbits favour dunes for their warrens, with acacias giving good cover from predators.
3. *Mallee woodland:* open areas near the transition to mallee woodland. Kangaroos often use mallee vegetation for shelter and shade, and feed on the nearby grasslands.
4. *Buloke woodlands.*

At each site, the seedlings were randomly assigned one of three levels of protection from browsing. The three treatments were:

1. *Unguarded:* allows access to all herbivores
2. *Partial guards:* allows rabbits and hares access but excludes larger herbivores such as kangaroos and feral goats
3. *Full guards:* keeps out all browsing animals

We surveyed seedlings and herbivore activity four times during the study period. The final survey was 13 months (406 days) after planting. At each survey we counted rabbit and kangaroo scats to gain an idea of their density and browsing activity. During the final survey, we measured the height and stem diameter of all seedlings, recorded whether each was alive or dead, and categorised the level of browsing damage to the main stem.

Our expectation was that unguarded seedlings in habitats favoured by rabbits, especially wattle dunes, would suffer high mortality, but we were less certain about the likely impact of browsing by kangaroos.

Remains of an unguarded seedling showing 'chisel cut' browse damage on main stem.

Partially guarded seedling.

Ami Bennett inspects a fully guarded seedling.

Key findings

Guarding

The level of browsing protection provided to a seedling was the most significant influence on buloke survival and growth. Results for the three browsing protection treatments can be summarised as follows:

Unguarded: No protection from browsing

Unguarded seedlings had extremely high mortality, and of the small percentage that were still alive after 13 months, the majority were extremely damaged. Only about 5%, or one in 20, unguarded seedlings were still alive and undamaged at the end of the trial of just over one year. As such, this indicates that any regeneration strategy that does not guard seedlings is extremely likely to fail, and would not be an effective investment.

Partially guarded: Protection from kangaroos but accessible to rabbits

Any type of guard improved survival: roughly 75% of guarded seedlings survived.

While partial guards were intended to allow access by rabbits, and only exclude larger herbivores, we suspect that even partial guards reduced rabbit activity, therefore, the results of this treatment may under-represent the true effects of rabbits on seedlings. Rabbits may have avoided the confined space of the guard because other food was not limiting.

Even though partial guards substantially improved survival (compared to no guards) they were not good at preventing damage to seedlings. Roughly half of surviving seedlings in partial guards were damaged, and the proportion damaged was highest near wattle dunes, which are the landscape location most favoured by rabbits.

While there was variation in growth, overall, plants in partial guards were unable to grow fast enough to compensate for browsing impacts: at the end of the 13 months, seedlings in partial guards were 1.5 cm shorter (mean) than when first planted. This indicates that long-term regeneration is unlikely to be achieved while rabbits or hares can access seedlings.

Full guards: Protection from all browsers

At the end of the survey period about 75% of fully guarded seedlings were alive and undamaged. Complete protection from browsers was also the only treatment which resulted in a net positive growth of seedlings. The fully guarded seedlings grew 2.3 cm on average over the survey period. This demonstrates that complete protection from browsers is the only treatment which is likely to enable long-term regeneration of these woodlands.

Landscape locations

Although far less significant than the effect of browsing protection, there was some variation in the outcome of seedlings across the four different vegetation types.

Surprisingly, survival was poorest in buloke woodland sites, even for seedlings in full guards. The reason for this is unknown, but could include kangaroo camps, competition for water from mature buloke trees even though they were at least 13 metres away, or less available soil water due to heavier soils.

For plants with full guards – the treatment most likely to support effective regeneration – the best growth and survival occurred in sandier soils at the foot of dunes, and near transitions to eucalypt-mallee woodlands, even though kangaroo and rabbit activity was higher in these areas.

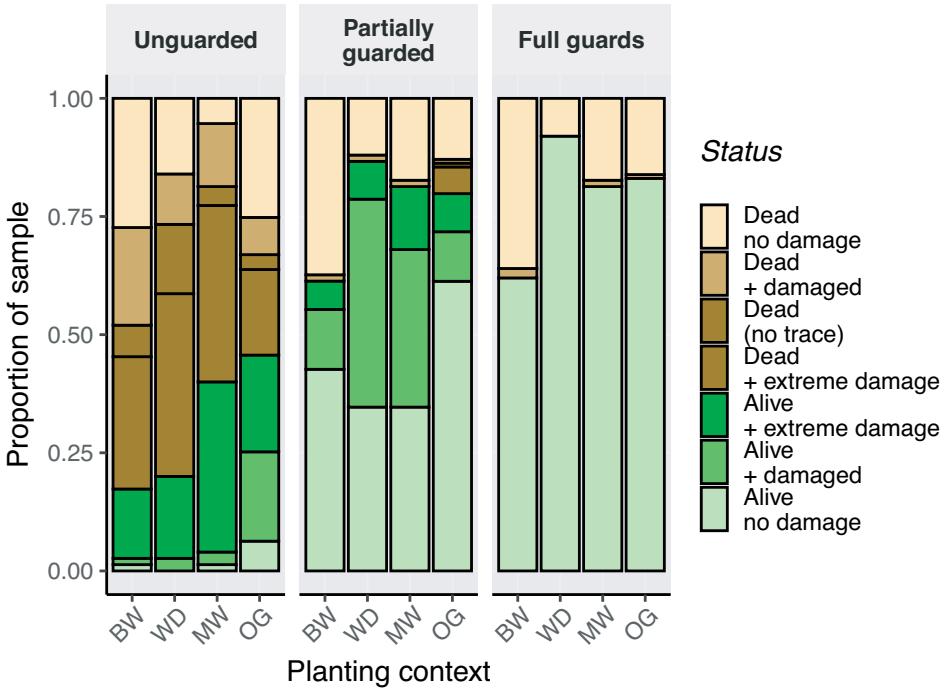


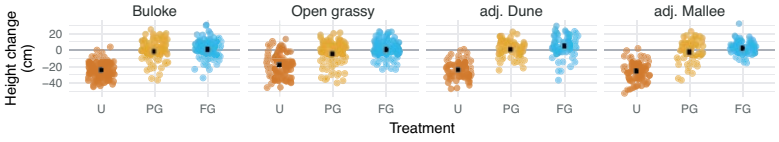
Figure 1: This stacked-bar graph shows the final status of 1275 hand-planted buloke seedlings after the 406 day trial period, across three protection treatments in four vegetation types: buloke woodland (BW), adjacent to wattle dune (WD), adjacent to mallee woodland (MW) and open grassland (OG). Status refers to if seedlings are alive and the amount of damage to the stem. 'Dead (no trace)' are shaded the same as 'Dead + extreme damage', as that was their most plausible fate.

Rabbits versus roos

Data on the level of kangaroo and rabbit activity was collected at all sites based on the number of scats present. This information was combined with all other data into a statistical model.

The model found that, all else being equal, more activity by rabbits (more scats) was associated with a higher risk of mortality to buloke seedlings while more activity by kangaroos was not. It should be noted that over the survey period, densities of both rabbits and kangaroos varied at levels considered low to moderate by management standards, so these results can't tell us what the relative impact of rabbits and kangaroos may be at moderate to high densities.

Figure 2. This graph details the height change outcomes for the 1275 hand-planted buloke seedlings with the group average superimposed. The growth calculations were made at the end of the experiment (after 406 days), or during the census when individuals were first recorded as dead. Tabulated are the height and stem diameter growth mean +/- 95% confidence interval for the same time period averaged over the entire treatment cohorts.



	Treatment summary (n = 425 per cohort)		
Change over experiment	Unguarded	Partially guarded	Full guards
Height (cm)	-22.2 (12.2)	-1.5 (12.5)	+2.3 (10.9)
Stem Ø (mm)	+0.9 (1.1)	+2.7 (1.6)	+2.7 (1.6)

Caveats

Our experiment focused on buloke, which may be particularly palatable at seedling stage. Survival rates for slender cypress pine (*Callitris*), which co-dominates the buloke woodlands, might be better.

These results corresponded to a benign year with above-average rainfall. Survival rates could be substantially worse across all treatments in drier years.

Recommendations

In buloke woodlands, even when kangaroos and rabbits are at low to moderate levels, their browsing is sufficient to prevent the growth of buloke seedlings and hence to prevent the regeneration of the woodland.

Guarding seedlings to prevent browsing is an effective strategy to allow seedlings to survive and grow. As seedlings need to grow well enough and for long enough to escape the impacts of browsers, in buloke woodlands tree guards may need to be maintained for a decade or more.

Guarded seedlings planted near wattle dunes have the highest survival and growth rates, while those planted into existing buloke woodland, even sparse ones, had the lowest survival rates. This information can be used to improve the success of future planting programs.

We are continuing to monitor the growth and survival of these seedlings with support from Parks Victoria.

Further Reading

Bennett, A., Duncan, D. H., Rumpff, L., & Vesk, P. A. (2019). Disentangling chronic regeneration failure in endangered woodland ecosystems *EcoEvoRxiv* https://doi.org/10.32942/osf.io/342nc

Further Information

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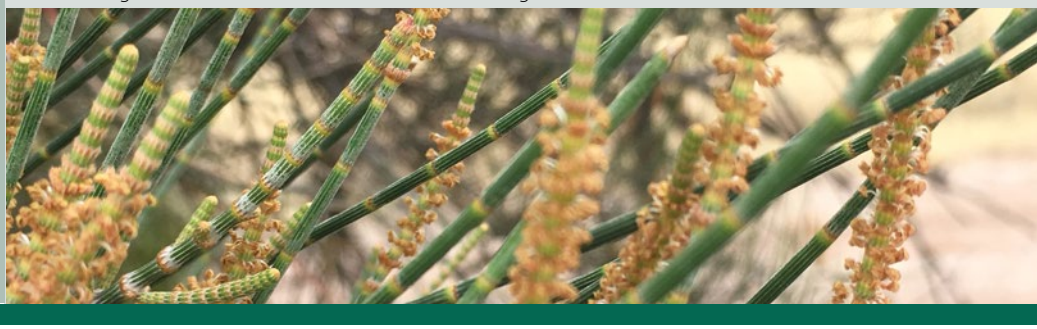
A flowering male buloke (Allocasuarina luehmanni). Image: David Duncan



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