doi: 10.1111/emr.12116

Reconstructing grassy understories in south-eastern Australia: Interview with Paul Gibson-Roy

By Paul Gibson-Roy and Tein McDonald

A marriage of ecology with agronomy is successfully restoring diverse herbaceous layers, to the extent that some reconstructed grasslands on ex-agricultural land and rural roadsides have been found eligible for federal protection as threatened ecological communities. Can lessons from this improve our management and expansion of grassy ecosystems more broadly?

Key words: *direct seeding, ecological reconstruction, grassland restoration, grassy woodland restoration, seed production.*

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TM: Your main work has involved developing techniques for the reconstruction of the herb layer – grasses and forbs. This is important as grassland is, of course, a valid subject of restoration in its own right – particularly in Victoria where you have done your main work to date

PG-R: Well, yes, in Australia, there are extant areas of what we would describe as 'grassland', similar to what would be described as 'prairie' in North America, where trees don't exist for one or other reason. This has been the subject of restoration attention over decades, particularly in the southern Australian states including Victoria where I have done most of my work. But my teams have also done a lot of work in grassy woodlands. These occur right throughout and across south-eastern Australia and Western Australia and are also threatened because they occur on areas amenable to agriculture (Fig. 1).

In Victoria, various grassland communities were listed as threatened

Figure 1. The author Paul Gibson-Roy pictured enjoying a complex remnant grassland at Woorndoo in south-western Victoria. This grassland has been preserved due to its historic use as a town common (primarily for bushfire refuge). It is one of the best remaining examples of high diversity subdominant grassland in western Victoria. (Photo Liz Fenton).

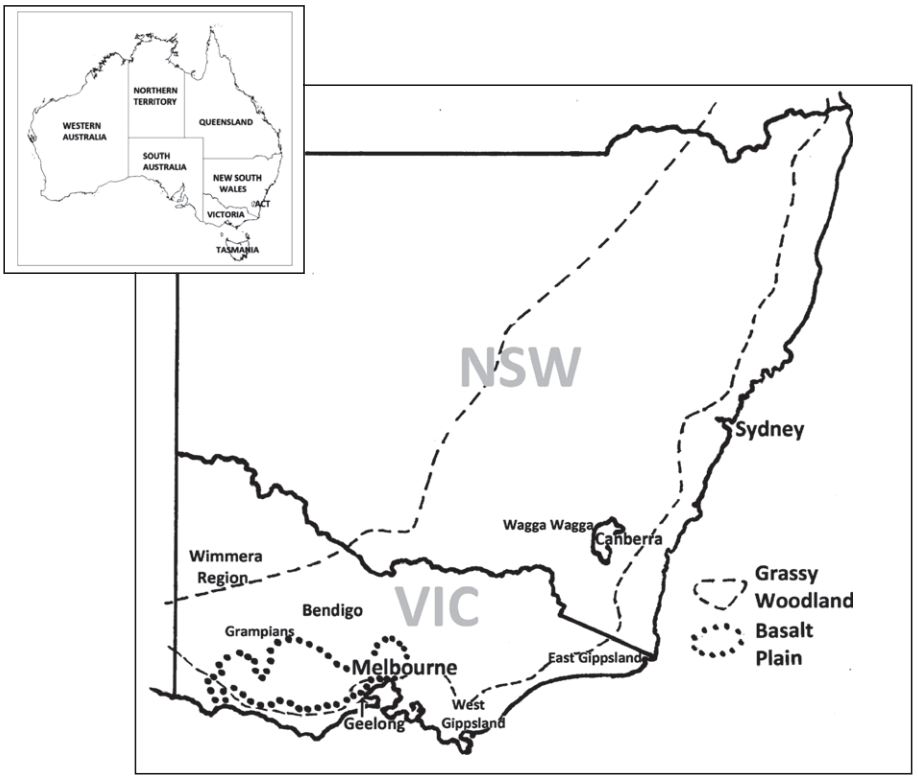

Figure 2. Map of locations referred to in this interview. Dashed line represents the area in which the critically endangered ecosystem 'Grassy Box-Woodland and derived and native grasslands' occur. The dotted area is the extent of previous extent of the Basalt Plains grasslands. Less than 10% of each remains and both are listed nationally as critically endangered. (Source: Department of Environment, Climate Change and Water NSW).

under the *Victorian Flora and Fauna Guarantee Act, 1998* and in 2008 were listed under the Federal *Environment Protection and Biodiversity Conservation Act, 1999*. There are also other state and federally listed grassy ecosystems across Australia (Fig. 2). The herbaceous layer accounts for most of the floristic diversity of these ecosystems; so ignoring it just doesn't make sense. We feel there are many practical reasons why working on it in the first instance can produce better outcomes.

TM: Yes, in reconstruction cases, there is often a focus on putting trees and shrubs in and ignoring the ground layer, assuming it will come in later. But you take the opposite view?

PG-R: Yes, I think evidence from the literature and experience show that the herbaceous layer doesn't automatically come in later. That's perhaps just wishful thinking. It's not to say that you don't get certain native understory components such as Dichondra (*Dicondra repens*) or Lobelia (*Lobelia* spp.) or lilies that have a long-term vegetative presence emerging. But essentially these sites tend to be dominated by an exotic herbaceous flora and/or swamped by overly dense native tree canopies and shrub layers.

TM: And a difference about your work is that you have been utilising more agronomic approaches to grassy understory reconstruction; perhaps because of your own rural background?

PG-R: Well I was very aware of the small-scale grassland restoration projects around Melbourne and inspired by all the people involved with them. But early in my working life, it struck me that, because all the pressures upon these grasslands located closer to urban centres, it would make sense to try to test reconstruction methods well beyond an urban perimeter. So I went out into the regional areas where it was possible to get the support of farmers and rural people who have some great technology and expertise. Here I had the opportunity to work in farm paddocks, with essentially a blank palette and no chance of disrupting or destroying an existing native remnant. You can learn in that environment and, if things work out, take important lessons back to the more challenging peri-urban landscapes.

It's also true that my rural background played a part. I was born in Sydney and lived in nearby Wollongong till the age of five, but spent my teenage and early adult years mainly in Wagga in southern New South Wales. We lived on the town's outskirts and my overwhelming memory, like many kids growing up in regional areas, was essentially just being let loose; roaming rocky hills, climbing trees, scrambling in and out of wombat holes or jumping into the Murrumbidgee River from huge Red Gums (*Eucalyptus camaldulensis*). This somewhat idyllic young life helped form a very strong connection to that rural environment.

I went to an Agricultural boarding school just out of Sydney, as many kids from regional NSW did. So I also had a network of friends who came from farms all over NSW. The school itself was a working dairy farm, so we often had to get up before dawn to go up and milk the cows and help run the farm on top of immersing ourselves in agricultural subjects. This consolidated that connection to that landscape. On holidays I'd catch the slow train back home and when I wasn't getting up to mischief with my Wagga mates I'd be working at the saleyards with my step dad who was a stock and station agent; or out drafting cattle with him or doing other bits of farm labouring.

TM: So what how did you move from agriculture to ecology?

PG-R: I'd always loved science and the natural world. But like many teenagers leaving high school, I didn't have a clear idea of what I wanted to do, and couldn't decide. The expectation at the time was that you'd go to university, so I chose the opposite, much to my mum's horror. Then I fell into theatre school by complete chance and absolutely loved it. I wasn't too bad at it, and so during my 20s, I worked regularly on the stand-up comedy circuit around Sydney, worked in theatre, including acting and directing, and played in bands which I do to this day. So I was always a bit of an oddity with my rural counterparts – particularly out at the saleyards, with the old blokes and drovers giving me flack about being up there on the stage with 'those acting blokes and sheilas', as they put it.

I found the world of theatre a stimulating but odd place. The real arbiter of success is the audience in front of you. You get instantaneous feedback on the night, good and sometimes bad, but no one gives you a certificate saying you got an H1 or failed – the feedback is instantaneous, raw and a very transitory thing. I loved the mental stimulation of that world but began to crave a more structured intellectual framework to balance it. By then, in the mid- to late 80s I had moved to Melbourne and was working regularly as a musician and doing performance poetry in pubs while working in the gardens of Melbourne University. This was at a college run by nuns, a remarkable group of women who allowed me to jump off the mower any time to write a poem or to be 'creative' (as they put it). I was sort of considered the college bard which was very sweet. Happily for me it was also a time when the Australian government required workplaces to direct some of their payroll into staff education, so the nuns sent me to Burnley Horticultural College.

Burnley was in its halcyon days then, so getting into any course was incredibly difficult. I started an 'Introduction to Horticulture', part-time of course. This was a pre-TAFE course and I loved it and did well, so the nuns supported me to keep going. I did the full TAFE course and enjoyed that and worked my way through the various stages: undergraduate years through to the degree, then honours and right through to PhD. So that brought me into formal education and provided the structure I was looking for.

At the time, horticulture at Burnley was strongly associated with urban landscapes, but it had amazing people like John Delpratt on staff, a wonderful teacher who became an important mentor and friend. Other staff members were the then Principal Greg Moore, a renowned educator and tree person, and James Hitchmough, now professor of Horticultural Ecology at Sheffield University in the UK. I think it was James who triggered John's interest in the first instance in grasslands and wildflowers.

The Burnley degree gave me an opportunity to gain all the technical skills of growing plants, working with seed and so on that were common in the horticulture industry; techniques and principles that have been applied by humans for millennia. During that time, John and Greg and other great lecturers raised my awareness of issues related to ecology, conservation, restoration and in particular the issues faced by temperate grasslands. Of course people like Jamie Kirkpatrick, Neville Scarlett, John Morgan, Ian Lunt and many others had been doing trail-blazing work bringing to the public's attention the dire state of grassy ecosystems and influencing legislators to set up frameworks and policies to halt their decline. But what piqued my interest in particular at the time was the concern that, if conservation on its own was not working (and it wasn't), simply putting a fence around a remnant or reserve would still not prevent its decline. We would have to attempt something else – and quickly – or grasslands were surely going to disappear. As I've mentioned, I had grown up seeing how farmers maintain the land in a very structured and deliberate manner – and that got me thinking about how we could overlay some of this agricultural learning in a way that complemented conservation and restoration. I entertained the notion that perhaps we could add to the larger conservation effort by going to a new site and (like horticulturists and farmers do) work from scratch to build new grasslands or go to a highly degraded site (such as a large weed patch) and reintroduce grassland species. I was certainly building on thoughts of John and James and others, but taking it down a practical pathway and marrying it with ecology.

TM: So what were your early projects?

PG-R: My first foray into the question was my honours study, which I structured as a Masters over 2 years. I tested the germination and dormancy characteristics of seven species from the broad functional groups; then, utilising this information, seeded plots where I manipulated nutrient settings and seed rates. The thinking at the time was that it would be difficult to recreate grassland from seed because germination in the field is quite sporadic and unpredictable. The herbaceous genera were seen as an unknown quantity, with potential dormancy mechanisms. Exacerbating the issue, seed was (and remains) in critically short supply. So I thought I'd like to at least test the notion that we could characterise and then use seed of these species in the field. The very positive results for this subset of species gave me encouragement to think that I may have similar success with a broader suite (Fig. 3). So for my PhD work, I expanded to a much larger suite of 64 species from reference communities to the north of Melbourne.

At that time, it worried me that, in reconstructing communities from scratch, we were usually picking spe-

Figure 3. Scalped site at roadside restoration No.1, approximately 3 km west of Wickliffe, Victoria, showing the GGRP seeder in action direct seeding. Scalping is routinely carried out on Greening Australia's grassy reconstruction sites if a site assessment indicates nutrient levels or weeds are likely to be an ongoing problem. (Photo Paul Gibson-Roy).

cies we thought would be winners, or were selecting on the basis of availability. I also became interested in the more theoretical ecological literature around diversity and functionality; those broad questions of whether increasing diversity has any beneficial use to resources in a system. So my PhD included testing how increasing gradients of species and functional diversity correlated with nitrate levels and light interception. We did get statistical significance in the correlations between diversity and those resources. So it did indicate that, underpinning this world we see in a paddock or roadside or anywhere else, gradients of biological complexity do play a role. The implication of this work to grassland restoration and management was that, in the Australian setting with low nutrients, it is the subdominants that create the opportunity for diversity. Remnant grasslands, dotted on roadsides across western Victoria, are essentially rich assemblages of subdominant species where gaps and opportunities for recruitment are maintained by the very fact that it is not dominated by one or two high biomass grasses.

TM: Ha! So diversity created opportunity for more diversity – as less dominance by individual species allows for more open niches. And nutrient levels also play a role?

PG-R: Over time, we found clear relationships between higher and lower nitrogen and phosphorus levels and diversity, tested across a whole range of sites. Measures for both those nutrients in reference communities were consistently lower than those found in the agricultural landscapes. Since then we have also found that the most complex and resilient reconstructed sites, those that look like high-quality grassland are inevitably established on sites where we have been able to get those key nutrient characters below certain parameters.

Indeed it became clear that lower phosphorus settings (<20 mg/kg Colwell) gave us higher numbers, vegetative cover and diversity of native forbs – whereas increasingly higher phosphorus (20+ mg/kg) gave a higher proportion of the broad-leaved weeds. Conversely, we found nitrogen more linked to the grasses and that both native and exotic were strongly responsive to high and low nitrogen for growth. In a nutshell, we are finding that native and exotic grasses are both fine with higher levels of nitrogen – with the exotics almost always doing better than the natives (hence the problem), but the native forbs preferred lower phosphorus and the exotic forbs preferred higher phosphorus.

TM: So this work on 64 species used in your PhD, lent more weight to the idea that you can potentially reconstruct grassland?

PG-R: Yes, from work done by restorationists in the 1990s, it was clear that installing containerised grassland plants was feasible in small settings where you could water and so on. And there was substantial earlier work being done overseas on direct seeding of grasses and forbs in prairies; for example Betz's Fermilab restoration of the early 1970s at Batavia, Illinois, and Wells' meadow reconstruction in the UK in the 1980s. From these, I drew insights and inspiration. But what I was looking for were technologies for direct seeding that were applicable in Australian landscapes.

When completing my PhD, I had a number of groups interested in the possibility of direct seeding, including at the university, Natural Resource Management agencies and environment departments. However, most thought my work needed to be scaled up and proven in the broader landscape where things were less controlled experimentally. To do that I had to get funds and that was a great challenge. At the time, Greg Moore, who was also a long time board member of Greening Australia (GA) in Victoria, had been advocating that GA include a more applied ecological research focus in their restoration

work. So I worked with GA to apply for Natural Heritage Trust funding in 2003 for a large direct seeding project that was equally research and practice. It was called the Grassy Groundcover Research Project (GGRP). Following funding approval, GA developed a partnership with the university, with me a Research Fellow at the Uni as head of the GGRP. This meant that GA gained access to the university's facilities, resources and expertise; and the Uni gained access to GA's on-ground experience, staff and networks. I immediately went about setting up a replicated experiment on 13 individual sites including farms and public land across a range of Victorian regions from the Volcanic Plains in the south-west, the Wimmera in the west, Gippsland in the east, the central Box Woodlands around Bendigo in the north and to Melbourne's peri-urban west. It was no small undertaking.

At these various locations, we identified reference communities appropriate to the region and attempted to collect representative species/functional groups and populations from them. We also tested restoration site preparation methods. At each receptor site, we tested whether we could deplete weed loads by spraying and fallowing four times a year, with shallow-harrowing in between, over 3 years – and compared this each year against removal of 100 mm of topsoil (material that contained elevated nutrient and the majority of weed seed) (Fig. 3). This removal or 'scalping' was experimentally found to be by far the most statistically significant in terms of restricting weed emergence or re-colonisation. So today, if a site assessment indicates that nutrients and/or weed loads are going to be an issue, we scalp rather than spray and fallow. We see this as a management cost that pays dividends many times over compared to not doing it.

Obtaining native herbaceous seed was a huge challenge. We set up networks linking into all the regional restoration groups and plant growers. But as most of the seed collectors couldn't recognise many of the species, there was an enormous learning curve and a lot of training involved. We changed the method of payment from that based on volume to payment for people's time. We didn't want huge volumes at that stage as we initially used 2 m × 2 m test plots at 13 sites. For many species, there might only have been a tiny amount of seed available, but that was still important. Collectors would nervously ask 'you're giving me this amount of time to find things, but what if I don't find them?' Our response was that 'we trust you and you know the process; and if you don't find them, then that means they're not there, but you'll hopefully find something else.' We were working with a suite of 400-odd vascular plants and eventually we managed to capture at least 250, well over half of them. All were from the herbaceous component, from all functional types, a magnificent achievement on our collector's part I think.

Incrementally expanding the experiment to 1 ha areas meant we had to shift to a seed production model (Fig. 4) as it was the only way we were ever going to secure appropriate volumes of seed without risking damage to our reference communities. So we set up regional production facilities using the small amounts of seed collected from reference populations to grow seed crops. At the time, we were learning wonderful things about growing these rare and seldom used species in cultivation: how to harvest and maintain them and how to process the seed. We also had to develop seeding machinery capable of seeding multiple species. We used equipment developed for the turf industry to aerate compacted sports grounds and modified its hopper, allowing us to sow any number of spe-

Figure 4. Reconstructing grassy ecosystems requires large volumes of seed from a broad range of species. This can be achieved by the establishment of dedicated seed production areas that utilise horticultural techniques to grow common and rare species as seed crops. This image shows a local daisy species, Common Everlasting being grown as a production crop by David Franklin of Chatsworth. (Photo Paul Gibson-Roy).

cies at a time without cleaning it down to bare seed. Cleaning the seed would have cost a fortune; and, importantly, we didn't want to knock off all the fruits awns and attachments because we had no idea what the ideal seeding depth was for these species. The machine worked up a wonderful seed bed and we sowed the seed mixed with sand as a carrier; so it was all well homogenised. The seed was sown as a curtain instead of in drill lines, after which it was pressed-rolled in by the machine.

We seeded the original GGRP sites during 2005–2008 at the peak of a 'worse than 100 year' drought. Just about everyone outside the GGRP thought we were mad. But it transpired that leaving all those attachments and awns and fruits was important in allowing species to germinate and emerge at a time of their suiting. Some species didn't emerge for 12 months (or in some cases longer), while others emerged quite quickly but remained as very small plants (while below ground they were growing like crazy) until rains allowed growth of above-ground parts.

Overall we worked with approximately 250 species, less at each site where we sowed a different combination representative of a region. We achieved considerable success in establishing a high proportion (80% plus) of the diversity that would locally occur at any receptor site (Fig. 5). The main factors determining success were whether we had achieved sufficient seed volumes, appropriate seed beds and control of the nutrient/weed load. Climate obviously was a factor but interestingly not the main driver. We found some clear ways forward for seeding technology and that all important nutrient consideration, as well as some idea of the costs of implementing the ideas.

Critically, we were applying exactly the same principles and techniques across all these very different climatic, soil and social regions and were finding the same success. It was an amazing time, and a bit of a whirlwind of discovery where we were developing and testing multiple approaches to restoration and bringing together people from different regions of Victoria to do so. I was privileged to work alongside inspirational and deeply motivated people who contributed enormous inputs of energy, buy-in and commitment. When I started this project, I had my science hat firmly wedged on, because if I didn't get the experiment right I couldn't analyse data. I suspected that the social component would be important, but I can say now that I didn't anticipate its actual significance; the hundreds of people that would become involved directly with the project and many subgroups that were project spinoffs, even to this very day across Victoria and now in other states. Over the time, we've run many field days (always oversubscribed); and engaged rural schools in learning about grasslands (even encompassing art projects). There have been busloads of university students from Victorian Universities coming and working in and interpreting these sites. We've also had a group of 50 Masters of the Environment students from Stanford Uni in the USA visit a site. I'm told tourists are even visiting some sites for their wildflower displays (Figs 5 and 6). So I am adamant that while the science, the machinery, the agriculture, the horticulture and the ecology are important, the people are absolutely critical as well.

Figure 5. A typical low biomass herb-rich reconstructed grassland, located on a rural roadside near Wickliffe and the Grampians. In these sites, the aim is to optimise species and functional diversity by avoiding domination of niches by a few high biomass native grasses or weed species. (Photo Paul Gibson-Roy).

TM: So as that is part of GAs approach anyway, they would have backed you on this. And maybe even your theatre training has even come in handy here, communicating with partners and volunteers and landholders?

PG-R: Yes, GA is keenly focussed on connecting people with the environment. And I guess my animated nature has made it much easier for me to engage with people or audiences. And I do feel the area I'm involved in (restoration ecology/ecological restoration) is important not

Figure 6. The GGRP involved numerous field days such as this example from a site near Hamilton. Increasingly, people interested in the preservation and conservation of native flora and fauna visit native grasslands (including local farmers and others from across the state, around Australia and from other countries). Such interest helps to raise awareness of the potential to increase grassy components in the agricultural and urban landscapes for aesthetic and amenity purposes. (Photo Paul Gibson-Roy).

only to biodiversity but also because it can help us humans to recognise that we can effect change in a positive as opposed to negative fashion. That's a very important message. We often seem to be resigned to our negative effects on biodiversity. I think it's very important to show people that with the will, we can also rectify some of these impacts. GA has a stated mission to engage the community in conservation of our natural environment; so we were singing from the same hymn book.

Very early on in the GGRP I set up a newsletter, the *Grassy Gazette,* to link people directly associated with the project. Since our early *Grassy Gazettes*, circulation has grown substantially, especially after inviting people from the broader restoration sector to contribute; but I have always tried to keep it strictly focused things grassy rather than as an advertisement for our or any other organisation. One of the great joys is to see the various contributions from GA people, farmers, seed collectors, Uni students, school kids – you name it – who have written of their experiences. They have contributed something of real value to the sector, so it is striking a chord somewhere between the technical and the social.

TM: And the Grassy Groundcover Research Project has expanded to many other sites now, including the Moolapio project at Geelong?

PG-R: The GGRP was originally funded for 3 years only. I then started agitating for additional funds and we managed to gain funding from various other partners including private organisations, CMAs, Federal and State government agencies (including the road authority) and industry. With that we were able to keep moving into new areas and developing new sites. Probably our most important single contributor was Alcoa of Australia, who had 500 ha of land buffering their smelter at Moolap near Port Henry and Geelong and approached GA to oversee the management of that landscape. I was able to convince them to allow us to work on parts of their land used for agricultural cropping; to work towards a goal of restoring 100 ha of complex grassland (Fig. 7). Unfortunately, global and local economics has meant that Alcoa is winding up operations at the Point Henry smelter. While we now have concerns about the long-term tenure of the restored grassland, the Moolapio project allowed us to demonstrate it is possible to establish large areas (16 ha) of complex grassland in locations from which it has been largely absent since European settlement. It's our single largest individual site and 8.3 ha of it was recently independently assessed by environmental consultants who ascribed its Habitat Hectare value as 3.9 ha, with a 2.6 ha improvement factor over a 10 year management period. The current market value for grassland in the Victorian Offset market is around $150–200 K/ha. They concluded the grassland represented 'High to Very High Conservation Significance'. This independent appraisal using a well-tested metric suggests our techniques are creating plant communities with critical market as well as conservation benefits.

TM: How many herbaceous species have you managed to establish in the Moolapio site?

PG-R: Over 80 species, representing a range of functional types. It is dominated by the tussock grasses with a mix of gaps and wildflowers. Within that community, we have populations of listed threatened species that are stable and well managed. This includes the nationally threatened Button Wrinklewort (*Rutidosis leptorrhynchoides*) and Hoary Sunray (*Leucochrysum albicans* ssp. *albicans var. tricolor*). We've also got Small Milkwort (*Comesperma polygaloides*), another regionally threatened species,

Figure 7. The seeding machine used to restore GGRP sites was an adapted AERA-vator® (1st Products Inc., Tifton, GA, USA). The seeder operator in this image is Rod White, then manager of the Moolapio programme. (Photo Paul Gibson-Roy).

and Large-fruit Groundsel (*Senecio macrocarpus*) which is nationally threatened. The site offers a wonderful seed resource in that region that is far above what occurs locally. We've run two field days a year for the last 4–5 years and attracted people from all over Australia. Importantly, because historically this site supported grassy woodland, we have reintroduced eucalypts into the site from local Bellarine region seed; so we have Red Gums establishing. We envisage that in 200–300 years they will be very big and very beautiful. I should say that at least half the sites we've worked on are in areas that were considered to be grassy woodlands. And at almost all those sites either trees have naturally recruited back (where there are nearby canopy trees) or acacias (*Acacia* spp.) have come up from seed banks after not having been seen for generations.

TM: What other major sites are there in Victoria?

PG-R: All up, I think we are probably approaching 90–100 ha of reconstructed grassland in Victoria, across about 50 sites. This may not sound like a large area in agronomic terms, but considering the level of threat to grasslands, and noting that 88% of grassland remnants occur as patches <1 ha in size, this is a significant outcome. Two closely located GGRP sites that highlight this point were established for VicRoads between Wickliffe and Glen Thompson near the Grampians. Both sites hosted historic roadside plantings of exotics and nonlocal native trees and shrubs – embedded right in the middle of some of the best roadside grasslands on the volcanic plains. VicRoads decided to remove the plantations, and Frank Carland, Natasha Kennedy (VicRoads) and I proposed a programme to replace them with reconstructed grassland of what we hoped would be comparable quality to the surrounding vegetation. Initially, there was considerable resistance locally and from the sector, but those fears were allayed by the results. We collected seed from a large number of species which represented a unique snapshot of the surrounding grassland; and scalped and seeded without damaging the surrounding area. The result was a relatively weed free reconstructed grassland dominated by low biomass native grasses, interspersed with high biodiversity forb-rich patches. So I'm eternally grateful to Frank and Natasha who both put their neck on the chopping block to support us.

Interestingly there were a few individual Hoary Sunrays (a threatened species) near the site. We collected seed from those and others in the region and multiplied it in production. Now, following the seeding, we've got a population of several thousand Hoary Sunrays that are also colonising outside that boundary. The site was also located near to a very small population of Button Wrinklewort – 22 plants – which were genetically precarious and certainly inbred. But I was doing some work at the time with Melinda Pickup and Andrew Young from CSIRO and they had done work on Button Wrinklewort populations in NSW and Victoria. From that I knew that the small nearby population and the largest population in Victoria (at Rokewood Cemetery) happened to be tetraploid, which meant they could be mixed and produce fertile offspring. So we collected seed from both, grew it in production and seeded the new sites with that species. It worked out remarkably well. We've now got thousands of Button Wrinklewort at the sites which now possibly represent the second largest populations existing in Victoria.

I'm really positive about the implications for these types of sites. They demonstrate that on the tens of thousands of kilometres of rural roadsides (particularly those wider three chain roads largely dominated by high biomass exotic grasses), the opportunity now exists to begin transforming them back to low biomass native grasses, interspersed with high biodiversity nodes of forb-rich grassland. The restored

sites would harbour a large proportion of our native herbaceous flora, going a huge way to reversing the loss of these herbaceous communities. If governments and authorities can be convinced of the many benefits, including cost savings of using low biomass native vegetation to mitigate against fire risks to people and property, there would be huge and ongoing opportunities for people who want to grow seed and to restore and manage grassland. It might even create liveable wages for people, something that is very hard to do in this sector at present. In fact I would envisage that the more the industry builds and diversifies to restoring roadsides and private land, or seeding swathes of wildflowers into urban gardens and parks, there would be greater and greater economies of scale. As infrastructure became more sophisticated in any region, there would be decreasing costs, increased capacity and certainly profoundly better biodiversity outcomes. You might even begin to get the broader community better understanding and accepting of our native flora and fauna. That would be something.

TM: Speaking of diversifying, you have now moved from Victoria back to NSW and are in the early stages of a project with GA (NSW) – a similar restoration project in Sydneys peri-urban grassy ecosystems on the Cumberland Plain

PG-R: Yes, we have been funded by the Federal government to reconstruct (over the next 4 years) 40 ha of complex grassy understory of the Cumberland Plain, another nationally listed community. Western Sydney is where first European settlers to Australia undertook agriculture in the late 18th and early 19th centuries; and from then on it has continued to be modified by development and population growth. We are aiming to work in agricultural paddocks that adjoin Cumberland Plain woodland remnants (most of which are badly degraded). As with our Victorian model, we have started by establishing seed production capacity aiming to grow as broad as possible a suite of herbaceous species, utilising genetic material from reference communities. Sourcing species and seed, even tiny amounts, has as usual been a huge challenge due to the level degradation of this plant community, but then that's why we are doing the project. In the next stage – using a 5 ha site as an example and following testing of nutrient and weed bank characteristics – we are likely to use some level of scalping to counter the herbaceous grassy weeds. I think we'll have to further adapt our techniques from the Victorian experience. Scalping at large scale will be expensive, particularly if you have to move the soil offsite, which we try to avoid. So this time we are going to shallow scalp, stripping defined strata and depositing them, layer by layer, with deepest layer on the top as 'islands'. And on those islands we'll sow complex mixes of native broadleaf species (wildflowers) and probably plant some trees. On these islands we can manage grasses (native or exotic) with selective herbicides. Into the large scalped areas, we'll seed complex native grass mixes. The shallow scalping will still give them the chance to establish and we can also manage these areas for broad-leaf weeds with selective herbicides. So in total, we'll have large matrices of complex native grassy sward interspersed with smaller islands of broadleaf complexity (represented by all the native wildflowers and the trees). Over time, as things establish and settle, I'm confident we'll be able to manage the site so the wildflowers recruit out into the grassy matrix and, unless we don't want them to, the grasses will recruit into the broad-leaved areas. We will also manage the areas that abut the bushland to facilitate species migrating into the remnants and increasing understory complexity there. There is evidence of this happening in all our Victorian sites where sown species have expanded beyond original areas. This variation on our Victorian approach is untested at this point. It's sort of a leap of faith and a big challenge – but things are up and going and I guess time will tell if it all works.

I should add we've also received valuable funding support from the NSW Office of Environment and Heritage (OEH) to build our seed production capability. I'll also try to bring other funding into the project to complement existing programmes. We currently have two linked research projects to help to inform our on-ground techniques, one with Charles Morris and one with Paul Rymer, both of the University of Western Sydney (UWS). The project with Charles (supported by Landcom and UWS) is focused on a bushland remnant within a Landcom housing development (the Ponds). We are testing different management techniques including fire, cutting and baling, carbon addition, scalping and seed addition. The second project (supported by OEH and UWS) is investigating the genetic characteristics of different populations of Kangaroo Grass (*Themeda triandra*) and Weeping Grass (*Microlaena stipoides*) from this region and beyond – and we hope to expand that to broad-leaved species. We are also planning to develop this work further with Linda Broadhurst at CSIRO to quantify a collection population for seed production, and track the genetic characteristics through a production cycle and seeing how similar they are at the other end.

Together, all this Victorian and now NSW momentum has been generated by a quite remarkable group of people including our wonderful teams and colleagues within GA, our farmers, seed collectors, growers, students and volunteers. And I would not have achieved any of this without the support of family members, who have been very forgiving during some

periods of quite high pressure. Valuable contributions have also come from those more loosely associated with the project, such as grader operators or farm engineers. I've been privileged to work alongside them all. Our work continues to roll forward and create tangible outcomes. I think this is very important. People tend to get swamped by the scale of problem, but we've found positive outcomes really change attitudes and create an appetite for action. In fact, there are many other groups applying our techniques with success in south-east Australia, which is a wonderful outcome and a great compliment. We are also quite regularly contacted from researchers and restoration ecologists from other parts of the world including Europe, China, North and South America, who now are aware and very interested in our results in south-eastern Australia.

At all times we have tried as much as possible to embed appropriate levels of research along the way; setting up substudies testing things like the germination of particular species, seed resources and production, nutrients, scalping, arbuscular micorrhizae and issues relevant to ongoing management. Of course others have explored these things as well. But I took the approach early on that essentially you could take tiny little research-based nips of this overwhelmingly large problem (where we are already at a few minutes to midnight) or alternatively we could try at least to take big leaps forward and inspire change (embedding research along the way where we could). So we made some assumptions that nutrients, seeding technologies and seed production were critical. I felt that if this gamble paid off, we could take our work forward a great distance. You are not going to capture every single thing that can or should be tested along the way because that is impractical. But the big leap forwards allows you to look back and identify particular areas that need addressing through research in more detail. In this way, things tend to progress more than they stagnate. And in terms of biodiversity conservation, we definitely need progress.

TM: Well, yes, you have taken leaps, meeting some resistance along the way

PG-R: Yes, I guess that's true to say. I think people sometimes express nervousness about wholesale reconstruction because they fear that if you can demonstrate that it is possible to re-create complex communities (such as grasslands or grassy woodlands), there will be nothing to stop wealth-focused developers of the world just wrecking everything and saying we'll rebuild it somewhere else. I understand that concern, but there are really two separate issues here. Firstly, there are fleetingly few high-quality remnants left, and if we don't act effectively, they will disappear; so surely if we are able to develop methods to effectively reconstruct them, this should not be ignored. Secondly, this perceived risk that unscrupulous people will use the promise of reconstruction as a licence to destroy things is really about human behaviour and societal regulations. Society must create effective and transparent systems, structures and regulation to prevent this. I accept that our track record so far is somewhat poor, but I'm convinced we have to continually strive to improve the way we manage and regulate against this. We and all other species have a lot riding on that succeeding.

Another point of resistance we have encountered is that people, particularly in the conservation sector, perceive what we are doing as not being quite 'environmental' enough; perceiving our work to be more horticulture, farming or landscaping. This leads to the idea that our reconstructed communities are not 'natural'. Yet the notion of 'natural' grassland or grassy woodland is a slippery concept. For example, most people think high-quality roadside remnants are the 'real deal', remnants of pre-European contact. However, I'm convinced that many roadside remnants are actually artefacts of the disturbance of road construction following which cleared patches were re-colonised by natives (which were then locally abundant). These have remained intact for many decades due to the nutrient-restricted nature of the site, fencing from livestock and possibly roadside burning. And we now understand that most if not all pre-European settlement grassy ecosystems were likely to have been moderated by human influence and held in those states through at least some intentional management action by Aboriginal peoples. So what then is 'natural' when humans are so critically implicated in development and maintenance of community structure? Clearly, it is not about humans per se but about whether what humans do is appropriate ecologically. Humans' ability to create an acceptable narrative around what is natural and what is not often astounds me and I find it frustrating that we create these simplistic narratives that have nature on one hand and humans on the other. It is more complicated than that.

TM: And that brings us to the need for human management of grassland after they are constructed. It would seem that management is a key to maintaining and improving the condition of grassy ecosystems

PG-R: It is. Obviously natural influences are critical in shaping vegetation and ecosystems (e.g. climate, geology and hydrology); however, clear evidence exists that human intent and action have for millennia also been a shaping factor. So if appropriate human management is absent, grasslands can be shaped only by what natural processes are still functional (e.g. competitive exclusion) and will transition to and through various states, often losing species

through increasing dominance by higher biomass species. So ecologically appropriate management is needed to manage biomass.

At GGRP sites, we use a number of tools for managing biomass. Fire is very effective and we have been able to use it across most of our sites. Burning is relatively inexpensive because relatively large areas can be burnt very quickly. But being able to conduct a burn when you want is not always easy. In Victoria, we burn our sites after fire restrictions are lifted, from autumn right through winter (as conditions allow). You are always working towards a window of opportunity trying to pull together a range of factors related to the vegetation goals and always focussing on mitigating against risk to life and property. This is even more critical in urban areas with large human populations, complex and extensive infrastructure and property values in the multimillions of dollars. In addition, there is the smoke factor which impacts on people's health and visibility on roads and freeways. So logistically it is much easier to use fire in rural and regional areas where there are local fire crews or farmers who are part of fire crews to assist. All this highlights the realities of modern landscapes. In pre-European times, populations were small and mobile, there was little or no property or infrastructure in the sense that we have it, and all plants and animals were effectively native. Importantly, decision making would have been localised and straightforward. None of this is the case today. We now have to consider myriad factors that mean burning is no longer a simple proposition. It can be very effective, but we have to realistically weigh up the issues around it.

For these sorts of reasons, we have tried to come up with agronomic or horticultural alternatives. For example, we found cutting/slashing and baling a very effective tool. It is relatively easy to organise, cheap and can be done almost any time you want. Depending on timing of the cut bales can be used as fodder for stock or as a native seed hay to restore new areas or improve degraded ones. If it is used as a seed hay, then you just roll out the round bales onto the prepared receptor site as a sort of mulch, which in the short term, restricts weed emergence and in the longer term (depending on how much seed is contained in it and how effectively the seed enters the soil), breaks down and allows for emergence of grassland species. There are some issues of course. Large or heavy tractors and balers can be inappropriate if you are working in a delicate roadside remnant or on wet soils. So access to compact hay balers available in the hobby farm sector can be important.

We also use herbicides to manage biomass, but to a much lesser extent. We might use them for a complete knock-down where needed – or for more targeted weed control as selective herbicides or herbicides applied at different rates to suit particular species. To target differential weed growth, we will often use particular herbicide rig set-ups such as mounted wick wands or use slashing at set heights to remove weed seed heads from within native vegetation.

So management is really critical. And it is an ongoing factor. Interestingly, people will say to me we want to reconstruct or repair grassland so they are self-sustaining and won't need managing. Self-managing grassland is an oxymoron. Even if you've got the most perfect grassland in the world or stepped into a time machine and went back to the middle of the volcanic plains 500 years ago, it's almost certain that those grasslands still had to be manipulated or managed to control the dominance of Kangaroo Grass, for example. Today is no different. So this notion that management you can be avoided or is not necessary in high-quality grasslands is too simplistic. You can certainly minimise the management required – quite dramatically as it turns out in low-nutrient, high-complexity and low-resource grasslands. Conversely in high nutrient sites, there is likely to be a need for high management inputs to reduce the dominance or biomass produced by native or exotic grasses such as Kangaroo Grass or Phalaris (*Phalaris aquatica*), a situation that in some agricultural cases has been achieved by cleverly managed grazing by domestic livestock. So whatever the case, management will be needed.

TM: How does this connect with your vision?

PG-R: Well, my vision in terms of grasslands and grassy woodlands is based on the idea that there is an inherent value to complexity, we have some moral obligation to preserve a place on the planet for those species with which we share it. Those species obviously can't articulate this, but it's hard not to conclude that for all those other species, it has been incredibly bad luck and/or timing for them to be occupying earth in the time of humans. Take for example, the apex predators we have and continue to push to extinction; in that case, it's clear we very much put ourselves first. But humans are clearly also capable of wonderful and good things. We need to acknowledge both the good and the bad; but I want to believe our capacity for good actions will outweigh the bad. This is what I've be trying to achieve in my own small way with grasslands.

We have to be realistic about the world we live in. I think this is especially so for those of us in the field of ecology. We are the ones who can guide, inform and inspire the broader community and our leaders. But we must see things as they really are. In Australia, today we do not rely on diverse native grasslands in the same way Aboriginal cultures did, for sustenance, tradition or even spiritual belief – although we do rely critically on other types of low diversity, exotic dominated grassy systems such as

annual grain crops and perennial pasture to grow meat and wool. Nonetheless, I think that society can (and should) still make conscious decisions to maintain or reconstruct grassy areas simply to conserve what remains of their biological diversity, or because their beauty gives great joy. But achieving this conservation requires commitment to actually manage and manipulate them to achieve that state. The reality is that this may cost a lot of money – more than the public purse is prepared to commit. And aside from the developing offset markets, there are no current drivers that direct private capital investment into managing our native vegetation. So instead we have grassland or grassy woodlands in private and public settings that are totally dominated by weedy grasses or have reverted to dense woodland. If that is what we/society wants then fine, but we have to live or be happy with the consequences, such as huge fire risks, insurmountable weed loads, uncontrollable feral populations, loss of amenity and so on. Generally, we are not fine with that. I think there is both a conservation and economic rationale for conserving or restoring grassy systems to approximate pre-European configurations in peri-urban and rural settings, even if the reasons are now different. But our sector has to articulate this feasibility and rationale more clearly so those who can provide the resources – including government agencies and resource companies and so on – will actually do so.

TM: This focus on grassy understories will resonate with many restorationists, especially those working in assisted natural regeneration who tend to be similarly passionate about managing soil seed banks and building new seed banks

PG-R: I hope that's the case. Many of the groups I've presented to over the years have some sympathy for these views. I do think reconstruction and regeneration can inform each other. I'm in a position now where I would argue I have equivalent knowledge about managing remnant grassy systems as anyone working with remnants, having had all this time and opportunity to rebuild, test and then push reconstructed communities. I find that the reconstructed and remnant communities I've observed or dealt with behave in almost an identical manner. We can have so much learning either way. Overall, I see this as an incredibly positive and uplifting story amidst the greater human saga. People love trees and the upper canopy – *I* love the canopy – but the complex stuff *under* the canopy in open ecosystems is where we can share the diversity. The story of grasses is critical to the human race. We have grown as a species to populate this planet on the coat tails of grassy ecosystems; they are fundamental to our story. And so the message I have been peddling for some time now is that we *can* effectively manage and we *can* reconstruct native grassy landscapes. It makes me happy to think that all is not lost. When I first came into this field the notion that these things couldn't, or shouldn't be done, was very pervasive and, frankly, very dispiriting. And if in the end it turns out that we don't commit the will and resources to conserve or restore the environment, such as we do for things that generate wealth or protect us from each other, that will be yet another sad human story for which we would probably pay dearly. But I choose to hope for the better part of our nature and the alternative scenario. Humans are remarkable. We have had a profound negative impact on many species, who have no capacity to articulate for themselves or stop us. But our unique ability to use reason and use it to develop ethics gives us the capacity to understand this fact and act upon it. I truly hope we can accept the responsibility beholden on us not to destroy a world that supports us and millions of other species.