Bolstering the Refuges Symposium
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Symposium Presentation No. 3

# *Functional dynamics, stability and resilience in temperate grassy ecosystems, and the role of fire in restoration*

**Paul Foreman**

La Trobe University and Blue Devil Consulting

*Transcript edited by Dr Peter Mitchell and Ann McGregor, Biolinks Alliance*

*Note: A selection of slides was taken from the powerpoint presentation to make this transcript easier to follow. The full set of slides is available on the powerpoint presentation.*

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**Summary**

*Historical surveys have allowed mapping of the original extent of native grasslands in northern and north-central Victoria. "New" sites in the eastern Riverina (not identified by EVC modelling) are different from sites further west such as Terrick Terrick. Records from early pioneers document how these grasslands have changed; they have become dominated by native and exotic grasses with declines in other species. These grass-dominated systems are functionally unstable; after heavy rains, the grass biomass increases and other species disappear. Strategic grazing has successfully reduced this biomass but many other species have not returned and grazing may not lift sites to a better-quality state. Aboriginal burning may explain the distribution of the historical grasslands and is now being looked at for long-term restoration. There are risks, but burning is simple and cost-effective and may expedite the restoration of native grasslands.*

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It's a pleasure to be here. And it's great to see so many people interested in Biolinks and the work that we are planning to do. My background is as an ecologist. I have a consulting business but I'm also affiliated with La Trobe through the PhD that I'm doing at the moment. Some of the stuff I'm talking about is relevant to that, but I'm also drawing on some other data and hopefully it will be useful, especially in relation to the burning that we are looking at this afternoon at the Euroa Arboretum, which I'm very much looking forward to.

I'm going to look at the original condition of lowland grassy ecosystems with a particular focus on grasslands. I'm also going to look at the current ecosystems, the remnants that are out there, how they work functionally and what that means in terms of our understanding of their ecology and conversation and management. And finally I will look at the role of fire and what that can play in restoration. There's a lot of talk, a lot of excitement around fire, especially the role of cultural burning based on Indigenous practices. I think there is a hell of a lot of scope and I'm really keen to launch ourselves into that more. Hopefully I can build that case today.

## The extent of the original grasslands

The lowland grasslands in southeast Australia are, as you know, one of the most endangered systems. They require vital conservation work.

Fig 1 shows the extent of natural grasslands in south-east Australian bioregions.

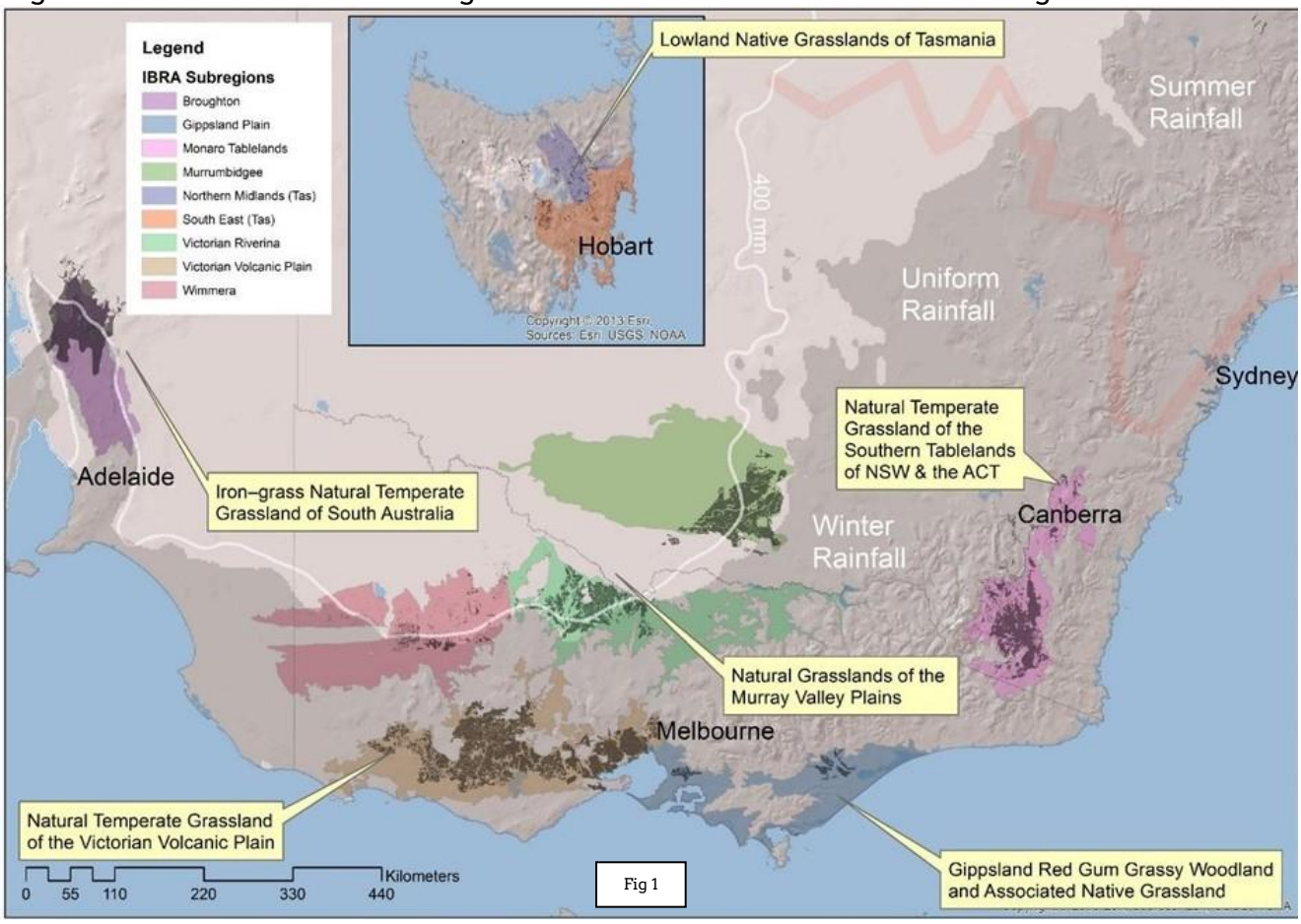



Fig 1

In the early days, the big thing was pastoralism and grazing was the boom industry. And as a result, the surveyors were very interested in the location of grasses and the open grassy plains in particular. They mapped these areas right across the state in quite some detail, which is quite an extraordinary thing when you dig into it. As part of my work, I've been

looking at the historical baseline - the old maps that were produced by the surveyors and some of the early European pioneers.

The 1851 example near Nagambie (Fig 2) has some very fuzzy dotted lines which sort of outline the boundary between woodland and open plain, which was grassland. A second map was done in 1863 in the same area (Fig 3). If you draw a line between Melbourne and Shepparton, you'll go right to the middle of this open plain (Fig 4).

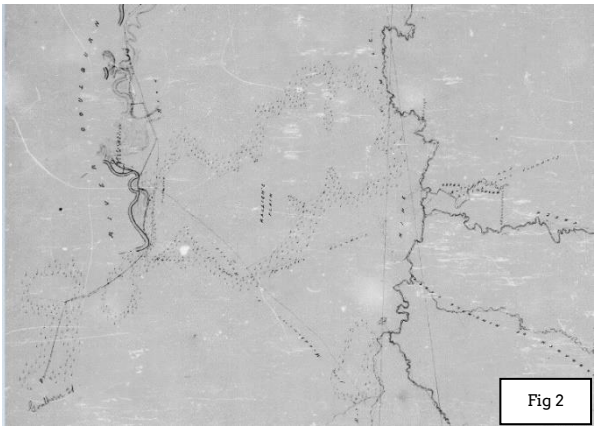


Fig 2

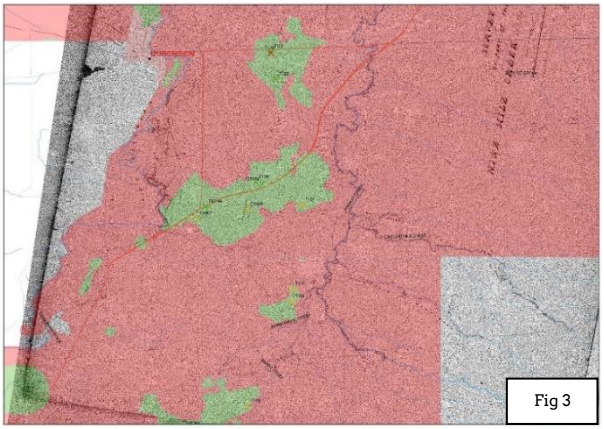


Fig 3

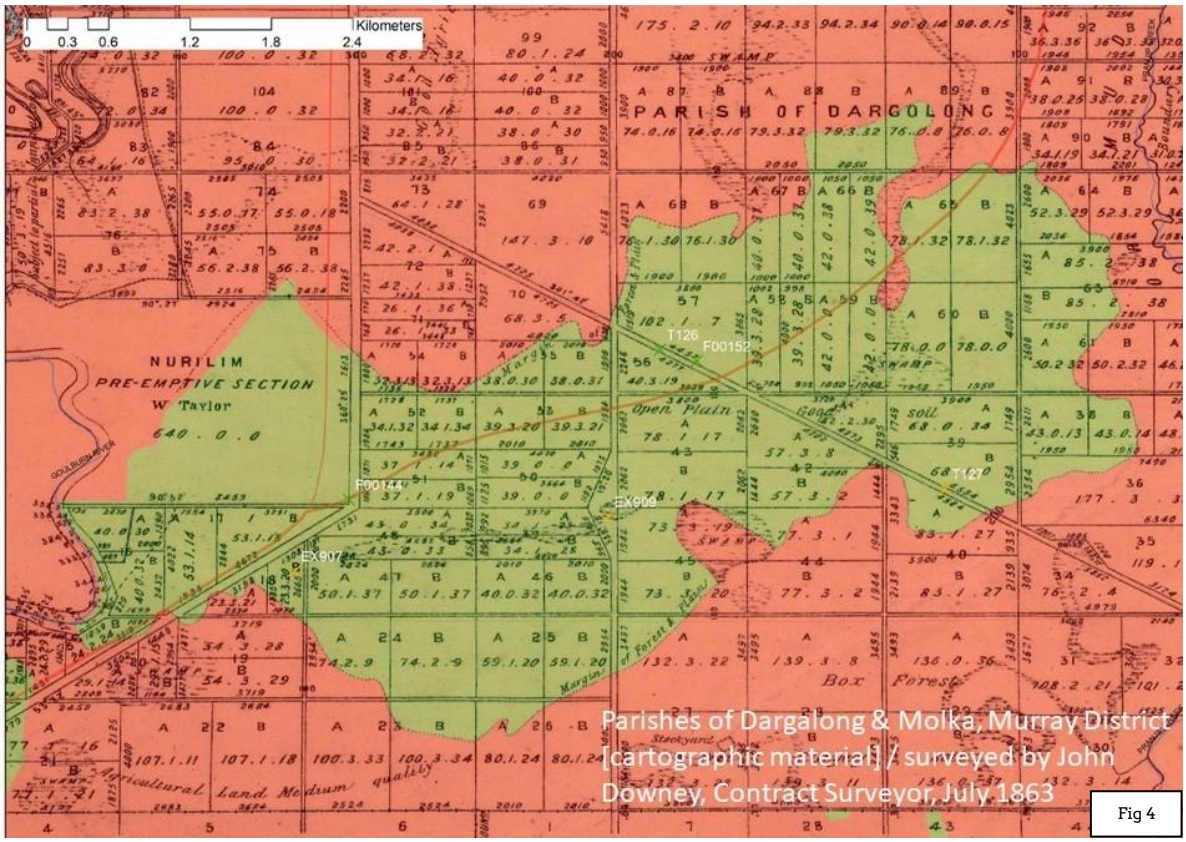



Fig 4

The patches and roadsides outlined in red (Fig 5) are actually little remnant areas of vegetation.

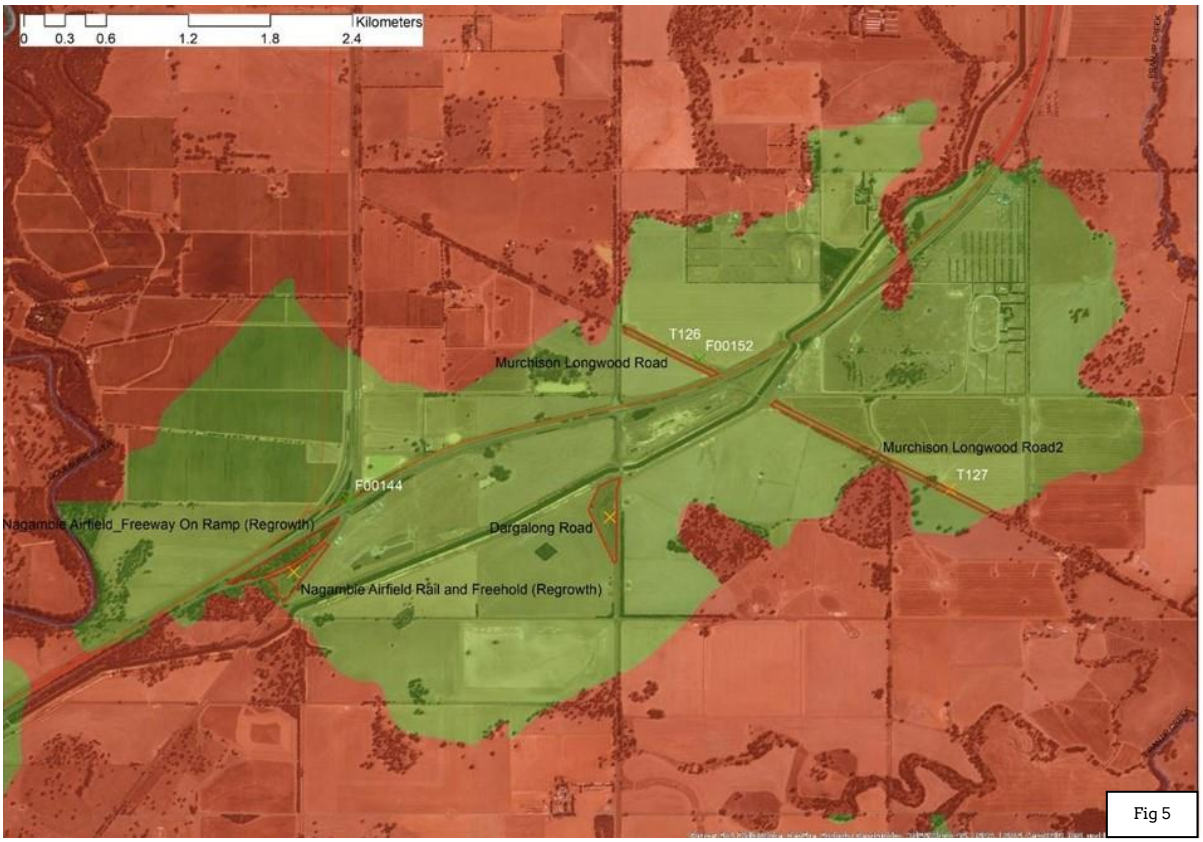


Fig 5

When you go and have a look at those remnants, they have plants such as Caesia, lilies, Lemon Beauty-heads, Blue Devil, Kangaroo Grass, Wallaby Grass, and lots of other things, often rare plants as well. In some places, there are invading shrubs; there was a small wildfire there a couple of years ago and the shrubs were killed. The role of fire in this landscape is something that's quite intriguing and I'm hoping I can build a stronger case around the original role of Aboriginal burning in the system.


Fig 6


Fig 7

I've sewn together all those maps and produced a composite map of looking at the distribution of these lowland grasslands throughout the region over quite a big area, particularly focusing on northern Victoria or north-central Victoria. The maps show the cover of the historical surveys compared with the supposed original grassland distribution based on state-wide pre-1750 EVC modelling. The "new" areas are grasslands outside the EVC maps that I have picked up from the historical data. These grasslands are quite widespread across the region, including up into the northeast.

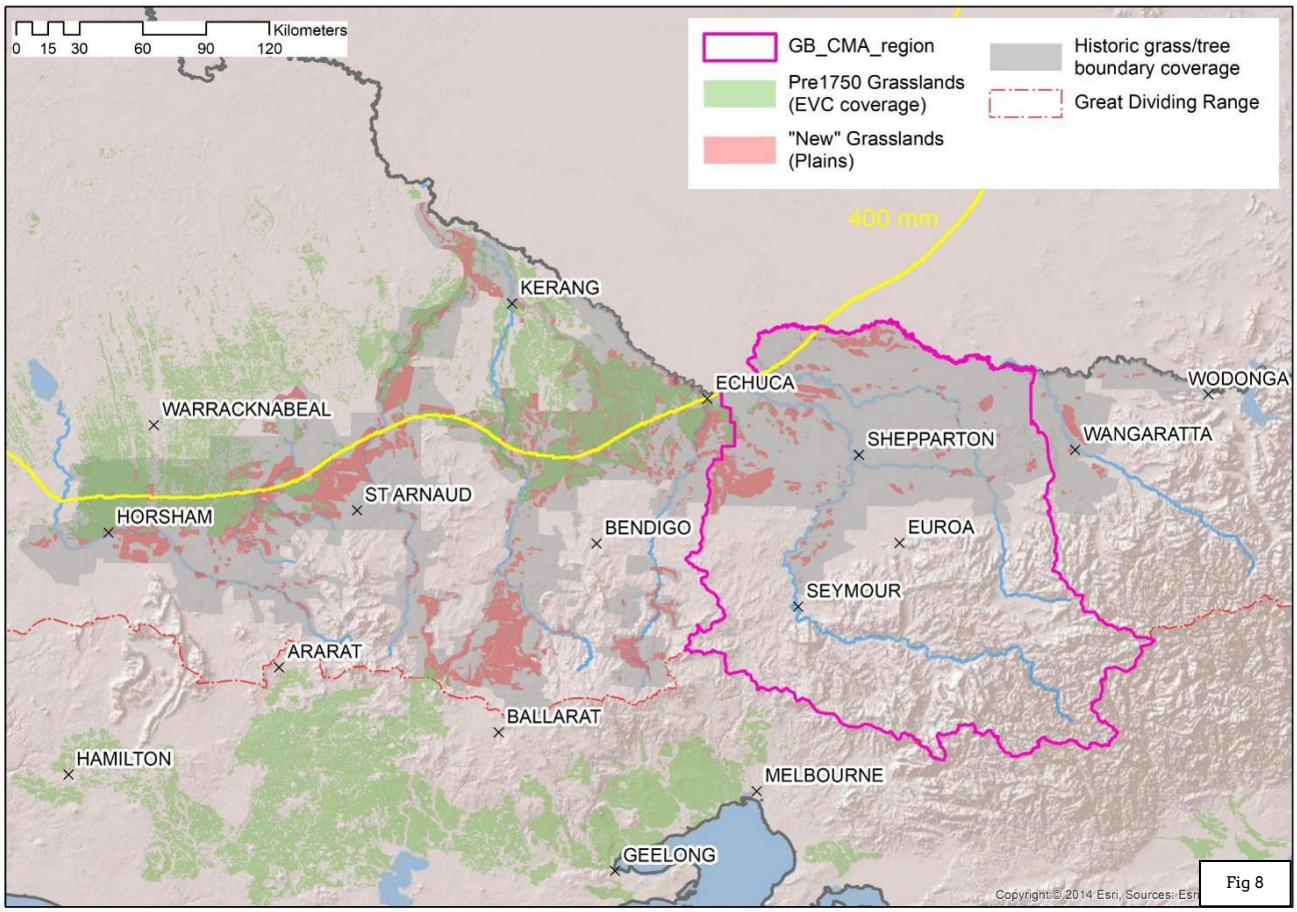
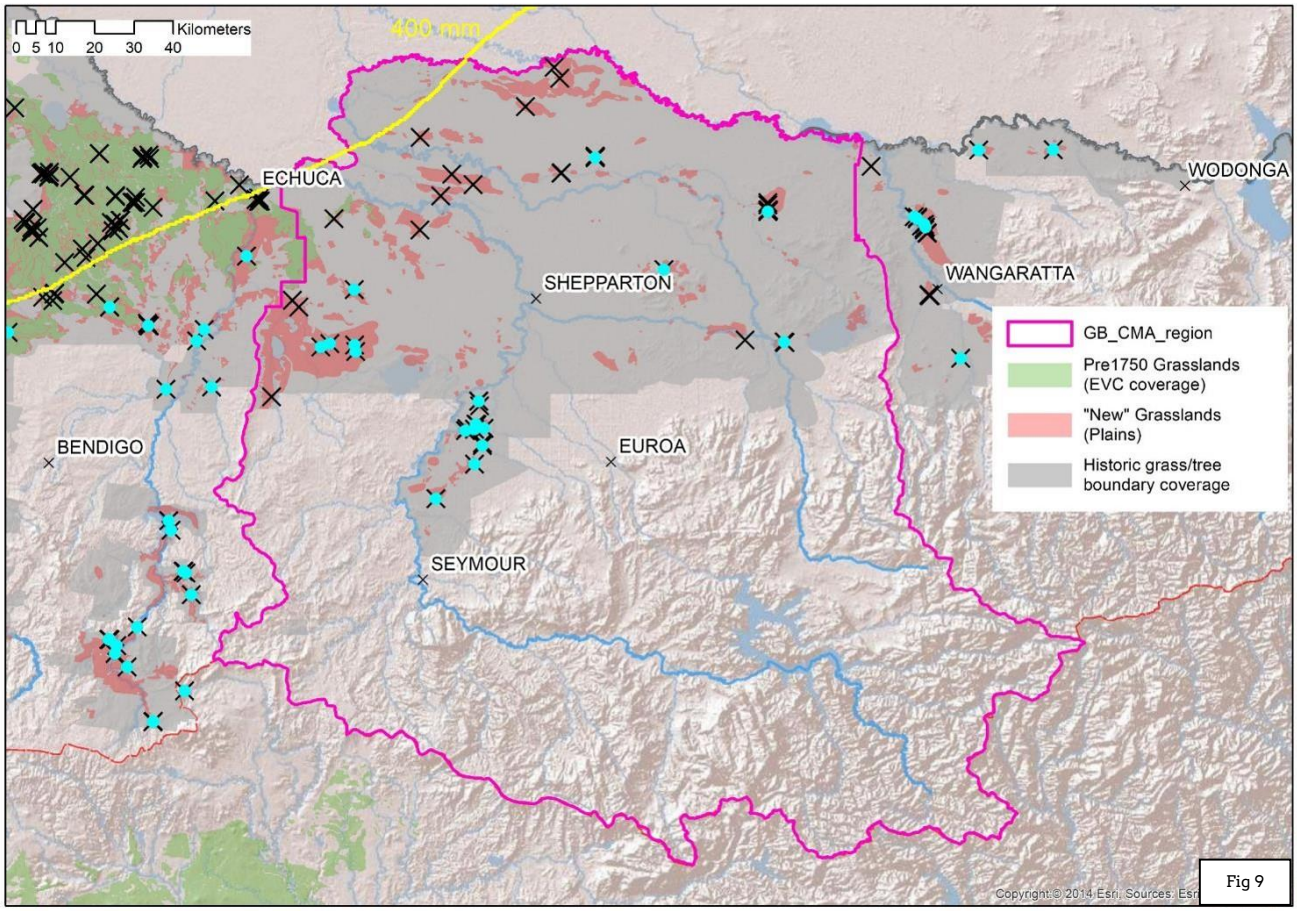


Fig 8

Zooming into the Goulburn Broken, and the Riverina Bioregion in particular, the "new" grasslands were big open areas of grassy plains. Until this work was done, it was thought that grasslands weren't here previously, or they were more or less extinct. They are essentially very close to extinct, but they're not all gone yet. There is some hope and there is some scope for us to do things if we focus our minds.




Most of the grasslands that we talk about in northern Victoria focus in the west around Terrick Terrick. Some of you might have been there. That area has got some terrific remnants and there's been some great progress over there with reservation and other management.

But the area in the eastern part of the Riverina in particular has got little attention. And it turns out that that it's quite a different kind of grassland to the one over in the west. The system in the east is higher rainfall and was originally dominated by Kangaroo Grass. I've identified the remnants that I found were dominated or co-dominated by Kangaroo Grass. And these remnants are actually much more similar to the Victorian Volcanic Plain grasslands than to the grasslands over in the west around Terrick Terrick.

## The historical changes in grasslands

I want to put in a bit of historical baseline information here. There are a couple of champions of the historical cause. Edward Curr, who you've probably heard of before, was a famous, somewhat pontificating pastoralist from that era. He made some interesting observations, much of which one should take with a grain of salt. But a couple of his observations are interesting. One of them was that he talked about the grasslands in the

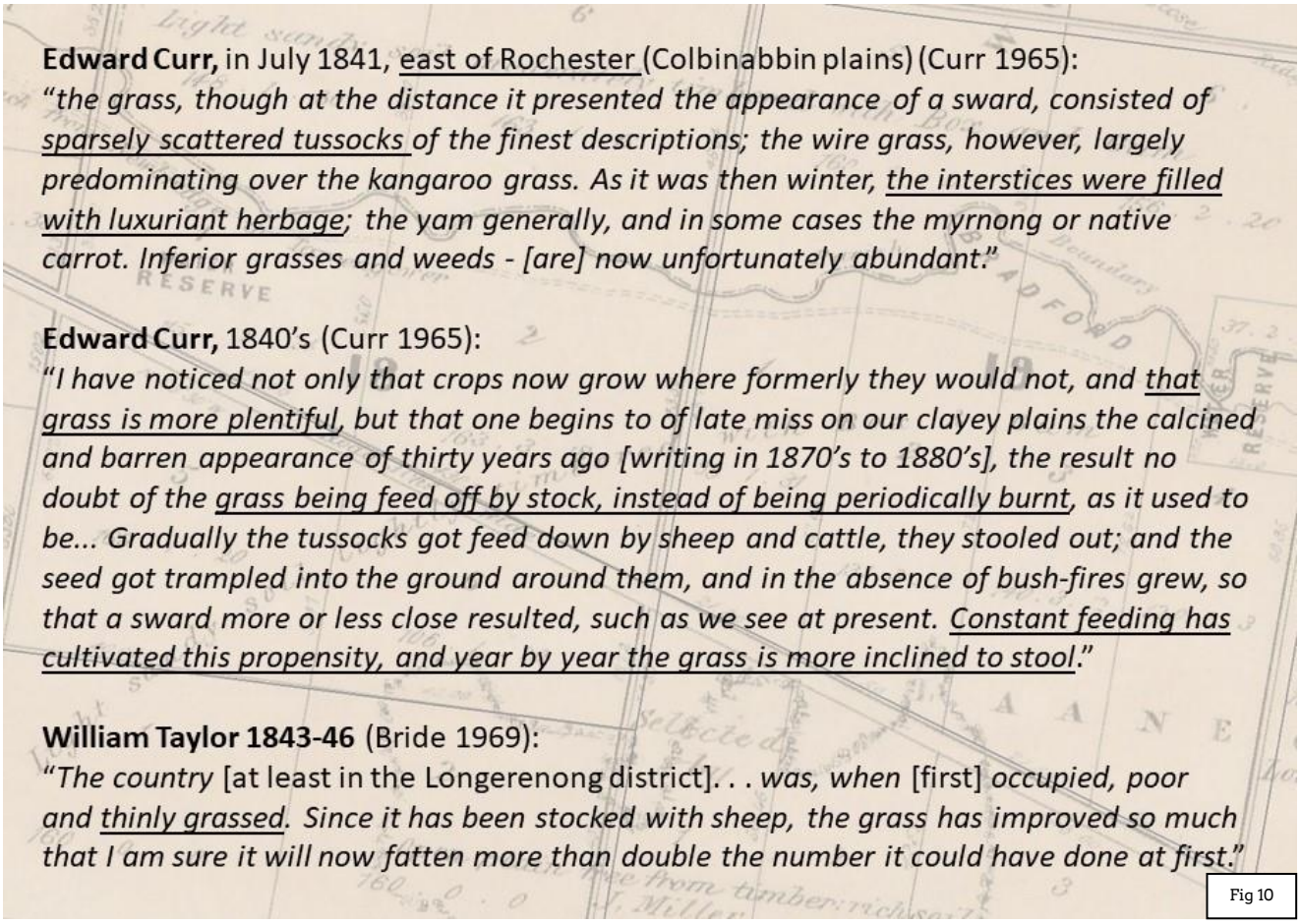


Fig 10

Colbinabbin plains which are south and east of Echuca. The grasses were actually quite sparsely scattered, with lots of stuff in between the grasses, like Yam Daisies. He talks about how that changed very rapidly with the introduction of stock, and also speculated about the cessation of traditional burning, which was quite regular in the landscape in those days according to him.

Another guy, William Taylor, over in the Wimmera near Horsham, made similar observations about how, when stock came along, the grass suddenly thickened up. I suspect that the thickening up was to do with two things. One was the invasion of weeds, which are all over the place these days, but also the increase in density of native tussocks as well, and, of course, the loss of a lot of the wildfires that occurred in between.

There are some examples in this area. One site near Benalla is a really important site for a rare orchid, Purple Diuris (Fig 11). It is in very small remnants, but it's still there nevertheless and if we pay attention to it we can potentially very easily look after it and maybe even extend its range.

Another site over near Wangaratta is absolutely sensational (Fig 12). Parts of this area is an old rail reserve that's been regularly burnt for a long time and is now burnt for conservation

reasons. It is supporting populations of very rare plants including the orchids. It's one of the most diverse grasslands that I know about in northern Victoria.


Fig 11


Fig 12

Another site is a remnant at the Murchison Golf Course that Sally Mann has been involved with. There's lots of really interesting plants there, including regenerating Blue Devil. The same site in summer shows the Blue Devils all coming up, and you can see the Kangaroo Grass patches. But what you can also see is a lot of wild oats. This area is burnt, but it's not burnt that regularly and it's quite a diverse site.

The point is that it's incredibly dynamic. It varies in its biomass within a year very dramatically. And this dynamic nature is part of its general fundamental nature as grasslands, but the dynamic is increased because of those changes. The changes we're talking about are even in the best remnants – they are all very modified.

As I mentioned before, native grasses are more abundant. Even in the better sites the native forbs are less. In fact, many of them have almost entirely been knocked out, as we've learnt from earlier talks. There have been plenty of extinctions of flora and fauna, and many more of which we probably don't know about. Exotic plants, of course, have invaded. And grazing and cultivation have replaced regular burning.

## The current state of grasslands

The current grassy systems are dominated by grass and it's functionally unstable. We think about grasslands and grassy woodlands as being about grass. But in their natural state, in their best condition, grasses are only a sub-dominant or a co-dominant element. I'll try and make that point.

I've done a recent survey of areas over in the west of the Riverina and we know there's lots of plants left, lots of flora species are still around, but they're often extremely rare. So it's a diverse system still, but a lot of species are very sparse and very scarce.

This is shown on the range of indigenous and exotic taxa classified by life form. Looking at the dominance of life forms in the better-quality remnants, what we've got is mostly exotic grasses, annual forbs (exotic and native), perennial forbs (mostly natives) and perennial grasses (mostly natives as well). Those are the four elements that tend to dominate. There's a big suite of other species and life forms that are still present, but in lower abundance.

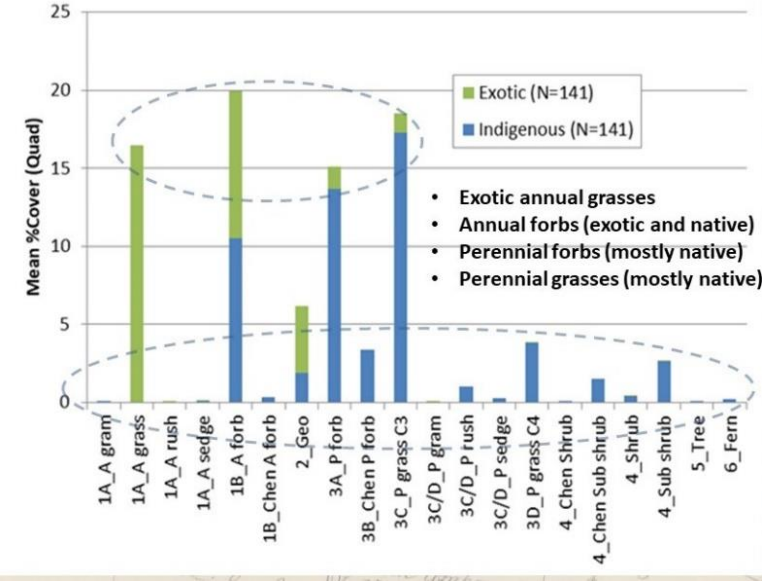



Fig 13

Fig 14

| | Cat.# | Category Name | Lifeform Abbr. | Lifeform Name | Ind. taxa | Exotic taxa | Total |
|---|---|---|---|---|---|---|---|
| 1 | 1A | Therophyte (Gramioid) | A gram | Annual Graminoid | 1 | – | 1 |
| 2 | 1A | Therophyte (Gramioid) | A grass | Annual Grass | 2 | 39 | 41 |
| 3 | 1A | Therophyte (Gramioid) | A rush | Annual Rush | 1 | 1 | 2 |
| 4 | 1A | Therophyte (Gramioid) | A sedge | Annual Sedge | 4 | 1 | 5 |
| 5 | 1B | Therophyte (Forb) | A forb | Annual Forb | 61 | 69 | 130 |
| 6 | 1B | Therophyte (Forb) | Chen A forb | Annual Forb (Chenopod) | 1 | – | 1 |
| 7 | 2 | Geophyte | Geo | Geophyte | 21 | 4 | 25 |
| 8 | 3A | Hemicryptophyte (Forb) | P forb | Perennial Forb | 107 | 26 | 133 |
| 9 | 3B | Hemicryptophyte (Chenopod) | Chen P forb | Perennial Forb (Chenopod) | 11 | – | 11 |
| 10 | 3C | Hemicryptophyte (C3 Grass) | P grass C3 | Perennial Grass (C3) | 33 | 5 | 38 |
| 11 | 3C/D | Hemicryptophyte (Gramioid) | P gram | Perennial Graminoid | 3 | 1 | 4 |
| 12 | 3C/D | Hemicryptophyte (Gramioid) | P rush | Perennial Rush | 10 | – | 10 |
| 13 | 3C/D | Hemicryptophyte (Gramioid) | P sedge | Perennial Sedge | 8 | – | 8 |
| 14 | 3D | Hemicryptophyte (C4 Grass) | P grass C4 | Perennial Grass (C4) | 11 | 2 | 13 |
| 15 | 4 | Chamaephyte (Chenopod) | Chen Shrub | Shrub (Chenopod) | 2 | – | 2 |
| 16 | 4 | Chamaephyte (Chenopod) | Chen Sub shrub | Sub–shrub (Chenopod) | 13 | – | 13 |
| 17 | 4 | Chamaephyte | Shrub | Shrub | 12 | 2 | 14 |
| 18 | 4 | Chamaephyte | Sub shrub | Sub–shrub | 16 | 1 | 17 |
| 19 | 5 | Phanerophyte | Tree | Tree | 5 | – | 5 |
| 20 | 6 | Hemicryptophyte (Herb) | Fern | Ground Fern | 7 | – | 7 |
| | | | | **Grand Total** | **329** | **151** | **480** |

I've also been working with Parks Victoria for some time at Terrick Terrick. Mark Antos has been doing some fantastic work at Terrick Terrick with a lot of volunteers (mainly on his volunteer time too, I should say) for the last ten years. They've been doing fauna surveys and have collected some unbelievably interesting information. Mark has very generously has given me some to play around with.

I compared the biomass dynamics and rainfall patterns in the better quality grasslands over the last ten years, including the start of the big floods that happened in 2010 and 2011.

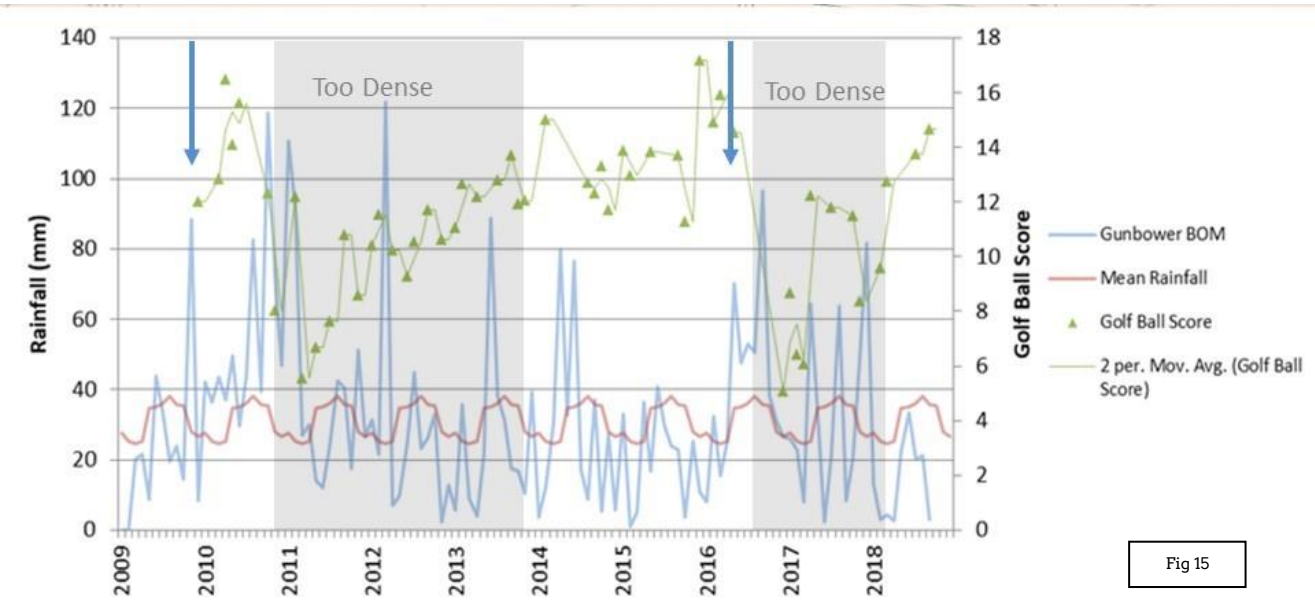



Fig 15

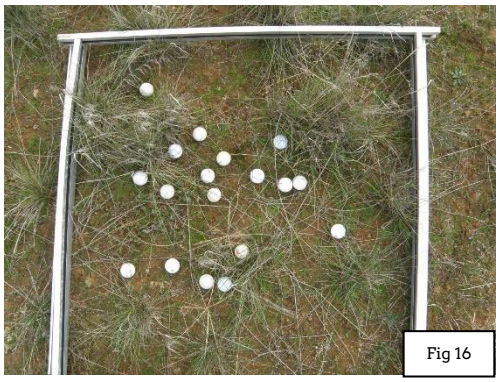


Fig 16

The metric here is called the 'golf ball index' which is basically a kind of an inverse surrogate of biomass - if the line goes down that means biomass is very high and if the line is up then the biomass is low. I'm not quite sure how it was developed, but it was probably on a fairway one day on a weekend. So there's 18 balls, and if you see all 18 then it gets a score of 18, that means the vegetation's very open and sparse. And if you don't see any, then it's very dense.

Fig 17

After the floods came along, the biomass dramatically increased and stayed that way for about three years. During that period, the grass was so dense that a lot of the plants, and animals particularly, that relied on that open-structured grassland more or less disappeared, including the Plains-wanderer which is one of the most unique birds globally.

That was very concerning but fortunately, with a bit of grazing management on the park over about two or three years and also drying conditions, the biomass started to improve and the birds eventually did start returning.

But then again, in 2016, we had another flood and the same thing happened. The biomass just went berserk and the birds temporarily disappeared. By then we were more ready, and the period of dense or over-dense grass lasted for a little less time, due to combination of quicker onset of dryer conditions and better grazing management. The key point is that the grassland is a very, very vulnerable and dynamic and unstable system in the current context because of its modifications.

If you add up the cover of all the key vegetation elements from Mark's data, it shows a dramatic up-and down-cycle, as you would expect, driven mostly by annual grasses. And that's the instability that I'm talking about. And that's in the context of fairly regular grazing with sheep to try and keep a check on it.

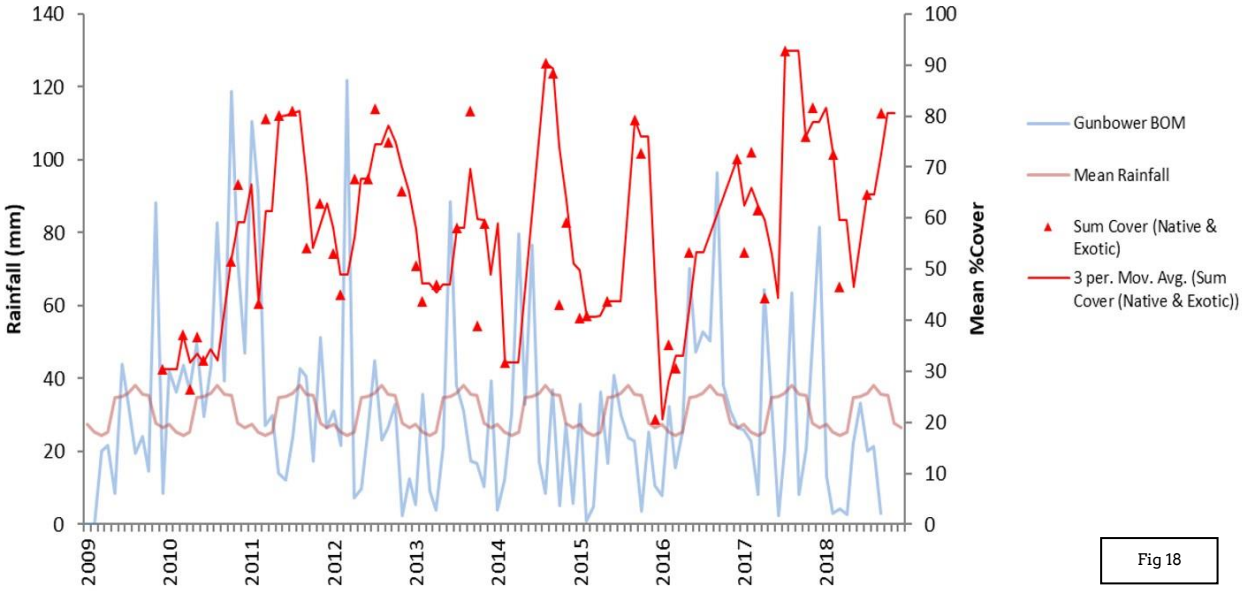



Fig 18

## Conservation grazing

Conservation grazing has been used in these grasslands for some time and, where there is a long history of grazing, it remains a very pragmatic and pretty successful tool for manipulating biomass. But there are limitations to it.

Fig 19 shows a particular site that has been grazed for 100 years and still has orchids, Yam Daisies, Swainson-peas and lots of other rare plants. This often cracks open the tropes that people have in their minds about grazing. But it's not just about grazing per se, it's about how you're grazing, it's the nuance, it's the detail of the regimes.

Fig 19

So grazing is used in reserves. In one of the higher-quality grasslands in Terrick Terrick, grass cover changed between September 2015 and October 2016. In 2016, wild oats and native grasses were absolutely hammering, even within weeks and months after the rain. That is the dynamic that creates risks around species extinctions and requires intensive management.

Typical grassy woodlands across the most of the landscape have paddock trees and grazed grasslands. The grasslands are grass-dominated, and a lot of the forbs and shrubs have been lost. When you lock these areas up for conservation, you certainly do get some positive responses. But unfortunately, a lot of the understorey that was there doesn't just magically return. Sometimes you have to intervene in order to improve the condition of that site, to move it from a lower quality state to a better quality state.

One of the better grassy woodlands I've seen in the region is, believe it or not, in the headwaters of the Muckleford Creek near Castlemaine, on private land (Fig 20). Grasses are there but they're scattered and they're not dominating the understorey. There's lots of other life forms and there's lots of other patchiness and other processes going on. At another site with White Box near Colbinabbin, the wildflowers are dominating in the grasslands and that is a good indicator of a better-quality site (Fig 21).

Fig 20


Fig 21

The point is that conservation grazing can certainly play a role in some areas and can maintain the values in particular situations. But it's not a panacea, and there are risks and it's sometimes quite intense and expensive. And it's also unclear whether or not it can play an important role in long-term restoration, of lifting sites from a degraded state to a better quality state.

## The use of fire

The question is: can fire play a role in restoring these grassy systems?

An example comes from some of my research on the historic observations in the Goulburn Broken area. The early pioneers observed fire that was caused or ignited by Aborigines for potentially traditional purposes (blue areas on Fig 22). Often they were associated with the open plains.

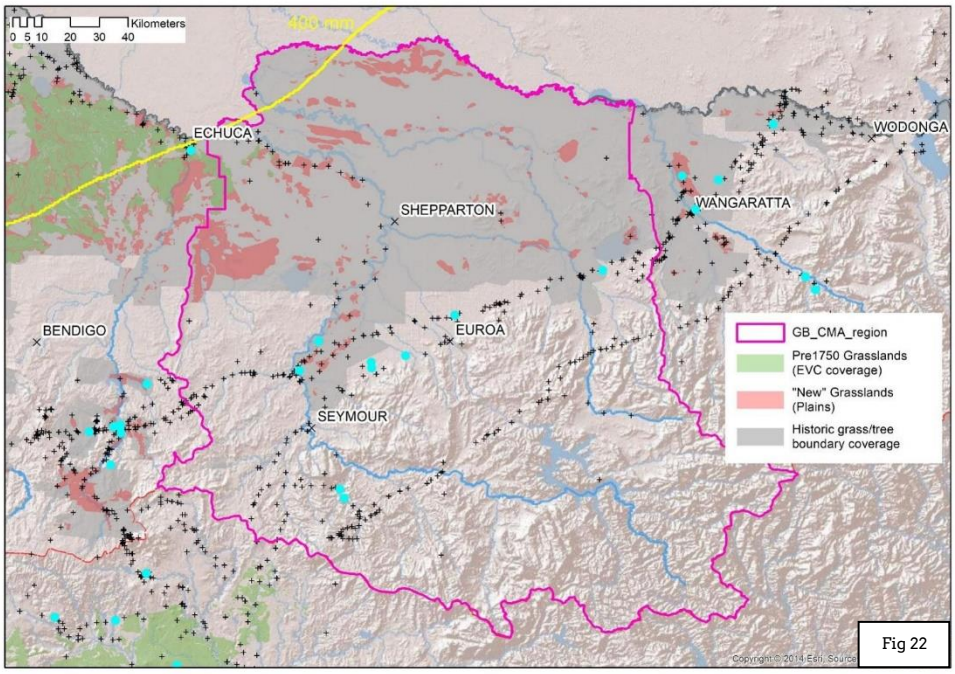


Fig 22

My research is basically looking at building three levels of evidence for this. The first level is looking for the existence of grasslands in areas where you would expect trees to dominate. The next level is looking at the fine-scale patterning of the distribution of those treeless areas to determine if this is possibly, at least in part, due to fire, and not just aligned to soil types. And the third level is finding some evidence that Aboriginal burning played a role in all this.

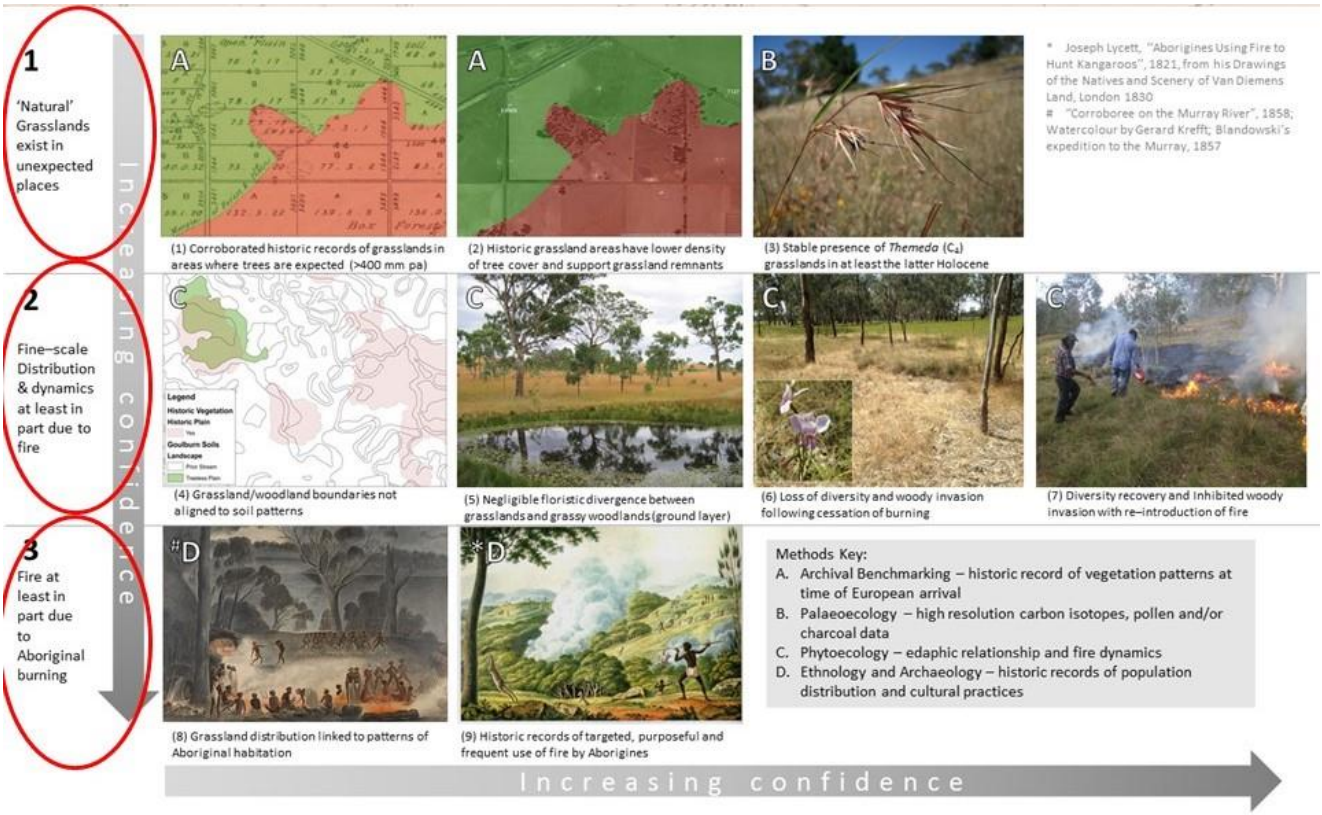



Fig 23

We know that there are ecological benefits of fire in grasslands. The role of disturbance to frequently reduce biomass has long been recognised, particularly in Themeda-dominated systems. We know that fire stimulates mass growth and flowering and seed production, leading to seedling generation when the climatic conditions are suitable. We also know that regular biomass removal of dominant life forms improves light penetration and creates space and gaps between the tussocks for less competitive plants to thrive - like wildflowers.

I want to finish up by presenting a little bit of data for a couple of projects I've been involved with. The first one is an ecological burning based on traditional ecological knowledge up in northeast Victoria. It began initially through Landcare networks and was then taken over by the Northeast CMA. It's a collaboration between a range of people including the Traditional Owners. The project was looking at the potential to use fire to help heal or restore remnant grassy sites.

It's not a hard-core academic scientific study, so you have to be a little bit forgiving of my clunky data. But it does tell an interesting story. We spent about five years doing burning regularly in plot-sized patches at four different sites.

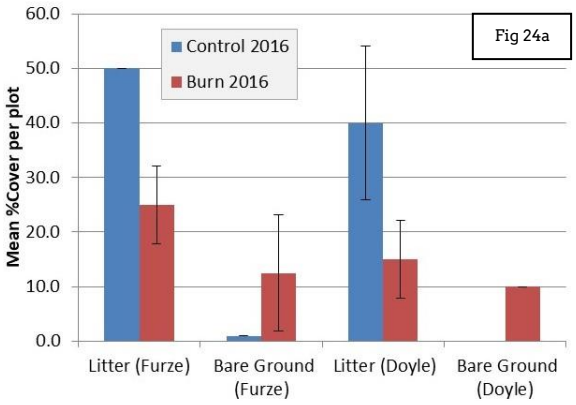
After three years of burning, the litter was significantly reduced and the bare ground significantly increased, as you might expect (Fig 24a). And that opened up the sward and allowed the regeneration of those plants that were present.

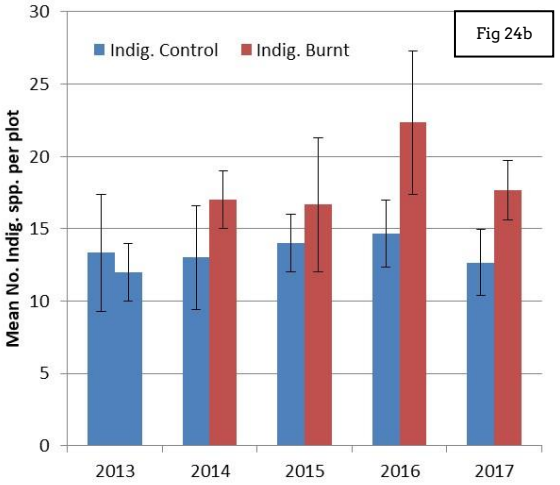
We also found that indigenous diversity actually increased over that time, at least at a couple of the sites (Fig 24b). So by year 2016 (the fourth year of the burning), we actually had an increase in the number of native plants at the plots, which was significantly different from control.

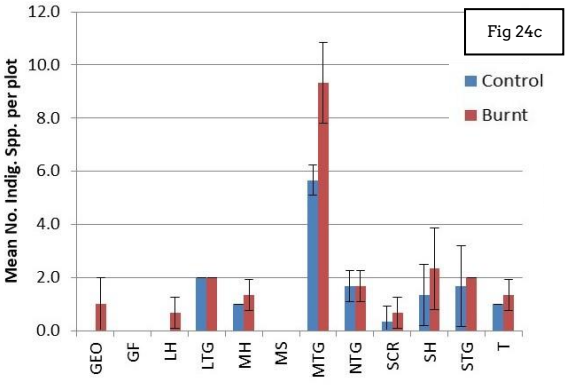
But it turns out that that increase was mainly to do with the richness of medium native tussock grasses (Fig 24c). In other words, the grasses which were present in the landscape were dispersing into those gaps created by the fire. A lot of other plants that were present but sparse in the landscape were perhaps too far away to naturally disperse, or there was no seed bank available for them to spontaneously regenerate.

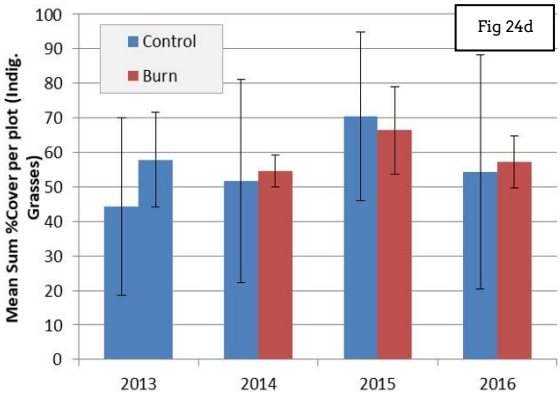
Because of this and because our sampling happened six months or so after the burning, when the grasses had time to rapidly grow after the fire each year, the tussock grass cover didn't really change that much.

Another point that I really want to make here is that the burning by the third year had a significant impact in reducing the exotic annual grasses Fig 24e). We think that's mainly because these grasses are quite small and delicate and have small seeds which are not that protected. If you have a reasonably intense fire, it can destroy the young grass germinants in autumn and diminish the seed



bank. If you burn over a series of years, you can actually significantly reduce the abundance of many common annual exotic grasses. And the example I've got here is Quaking Grass (*Briza maxima*, Fig 24f). It was reduced to almost nothing after about three or four years of burning.

Fig 24d

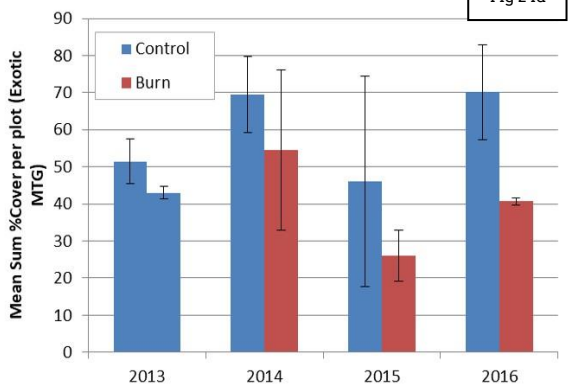
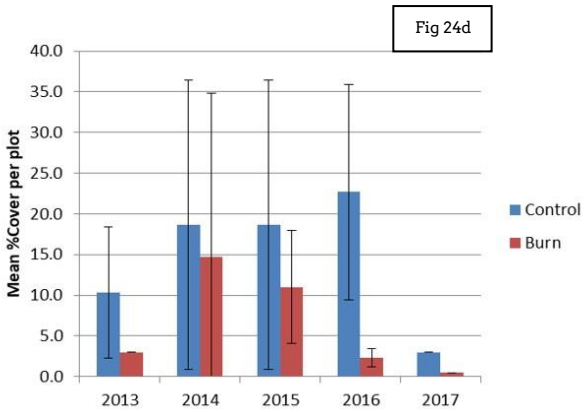



Fig 24d




I want to flick to a little bit of information from some work I did at Terrick Terrick in the 90s just to show similar things. This was also a burning trial where I did burning over three years. Once again, the bare ground was increased by the burning and the litter was reduced as per that other work (Fig 25a). And the cover and diversity of exotic annual grasses were reduced as well (although drought affected results in 1994; Fig 25d).

Fig 25d

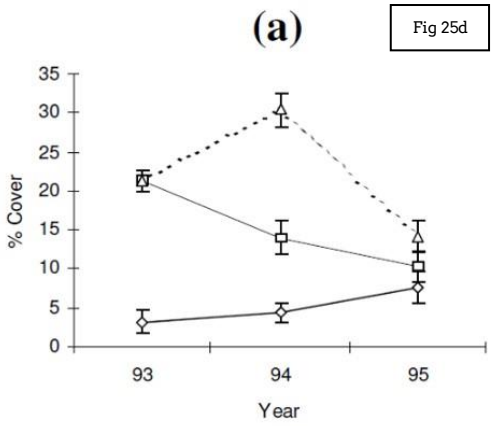
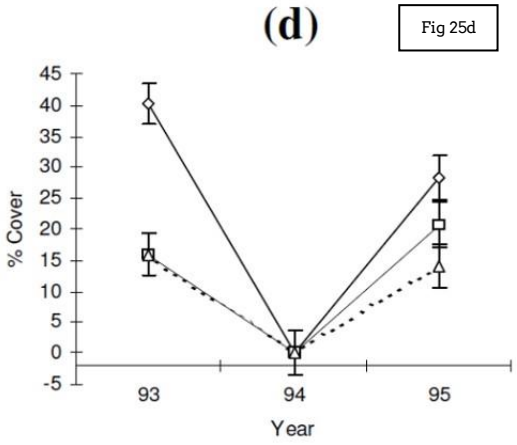



Fig 25d




So, in that environment we had a similar effect. Although in that particular case the richness of native plants didn't increase significantly over the time frame, which could be due to a number of other factors.

Burning has been tried as an alternative to grazing in a few different places and it certainly does have potential. There are also risks. But I wanted to point out that we're managing ecosystems - we're not managing for one species or another as separate situations. They're not separate. They're in the system together. The plants we know respond fairly positively

to burning, but there's a big question mark around the effect of burning on some of the other species, especially fauna. Especially with reasonably intense broad-scale burning.

There are big concerns that if you did intense broad-scale burns in high-quality sites, you might actually end up causing damage to some of the more significant fauna elements in the grasslands. So it's not all simple.

Fig 26

We don't want to graze any more. We want to flip across to using traditional practices and just burn these areas instead. There's more research being done in that space.

### State-and-transition in grassy ecosystems

Referring to the state-and-transition model approach that was mentioned by Jacqui Stol earlier for grassy woodlands: we have grassland states ranging from degraded cropland, sown pasture and volunteer pasture, through to native pasture and modified native grassland, and up to the high-quality reference areas. We know that, if you rest grassland areas over long periods of time, the nutrients are leached out of the system and there's time for some recovery of species still present in the landscape - you can get some improvement.

But we think that you may be able to use fire to expedite that process and get there faster. At the moment, given the issues that we face, I think speeding up the process of restoration and making it simpler and more cost-effective is worth considering.

The example of three different states of grasslands (Fig 27) shows one state (S4) more or less dominated by Ryegrass with a few scattered native perennials. The middle one is a bit of a mix with some native perennial forbs coming in. And then the high-quality site (S2).

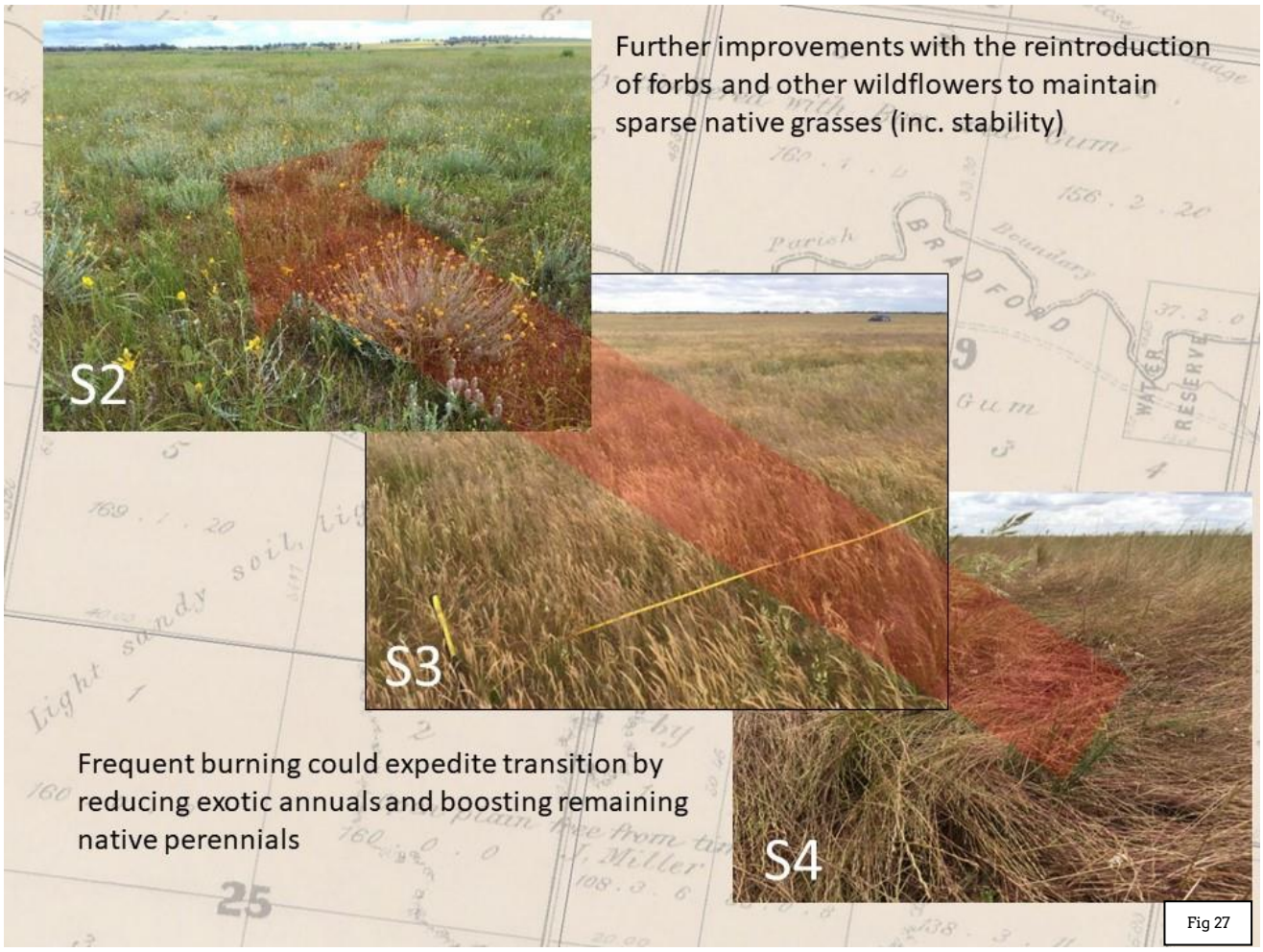
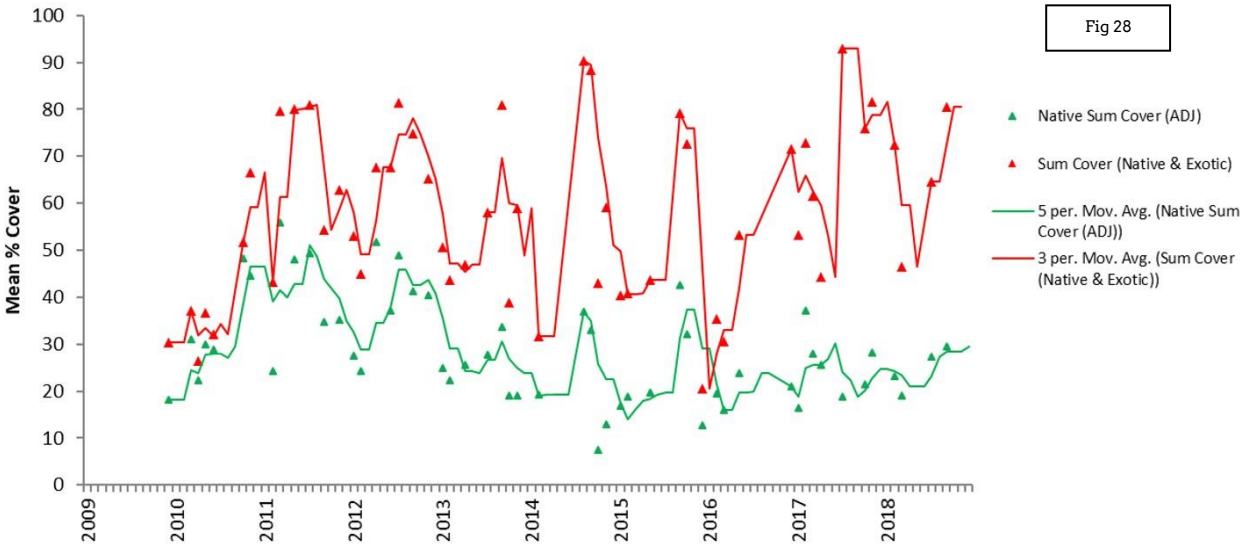


Fig 27

With regular burning, I think we could expedite the process of reducing the annuals and boosting remaining native perennials. And then keeping on burning plus making further improvements. The reintroduction of missing forbs and other wildflowers could help to maintain the openness and reduce the native grass dominance and get a system that basically goes from that really dynamic, unstable system down to a system where the biomass is lower and the dynamics are not as dramatic and where you may need less intervention for less cost.

Fig 28 models a restoration scenario at Terrick Terrick compared with records of the current system driven mostly by exotic annual grasses (Figs 15 and 17).




**Native Sum Cover (ADJ) =** hypothetical elimination of exotic species (mostly annuals) using fire and increase in native forbs by 50% (perennial and annual) which combined reduces cover of native grasses by 50%. Note: Only really possible on non-friable, reddish clay loam soils

That's the kind of thing that is happening at the Euroa Arboretum we'll be looking at this afternoon. The Arboretum is using techniques to try and reduce the exotic annual complement, encourage the native tussock grasses - but not too much - and also get those wildflowers back in the system as well. When we have that sort of system it's likely to be more stable and less vulnerable to species extinctions and possibly less expensive to manage.

That sort of level of restoration is really useful and needed in a whole range of different situations and I don't think it's too hard to do. Hopefully, if I'm right, we'll be able to show that the techniques are quite pragmatic and quite practical to do. We'll be looking into the detail of how to do this, this afternoon.

## Conclusions

I'll just finish off with a few conclusions. Grasslands were once widespread, and the distribution of grasslands, in particular in the higher rainfall areas, were linked to Aboriginal burning. They're not all gone and there are remnants left but they're in a highly modified state and they're often critically endangered.

I should say too, that the grasslands across central Victoria are off the radar generally speaking. They're still out there, they're still around, but they don't get the attention they need, and they certainly don't get the management they need. And reintroducing burning

and doing some basic conservation work would go a long way towards stopping them from going into oblivion in the next decade or so.

Land use change has driven massive increases in grasses and the loss of other species, and they have got into an unstable state that requires intensive management. There's a potential role for fire to reduce that grass dominance and to quickly transition to a better state that will be easier to manage with lower risks.

Thanks very much.