Adventures with a common wattle

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A few years ago I decided to pursue a dream of becoming an ecological modelling specialist. To this end I enrolled in a PhD, then started looking around for a topic. I eventually settled on trying to understand soil and canopy seed banks in fire-adapted native forests. We have many tree species in Australia that need fire to regenerate, but there are many unanswered questions about exactly how they do this, especially given that fire behaviour can be so variable, and sometimes downright terrifying, as the recent fires in southeast Australia have just demonstrated.

To ensure this was more than just a 'theoretical' study, I needed to choose a couple of tree species to look at more closely. A lot of ecological research involves rare or threatened species, but I was trying to build a model, so I needed lots of data. I decided to focus on two common species, *Eucalyptus regnans* (Mountain ash) and *Acacia dealbata* (silver wattle) – very plentiful in the forests of the Central Highlands, not far from Melbourne. This story is about my adventures with *A. dealbata* and describes some of my insights so far.

Firstly, I had to find patches of forest where silver wattle was the dominant overstorey tree. Remote sensing came to my rescue here – this particular *Acacia* shows up very nicely as a grey-blue colour in a sea of medium or dark green *Eucalyptus*. I wanted forest patches that were young, middle aged and old – to see if my computer model could reproduce how the seed bank changes over time. Finding young patches was easy – there are many areas in Central Highlands where (for one reason or another) *Eucalyptus* regeneration has failed, and *Acacia* is king. But finding the old patches was incredibly hard!

It turns out that in the Central Highlands the time between major fires in our forests can be quite long – well over a hundred years in some places – but Silver wattle rarely survives beyond 80 years. As far as I know the record for a Silver wattle tree is 92 years (Fedrigo *et al.* 2019). So as an *Acacia* forest patch gets older, the trees simply die one by one, and other tree and shrub species take over. Such places then become devoid of large trees, waiting patiently for another fire. Then *E. regnans* and *A. dealbata* will fight it out for control of the freshly burnt landscape.

Patch of young Silver wattle (centre of image), Nolans Rd Toolangi, NearMap satellite image taken April 2011.

On my first day out in the Central Highlands to measure trees and take soil samples, I was struck by how immensely tall these wattles can become. Unlike the multi-stemmed, almost 'mallee' forms that we see along rivers and creeks in Melbourne, these trees typically had very straight trunks and tiny canopies, suggesting that they were desperate for light, in an environment dominated mainly by fast-growing *E. regnans*. The tallest silver wattle tree I found was 39.5m, larger than any other record I have found.

I also noticed how stunningly beautiful these wattle forests can be. (That is, once I had recovered from trooping through leech-infested gullies and staggering through dense wiregrass and shrubbery in order to get to them). *Acacia* trunks were typically covered in lichen, and there was often enough light getting through to support dense fern growth, including mother shield fern (*Polystichum proliferum*), batswing fern (*Histiopteris incisa*), bracken (*Pteridium esculentum*), soft tree fern (*Dicksonia antarctica*) and rough tree fern (*Cyathea australis*).

Middle-aged (36-year old) Acacia dealbata forest patch along Mt Bride Rd, east of Yarra Junction

I did manage to find a few very old patches. The trees often had multi-lobed trunks leading down to supporting buttresses at the base. The outer bark was typically cracked and split, showing the ravages of time and occasional extreme weather. Where the base of the trunk was well sheltered and moist, an abundance of moss and other epiphytic growth could be seen. I'm still not sure exactly how old these trees are. I took some tree cores, but they were mostly rotten in the centre; they could be anywhere from 50 to 80 years old. In any case, these sites were truly amazing places to visit.

A towering old silver wattle at Britannia Creek, east of Yarra Junction, 15 March 2019

Lush epiphytic growth covering the base of an old silver wattle tree, Britannia Creek, 9 Jan 2020

A key part of my research involved digging into the soil, in order to find out how many *Acacia* seeds were present. A simple bulb planter was used to extract samples of soil to 10cm depth, but to get meaningful results I needed 32 such samples per plot. My field technician (Ben) did a great job of helping to carry soil back to our vehicle after each sampling operation. Over 7 days of field work, a total of 158 kg of soil was taken back to the lab.

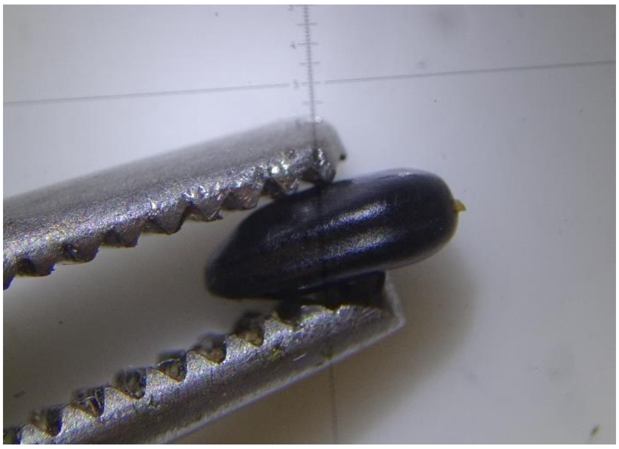
So, I hear you wondering, what do you do in a lab with that much forest soil? Well, the conventional method is to place the soil in an industrial oven to give any *Acacia* seeds some heat treatment, then lay out the soil in trays in a climate-controlled glasshouse, with automatic or manual watering, then wait for the seeds to germinate. By counting the germinants, and knowing how much forest floor area was sampled, you can calculate the soil seed bank density in seeds per square metre (seeds/m^2). The problem is, to make this work you have to make an assumption about the best type of heat treatment to use – and there is evidence that the optimum heat treatment can vary even within a single species (Liyanage *et al.* 2016).

There is an alternative, but it's not for the faint hearted - it involves systematically searching the soil for seed (Goets *et al.* 2018). I figured this would work because *Acacia* seeds have a distinctive shape and are large enough to spot visually. So I developed a method which allowed me to efficiently search through a few kilograms of soil each day, and got started. It took three months, during which I think I aged about three years! But having done this, I now have some valuable information on *Acacia* seed bank densities, which varied from less than 50 seeds/m^2 (typically in very young forests or on dry sites), up to several thousand seeds/m^2 at a 36-year old "wet" site (on a south-facing slope).

This was not the end of the story, however; there were still two more problems to solve. Firstly, I needed to be sure these seeds were *Acacia dealbata*, and not some other *Acacia*. Secondly, I needed to eliminate any empty, predated, or decayed seeds. The latter problem wasn't too hard - as I was collecting seeds, I did a quick visual inspection, and was able to eliminate any seeds that showed clear signs of predation or fungal decay. Later I was able to run my collected seeds through the "zig-zag aspirator" at the National Herbarium of Victoria, a clever device which uses an air blower to eliminate empty seeds. The problem of confounding *Acacia* species was more difficult.

I solved part of this problem by first looking for records of other common *Acacia* species in the Central Highlands, and obtaining samples of seeds from these species, to see what they look like. Bill Aitchison very kindly provided samples of *A. obliquinervia*, *A. frigescens*, *A. leprosa*, and *A. verticillata* seeds (some from his own garden), and I already had plenty of *A. dealbata*, *A. implexa*, *A. mearnsii* and *A. melanoyxlon* seeds from my own seed collecting efforts. With these collections handy, I then classified each of my forest soil seeds as "probably *A. dealbata*" or "probably not *A. dealbata*", on the basis of seed shape.

During this process I discovered that seeds of *A. melanoxylon* and *A. obliquinervia* are markedly different from those of *A. dealbata*, so when I found these in my forest soil seed collections, it was straightforward to exclude them. Seeds of *A. obliquinervia* have a very distinct "thick" edge – in fact, the edges are actually so thick that you can stand the seed up on its edge (see photos taken through the Herbarium microscope). Seeds of *A. melanoxylon* are generally rounder than *A. dealbata*, and often have a slightly ridged appearance on the top and bottom surfaces.



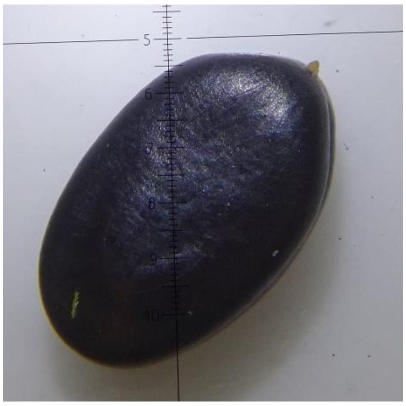
Acacia obliquinervia seed, viewed edge-on, being held by tweezers.

The same Acacia obliquinervia seed, now free standing on its edge.

Here are some photos showing the different shapes of *A. dealbata*, *A. melanoxylon* and *A. obliquinervia*, viewed from above. Fresh *Acacia* seeds are always shiny and black, but here I have shown what can happen to *A. dealbata* seeds after storage in the soil for some time – a fine brown fungus often covers the surface. I had seen this fungus before… in an earlier study where I had applied heat treatments to seeds then germinated them in the lab. After a couple of months in a wet petri dish, any seed that didn't germinate was covered in a brown fungus… and I wonder if this might actually be a part of the seed's own defence against other less desirable microbes. It's a tough world in the soil, if you have to sit there for decades waiting for the right conditions… so even though *Acacias* rely mainly on their hard seed coat, I would not be surprised if they also had beneficial microbes (Dalling *et al.* 2011).

Acacia dealbata seed, retrieved from soil

Acacia melanoxylon seed, fresh



Acacia obliquinervia seed, fresh

Burnt Acacia seed, probably A. dealbata

I also found what I believe to be burnt seeds within soil samples. These have a distinctly *Acacia* seed shape, but the surface is rough and typically broken or split, sometimes showing a dark material inside, which appears to be charcoal. These seeds were all found at sites with plenty of standing *Acacia* trees, so I expect that seed mortality through fire is probably a normal part of *Acacia* seed ecology. Ants will do their best to bury seeds, but not all seeds are buried deep enough to avoid being scorched.

After crunching some data, I noticed an interesting pattern – at sites where there had been a forestry coupe burn ("slash burn"), the smaller and younger the trees, the closer the seed bank was to zero. This suggests that coupe burns are probably reaching such high temperatures that they cause all seeds in the topsoil to either germinate or die, effectively pressing a 'reset' button on the *Acacia* seed bank. Fortunately, enough seeds survived and germinated at each of these sites to generate plenty of live *Acacia* plants. Indeed at one such site, *Acacia* saplings were so numerous that I estimated nearly 50000 stems per hectare (50 per square metre). That's a lot of wattle, but it will all self-thin down as plants compete with each other, and by the time these saplings have reached 80 years old, they will probably be growing at a density of only 100-400 stems per hectare.

The next step in my research is to subject samples of my collected seeds to a range of heat treatments, then set up a germination trial. I know from my own previous lab work with *Acacia dealbata* that freshly collected seeds can give a 99% germination rate if given the right conditions. So it will be particularly interesting to see what germination rate emerges from seeds taken from soil under old *Acacia* forests. I am also taking some core samples and counting tree rings, to find out exactly how old these trees are. Appearances can be deceiving – large, old looking trees might have just had a good location to grow in, so they may not be as old as they look!

It’s been a long process, and I still have a way to go, but what I have discovered is that even our most common forest trees are worthy of study – there are so many ecological mysteries to unravel, especially in terms of how fire interacts with trees and their seed, and how our forest wattles manage to survive over such long time scales.

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