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Restoring grassy ecosystems – Feasible or fiction? An inquisitive Australian's experience in the USA

By Paul Gibson-Roy

Many small-scale projects in Australia suggest that ground-layer elements of ecosystems can be restored, but scaling up of grassland and grassy understorey restoration has not occurred to date. Paul Gibson-Roy recently travelled through the USA, where well-developed markets for restoration have created a large, financially viable native-herbaceous seed production and restoration sector. Here, he shares his observations, which show how much about the USA situation can be a model and inspiration for Australian grassy ecosystem restoration.

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

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Figure 1. Successful species-rich ground layer restoration (Oregon, USA). Outcomes of this standard rely heavily on seed production, technical expertise, suitable technologies and markets for restoration. These factors are in evidence across the USA, but not in Australia, due to a lack of market drivers that have supported the development of a viable large-scale restoration sector in the USA. (Photo Paul Gibson-Roy)

Introduction

Australia is a significant world food and fibre producer with a large agricultural footprint. Our agricultural success in a competitive global market has been achieved using an intensive production model that has come at considerable cost to not only farmers and rural communities but also the natural environment (Gray & Lawrence 2001). In 2016, livestock grazing on exotic pastures occupied an area of 71 million ha (9.2% of total land use), while dryland cropping covered 27 million ha (3.6%) and irrigated crops, pastures and horticulture together took up a further 2 million ha (0.4%; ABS 2017). To varying degrees, all these forms of agriculture impact, exclude or replace native vegetation, as can extensive grazing of rangelands (Calvert 2001). As a result, native grassy ecosystems in southern temperate Australia are diminished to a tiny fraction of their original range and are among our most threatened plant communities (Rolls 1999; Williams & Morgan 2015).

It is possible to traverse many hundreds of kilometres of some rural roadways in the agricultural districts of south-eastern Australia and observe little or no native ground-layer vegetation. These landscapes are typically portrayed in film and television as 'iconically Australian' with their eucalypt-lined roads adjacent to (exotic) grassy paddocks where idly browsing cattle or sheep reside among scattered gum trees. Contrary to popular belief, these are no longer places where native diversity thrives, but rather places where native species are severely diminished or absent (Stevens 2002).

For many decades, protection has been the primary conservation tool to halt the

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loss of native grassy communities. The federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), complemented by state-based acts (e.g. Victorian *Flora and Fauna Guarantee Act 1988*, NSW *Biodiversity Conservation Act 2016*), has led to the protection of many grassy community types. However, ecological assessments continue to reveal ongoing degradation and destruction (e.g. State of the Environment Committee 2011; Victorian Environmental Assessment Council 2011), which brings into question the wisdom of our over-reliance on protection-focused environmental laws. The continued loss of native biota highlights the need for complementary approaches to halt and reverse grassy ecosystem loss, of which a prime candidate is ecological restoration.

Ecological restoration embodies a wide range of beliefs and motivations, but broadly speaking its goal is to restore or repair human-degraded native ecosystems (Higgs 1997; Choi 2004; Trigger *et al.* 2008; Anderson 2009). Interestingly, ambitions of returning degraded Australian landscapes to prior levels of composition and function have been canvased since the early days of colonisation (Bonyhady 2000; Ardill 2017). The 'field' of ecological restoration began to emerge during the 1960–1980s (Jordan 2010). However, despite benevolent goals, the validity of ecological restoration is questioned by some in the community who believe it capable only of creating pale imitations of nature. Others hold deeper objections, charging that the concept provides support for a human-centric world-view that 'nature destroyed' can be replaced through technology and human ingenuity when and where desired (Elliot 1982; Katz 1992).

Low confidence in the core principle of restoration (Katz 1992) or in its application (Lunt 1991; Coor 2003; Cole & Lunt 2005; Huxtable *et al.* 2005; Prober & Thiele 2005; Smallbone *et al.* 2007), particularly among researchers and practitioners (to whom policy makers look to for assurance and guidance), has the capacity to weaken governmental support for restoration of complex grassy communities. Evidence of this may be inferred from the fact that governments (on both sides of politics) have historically directed environment funding towards 'low-risk' restoration approaches, such as those focused only on tree and shrub layers (e.g. the 20 Million Trees Program) in the hope that ground-layer strata will naturally 're-appear' (Davies & Christie 2001). However, without support mechanisms, there can be no viable market for ecological restoration of complex grassy ecosystems in this country. This leaves the seed and restoration sectors small, poorly resourced and practically incapable of undertaking complex restoration at the desired scale (Wlodarczyk 2001; Firn 2007; Hancock *et al.* 2018).

This author has been involved in both research and practical grassland restoration in Australia for many years (Gibson-Roy & McDonald 2014). During that time, there have been some welcome small-scale successes that demonstrate it is at least technically feasible to restore high-quality grasslands and grassy woodlands in Australia (Gibson-Roy & Delpratt 2015; Cuneo *et al.* 2018). This on-ground experience has also revealed many factors that restrict our capacity to restore these systems. At the most fundamental level, complex ground-layer restoration is limited by a lack of seed – there is simply not enough available in the quantities, diversity and quality to undertake restoration at scale (Delpratt & Gibson-Roy 2015). This limitation is not insurmountable if seed production approaches are employed, nor are other factors of a technical or practical nature insurmountable (such as the need for suitable restoration infrastructure, equipment and methods) if there is a viable market to drive investment and innovation.

To determine if similar factors restrict grassy restoration in the United States (USA), I travelled to that country in 2016 with support from a Badman family-sponsored Winston Churchill Trust Fellowship. There I set out to examine the USA native seed production and restoration sectors. I met and interviewed seed growers and restorationists and toured seed farms and restoration sites to gauge the scale and complexity of these sectors and to contrast them with my Australian experience. I travelled extensively across a large area of the country during mid spring, so I could visit sites when crops and restoration works were actively growing. The trip took me from Texas in the south to Minnesota in the north, and from New York State in the east to Oregon and California in the west. My aim was to determine to what extent the practice of grassy ecosystem restoration was supported and practised, and if so, what structures, systems and markets were in place. From this experience, I hoped to be able to make recommendations that could help the Australian sector achieve the goal of using restoration (in conjunction with protection) to halt the loss of our native grassy ecosystems.

Grassy Ecosystem Restoration Industry in the USA

USA native seed production

Seed production (or seed farming) is viewed as a fundamental requirement to meet seed needs for restoration markets in agricultural landscapes of the United States (Fig. 1) where access to wild seed is often critically limited (McArthur & Young 1999; Dunne & Dunne 2003; Walker & Shaw 2005; Tischew *et al.* 2011). While researching and preparing for the tour it became clear that there are large numbers of enterprises in the USA growing or selling native seed. Most are privately operated; however, some are run by government agencies. Private organisations encompassed a variety of business or production models including distributors, wholesalers, retailers, wholesaler/retailers, growers of native and non-native seed, growers of native grasses, wildflowers, plants and seed, and seed grower/restorationists.

Infrastructure and capacity

My study tour focused on seed producers who grew both native grasses and wildflowers (some of whom also offered restoration services). Shortly after arriving and beginning to visit seed growers and restoration sites, I realised the state of the seed and restoration sectors was almost the opposite of that which I had come to know in Australia. Simply by experiencing the operation of these businesses, it was clear that the physical scale of native seed

growing in the United States was orders of magnitude larger than in Australia. For example, in Australia I know of no high-intensity native seed farms >20 ha in size (and those this size only grow native grasses); in the United States, I visited seed farms that were between 1000 and 5000 ha in size and grew crops of hundreds of species of grasses and forbs.

For me, the complexity of the enterprises I toured told a clear tale: seed growers are willing and able to raise the capital required to establish large-scale enterprises (Fig. 2). This is possible because viable markets exist for native seed (Dunne & Dunne 2003). These markets create income streams that ensure investments are paid down, operating costs met and profits made – again, an unfamiliar experience in Australia.

Almost all the owners I met had originally been traditional farmers with an interest in native flora. Their interest had turned into their primary business when markets for their traditional crops (such as tobacco or cereals) went through rapid change or prolonged downturns, and as native seed and restoration markets developed (Cain & Lovejoy 2004). This situation meant I visited multi-generational businesses where the original owner worked alongside sons, daughters and their offspring.

To grow native seed at a large scale requires significant amounts of infrastructure, equipment and human capital (perhaps even more so than for traditional farming, given that instead of growing a handful of cultivated species, native seed growers can cultivate several hundred wild species). This requires unique levels of specialisation and knowledge, and it was clear that the seed farms I visited had these. For example, seemingly simple (but actually complex and expensive) infrastructure, such as large agricultural sheds, were commonplace. I was frequently shown through several multi-level buildings on any given farm, each devoted to different sets of activities such as administration, seed processing, seed packaging and distribution, seed storage, equipment storage and upkeep. I was shown vast arrays of equipment (representing huge financial investments) used for seeding, crop maintenance, seed harvest, cleaning, packaging, storage and distribution. Some equipment was technologically sophisticated, some quite basic and some purpose-built.

From experience, I know seed production to be labour-intensive. In the United States, I found it common for seed businesses to employ between 20 and 100 staff (figures that dwarf any Australian operation I know). In many instances, these seed businesses were among the largest and most stable employers in their regions. With such large and complex enterprises, it also became clear that a highly skilled workforce was crucial to success. In this respect, the willingness of owners to invest in human capital (Wheelan 2002) was another inspiring feature of their business models. During discussion, many owners noted how important they considered human capital to be, given the competition and constant innovation required. I saw numerous examples where owners had invested considerable time and resources developing staff capacity, so they could specialise in areas such as seed cleaning, plant propagation, 'planting fields' (restoration), equipment design and maintenance or sales and marketing.

While I spent much time inspecting the operational side of seed businesses, it was clear that the administrative demands involved with managing accounts, information systems, promotions, sales, logistics and human resource management (HRM) were areas of significant expertise and importance. In most cases, these were multi-million-dollar enterprises and owners commented that having effective business systems were key to holding market share and delivering a valued product to clients. I visited one grower who had recently invested a significant amount to build a large architecturally designed administration block, so management and administrative staff could better cope with ever-growing demand, and so clients and visitors would have a modern attractive building to visit (e.g. they regularly hosted schools and community groups). I commented on how impressive the facility was and how effectively this aspect of his business appeared to be managed. He noted reception staff were receiving over 200 sales enquiries each day and so this level of capacity and professionalism was required. His comment was not made in boast, but rather as a simple statement of fact. I found it hard at that point to even dream of such a scenario in Australia.

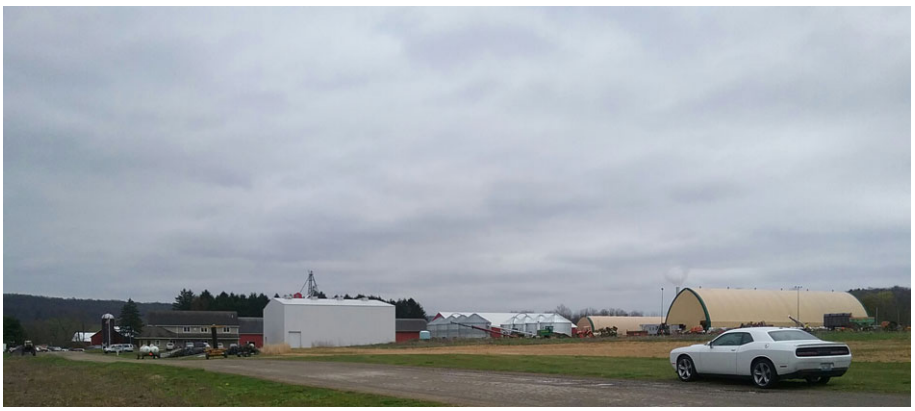

Figure 2. An example of the type of infrastructure investment directed towards growing native seed in the USA, which contrasts markedly with the scale of operations in Australia. Ernst Seed, Pennsylvania, USA. (Photo Paul Gibson-Roy)

Seed provenance

Native crops I viewed were established using 'founder' seed from the wild (remnants). Many growers harvested this base resource on an ongoing basis to initiate new crops or to source new genetic material to reinvigorate older ones. Others purchased founder material from government-operated Plant Material Centres (PMCs). At the time of my tour, there were 25 PMCs in operation throughout the

United States under the auspices of the USA Department of Agriculture and its Natural Resource Conservation Services wing. These were established last century to evaluate and bring into production species that would help achieve USDA soil and water conservation goals. For much of that time this scope focused on the use of exotic grasses, but over time the beneficial attributes of native grasses were recognised, and natives were more routinely evaluated and brought to market (i.e. via private seed growers).

When discussing the topic of founder seed and where it is sourced, it became clear that the issue of provenance is as keenly debated in the United States as it is in Australia (e.g. Lesica & Allendorf 1999; Walker & Shaw 2005; Johnson *et al.* 2010). Growers (and restorationists) expressed a range of views on this topic. A small number subscribed to the 'local is best' view and there was also some acceptance of 'non-restrictive' provenance ranges. Most expressed the view that overly restrictive provenance requirements resulted in few demonstrable ecological advantages (as seen in their production crops or restoration outcomes) and that they limited buyer markets to such a small size that businesses could not survive. Most growers also expressed the view that highly non-restrictive provenance ranges were ecologically undesirable (i.e. unfit genotypes) and economically questionable (i.e. low seed prices due to oversupply). However, some commented they did, on occasions, sell seed to very distant locations (e.g. to other producers, distributors or restorationists).

I was informed that buyer opinion was also varied, with some (although comparatively few) stipulating tight provenance ranges (i.e. within county) while others allowed very expansive provenance ranges (i.e. from the USA or Canada). However, it seemed the bulk of growers and buyers favoured 'ecotype' collections (Johnson *et al.* 2010). Growers described an ecotype-founded production crop (for any given species) as one initiated from combined genetic material taken from separate founder populations located across a defined geographical region that exhibited distinct climatic, geological and topographical characteristics (in many cases covering areas of thousands of square kilometres). Growers commented that seed produced from ecotype-founded crops gave hardier offspring and superior restoration outcomes. My impression was that growers favoured the ecotype concept because it gave credence to the importance of genetic health and gene preservation but was also more likely to represent an economically viable market footprint.

Growing systems

Species were typically grown as in-ground field crops at the multi-hectare scale (I only saw small-scale containerised or matted production systems used as test or demonstration crops). As in traditional agriculture, species were row-cropped with weeds in inter-rows controlled using selective and pre-emergent herbicides or mechanised weed chippers. Grass crops were typically established by sown seed (Fig. 3) whereas wildflower crops (Fig. 4) were generally grown at smaller scales and mechanically planted. At one farm I saw a planter capable of installing 30,000 plants per day. Growers noted that it can take up to 3–4 years to get a new species from the wild to full seed production. Therefore, before launching into large-scale production, most growers installed small test plots to determine if a new species was going to be suitable for production, to gauge its yield and explore potential markets. With such long lag times, growers were very strategic in allocating resources and managing their and their clients' expectations.

To lay out fields to a high degree of accuracy, a few growers had invested in whole-farm management software programs (of the type developed for conventional farming). These loaded GPS mapping of the farm and all fields into software for data tracking and aligned this information to GPS-enabled farm equipment. While this technology was expensive, growers believed it was more than repaid through increased efficiency and accuracy of seeding, spraying, cultivation and harvest. This lowered input costs and improved productivity.

To streamline activities such as weed control, seed harvest and irrigation delivery, most growers blocked grasses and

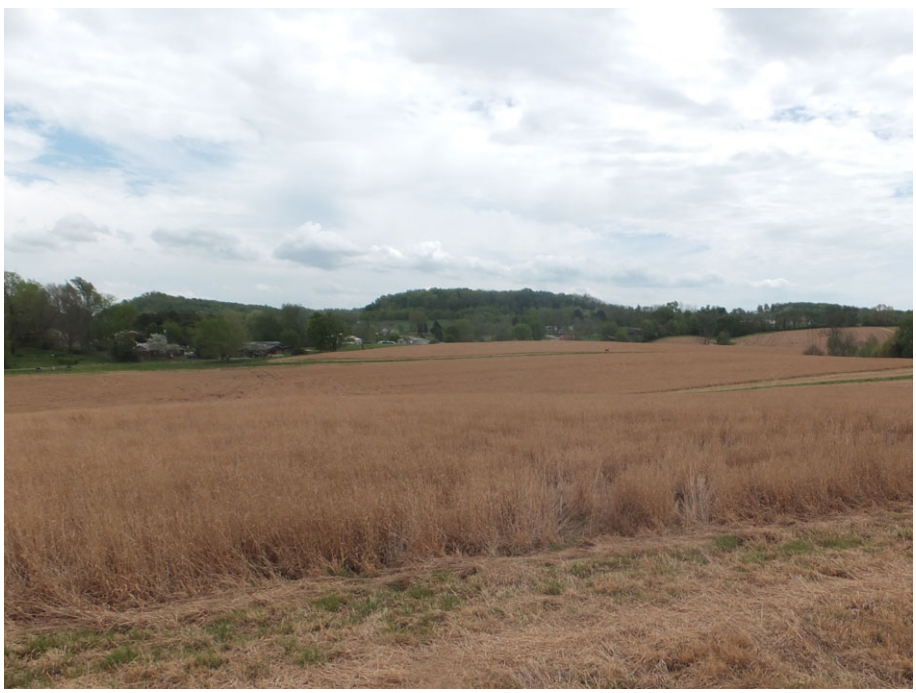

Figure 3. Large-scale native grass crop. Roundstone Native Seeds, Kentucky, USA. (Photo Paul Gibson-Roy)

Figure 4. In-ground native wildflower crop. Corvallis Plant Materials Centre, Oregon, USA. (Photo Paul Gibson-Roy)

wildflowers into separate growing areas. Others further sub-grouped to crop-types based on form and physiology (e.g. low grasses, tall grasses, tall wildflowers, short wildflowers). This resulted in better alignment of maintenance requirements and enabled more accurate tracking of production inputs and outputs, allowing growers to set appropriate sale prices for seed.

Biomass management was viewed as critical to rejuvenating crop vigour and fire was the most common tool used for this purpose. I toured many recently burnt crop fields (and several being burnt) and noted the similarity of approaches used back home when undertaking remnant vegetation burns. The process of burning large crop areas amid rural populations, animal stock and infrastructure required significant expertise and planning (in much the same way as organising and undertaking environmental burns in Australia).

Interestingly, one enterprise used stock (cattle and goats) to graze and then trample production crop biomass into the soil to improve soil structure and return nutrients for plant growth. They explained that hoofed animals (Bison, *Bison bison*, in particular) had always been a critical part of prairie ecosystems and so grazing stimulated new plant growth and kept their crops (and prairies) healthy and vigorous. They had also run comparative trials that showed their stock fared better in terms of condition and time spent on feed when grazed on diverse native pastures (i.e. their production species) than on single introduced species. Combining these two elements (seed and animals) gave these growers multiple income streams. They also advocated strongly this combination of native species and stock to graziers (as does the Stipa Native Grass Association, which advocates for the use of native pastures in Australia).

In wetter regions (e.g. Kentucky and Pennsylvania), irrigation was not commonly used to water grass crops although in many cases it was employed for wildflower crops (mostly delivered as inline irrigation). In drier regions (e.g. California), irrigation was considered crucial for producing good crops (grasses and wildflowers). Large whole-paddock travelling irrigators (centre pivot or lateral move) were commonplace and viewed as critical infrastructure on these farms (Fig. 5). The cost of purchasing, running and maintaining large irrigation equipment (combined with water licences and usage costs) was considerable and factored into seed prices.

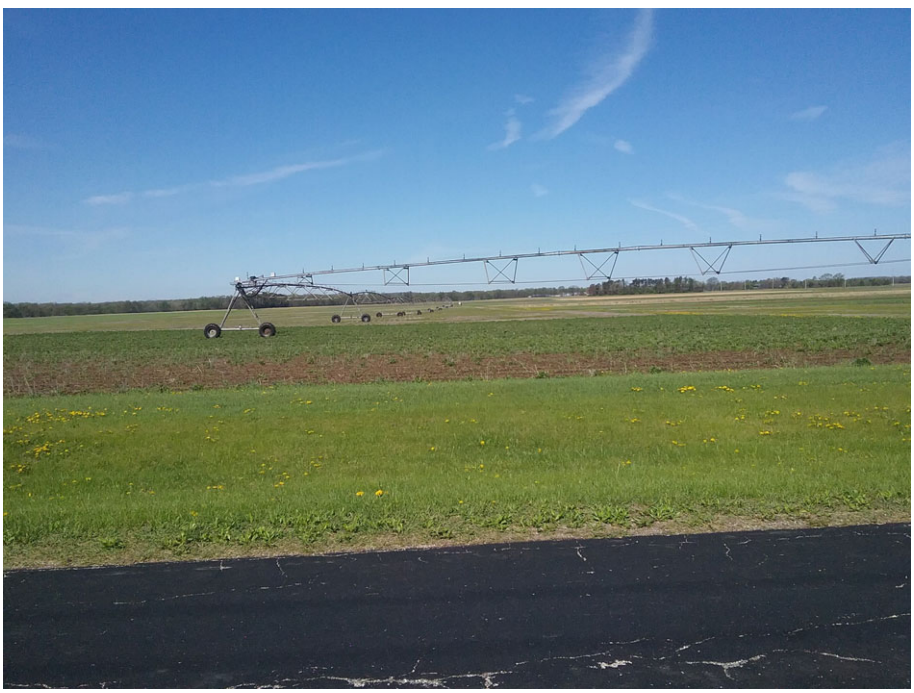

Figure 5. Field-scale crop irrigation. Taylor Creek Restoration Nurseries, Wisconsin, USA. (Photo Paul Gibson-Roy)

Seed processing

Cropping at the 1000+ ha scale meant growers required harvest and processing equipment that could deal with huge volumes of seed. I was shown a variety of seed harvesters including large conventional agricultural combine harvesters (Fig. 6) (one grower alone had four housed in their shed) to smaller purpose-built versions of the same type (i.e. the German-built Wintersteiger seed harvester) to 'home-built' equipment that employed combinations of brush and cutting bar approaches.

Prompt post-harvest drying of seed was described as critical for preserving seed quality and forced air was used to dry fresh seed during transport to and in storage silos. Moving harvested seed from silos to and through processing facilities was an important task and a logistical challenge. It involved moving collections from initial points of temporary storage (silos) to processing sheds and on to seed cleaners. Various types of equipment were used for this purpose including belts and augurs. At one facility, computer-controlled pneumatic transfer systems were used to achieve vacuum movement of seed throughout their facility with great efficiency and speed.

There is an expectation in the USA market that seed is sold in a pure or near-pure state (unlike in Australia). Growers produce huge volumes of seed annually and processing this product from a harvested to a saleable state was viewed as critical. Such were the seed volumes that growers noted that seed cleaning occupied most months of the year. To keep pace with demand during the most intensive harvest periods (spanning 3 months) cleaning sheds typically run 24 hours a day.

To clean and grade seed, growers utilised a variety of equipment types ranging in size from small laboratory cleaners to huge multi-level, industrial-scale plant. The large models were sourced from the commercial grain industry (i.e. Clipper Cleaners – A.T. Ferrell Co., 1440 S. Adams St., Bluffton, IN, USA). These used combinations of sieves, vibration and aspiration units to grade seed of the same species and to remove weed seed and other inert matter from collections. Other smaller types were length and shape separators (indents), brush and vacuum cleaners.

In the United States, there are strict seed standards (including for seed testing) that apply to native seed growers under state and federal legislation (Jones & Stanford 2005). For example, the Federal Seed Act of 1939 requires accurate labelling and purity standards for commercially sold seed and there are additional regulations required by each state jurisdiction. Regulations are strictly enforced by USDA inspectors who are authorised to conduct on-the-spot inspections of businesses to re-test seed lots and verify they are consistent with labelled information. I am aware of one grower I met being fined for a minor breach of federal labelling law.

Growers are obliged to undertake independent testing of seed of all species they produce in a season. Private and public ISTA-accredited laboratories (which include several linked to universities) are available to test seed for characteristics such as percentage pure live seed, viability (tetrazolium), germinability and weed content. Testing also identifies if a noxious weed is present. If it is, the whole harvest batch is banned from sale. The cost of seed testing ranges from between US $150–200 per sample and, multiplied over hundreds of samples, annually represents a large expense for growers. However, most maintained it was beneficial overall because good results gave confidence to clients and confident clients meant return customers.

Many growers I spoke to had joined seed accreditation programmes to increase the 'saleability' of their product. Programmes such as the Iowa Crop Improvement Association's 'Source-Identified' Native Species (Seed) Program was one example and the Texas Department of Agriculture's Seed Certification Program another. The purpose of accreditation programmes is to give seed buyers greater certainty about the collection source and place of origin of seed. I was told by growers that several major buyers (such as State Departments of Transport) stipulate in tenders that seed must be

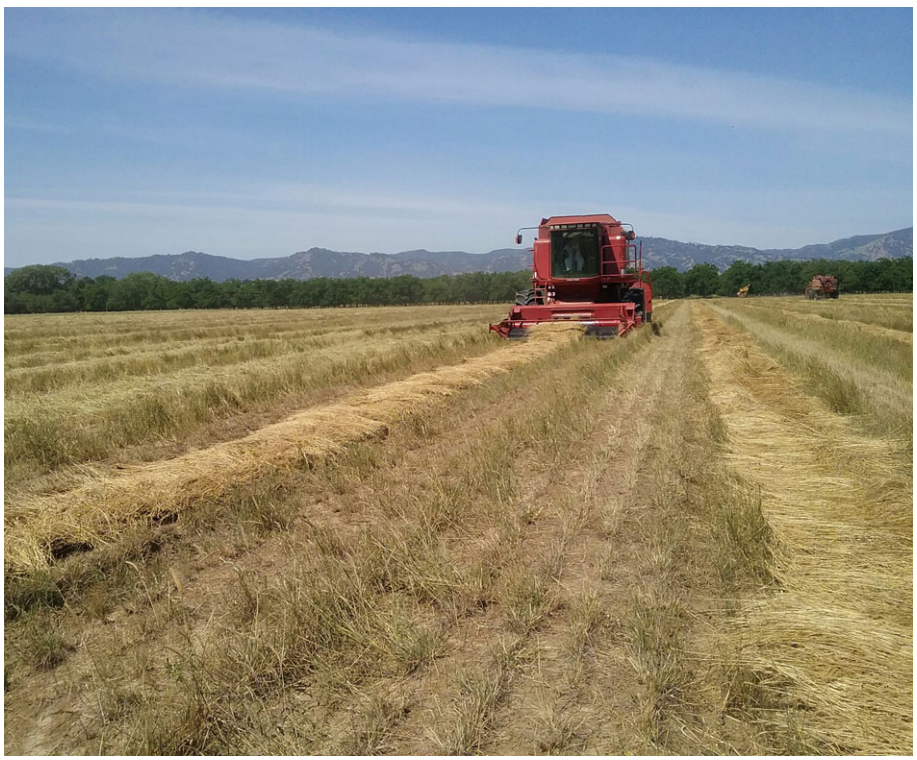

Figure 6. Native grass harvesters in action. Hedgerow Seed, California, US. (Photo Paul Gibson-Roy)

associated with accreditation programmes. Many of the growers I met were also members of seed associations such as the Western Seed Association, the American Seed Trade Association and the Atlantic Seed Association. These were formed to represent the interests of growers and to provide them with various member services and resources. Growers also felt membership in these sector-based associations was important because they facilitated networking and business opportunities.

At the completion of processing, seed was sorted, mixed, packaged and labelled. I was regularly impressed at the variety of 'seed products' offered to the market and the entrepreneurial flair that growers displayed in targeting market segments. Some of the product types I saw included seed mixes specifically designed for farm rental programmes (e.g. Conservation Reserve), faunal programmes (e.g. for Monarch Butterfly, *Danaus plexippus*), to increase animal habitat for hunting (e.g. for White-tailed Deer, *Odocoileus virginianus*, and Wild Turkey, *Meleagris gallopavo*), for attracting pollinators and honey bees, for erosion control, as cover crops, and for urban landscaping (e.g. high-amenity wildflower blends). This variety of product offerings was indicative of the size and complexity of the market for native seed.

While awaiting delivery, seed was stored in temperature and humidity-controlled facilities. I toured several large climate-controlled storage sheds housing tens of thousands of pallets of bagged seed stacked to ceiling height. This was yet another indicator of the strength of the USA seed market. Indeed, many growers commented that their stock volumes were routinely depleted by the end of each season (Fig. 7).

Markets for seed and restoration

One of the most striking aspects of my tour was the realisation that there were several large independent markets underpinning this dynamic and successful seed and restoration sector. Reduced to broad categories, these markets were: (i) federal and state farm-based conservation programmes; (ii) federal and state native roadside programmes; (iii) development offset schemes, and (iv) green urban or infrastructure-related programmes.

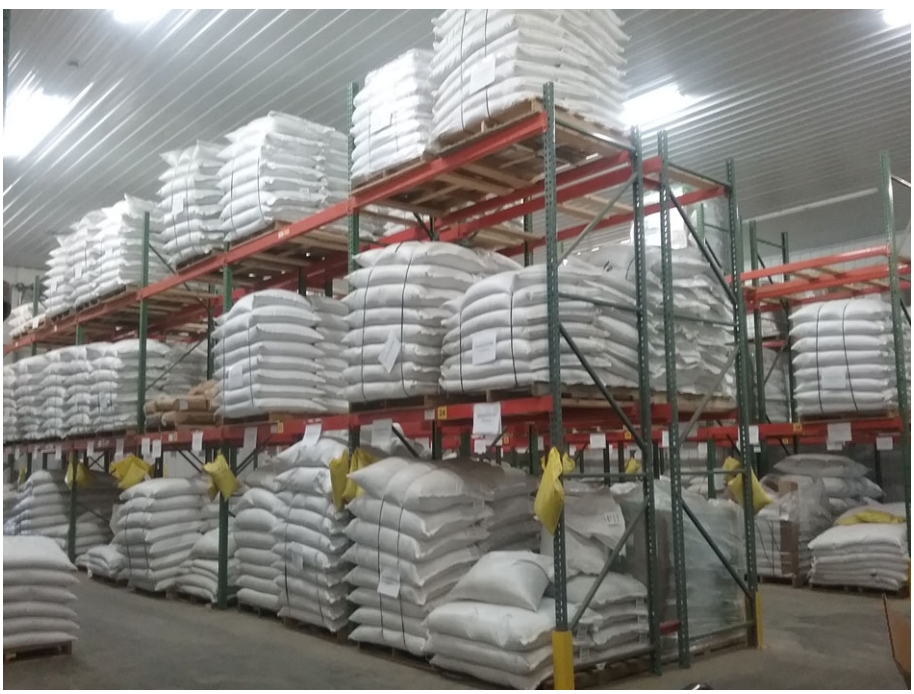

Figure 7. Bulk seed storage. Shooting Star Seeds, Minnesota, USA. (Photo Paul Gibson-Roy)

Farm programmes

Every seed grower I interviewed commented on the importance of farm-based restoration programmes as market drivers. Without question the most prominent was the federal Conservation Reserve Program (CRP) which had led to huge-scale restoration outcomes. By doing so, it had supported the growth of the seed and restoration sectors for many decades (Dunn *et al.* 1993; Jelinski & Kulakow 1996; Dunne & Dunne 2003; Cain & Lovejoy 2004; Wu & Weber 2012). Originating in the 1980s, the CRP was signed into law by President Ronald Reagan as a provision of the federal Food Security Act of 1985. The CRP is administered by the USA Department of Agriculture's Farm Service Agency and operates as a 'farm rental' programme in which the Federal Government rents (or retires from production) erodible cropland (e.g. corn, wheat, oats), which is then converted into native grasses, wildflowers and trees.

The incentive for farmers to enrol in the CRP is that they receive annual rental payments for a contract period of 10 years as well as half the cost of restoring the vegetation (i.e. farmers must also contribute). Growers told me that CRP payments are comparable (and in some cases, exceed) those that come from growing agricultural crops. Farmers bid for CRP places on a national basis with bids assessed using an 'environmental benefits index' (Putnam 2012). The index favours bids that offer higher environmental or biodiversity outcomes. However, while in theory this bias towards diversity incentivises farmers to use more species (and in turn seed growers to produce seed from a wider range of species) several restorationists and growers noted that in reality the CRP has quite rigid budgets, which means the bidding process is price-sensitive. This means that some who want to enrol their farms in acreage programmes tend to choose lower numbers of common species (whose seed is cheaper) rather than larger numbers of rarer species (the seed of which is dearer) for their restorations.

Cain and Lovejoy (2004) provide a comprehensive overview of the historical development of USA 'farm bills' which

were precursors to the CRP. The first of these was developed during the Great Depression when gross farm income had dropped by 52% and when one in four Americans lived on farms (Wheelan 2002). To avert social crisis, F. D. Roosevelt legislated the Agricultural Adjustment Act of 1933, which instigated the first of many farm programmes directing cash payments to struggling farmers. The Soil Conservation Act of 1935 created the Soil Conservation Service, which directed payments to farmers willing to establish specified soil conservation practices such as substituting 'soil depleting' crops (i.e. corn, cotton and wheat) with 'soil-conserving' species such as grasses or legumes (remembering this was the time of the Dust Bowl). Another aim of these programmes was to manipulate commodity markets (i.e. by limiting production) so farmers would get a 'fairer' price for their product.

During World War II, American farmers produced more to meet world demand and, following the cessation of hostilities, surpluses grew. The Agricultural Act of 1956 created the Soil Bank which took 11.7 million ha out of food production to reduce surpluses using farmer payments and transferred them into soil, water and wildlife conservation programmes. But surpluses continued through to the 1970s despite interim measures to curb corn and sorghum production (e.g. the Emergency Feed Grain Act of 1961). However, growers noted that during these years there was increasing awareness that native grasses were as or more effective than exotics for soil conservation plantings, and so the native seed sector began to coalesce and grow.

Until the 1980s, farm policy focused primarily on soil and water conservation, but during this period public awareness of the negative impacts of agriculture on wildlife grew. This, combined with lobbying from the environmental sector (who realised land-use change via farm bills was more likely to succeed than through environmental legislation) led to the 1985 farm bill (titled the Food Security Act of 1985 or FSA-85), creating the Conservation Reserve Program (Doering 2000; Cain & Lovejoy 2004). The CRP has run for 30 years (three 10-year cycles) and during that time has created the incentive and sector capacity to restore just under 9.7 million ha of native vegetation. This has occurred on 365,000 farms across America at an average annual rental payment of $29 per ha (Barbarika 2016). In doing so the CRP has provided farmers with a fair price to 'farm native biota' and helped create a viable and stable market for the restoration sector, enabling it to develop formidable productivity and capacity. Nothing of this type, scale or success has occurred in Australia to date.

Jelinski and Kulakow (1996) described the CRP as a 'vast laboratory for research in restoration and restoration ecology' and since its inception studies have been conducted to quantify the outcomes of this continental-scale programme. Critical among them are those that confirmed reversals in landscape fragmentation and regional declines in biodiversity (e.g. Dunn *et al.* 1993; Millenbah *et al.* 1996; Haufler & Ganguli 2007; Gleason *et al.* 2008). Through the creation of functional habitat, CRP restorations have led to wildlife increases in rural landscapes. This has been indicated by rebounding populations of Sage Grouse (*Centrocercus urophasianus*), White-tailed Deer, pheasants (*Phasianus* spp.), quail (Odontophoridae) and Wild Turkey (Millenbah *et al.* 1996; Drum *et al.* 2015; http://crpworks.org/). Indeed, the USDA estimated that quantifiable wildlife-related benefits from the CRP could be valued at $12 per ha per year (USDA FSA 2003).

In addition to biodiversity outcomes, other benefits have flowed from the CRP such as increases in farm soil quality (Gebhart *et al.* 1994), improvements in rural population health and provision of alternative income streams for farming communities (Putnam 2012; Wu & Weber 2012). For example, the USDA estimated that CRP lands achieved an average reduction in soil loss from 8.5 to <0.8 tonnes per ha per year (Cain & Lovejoy 2004). This is an important outcome and lesson, given the current emphasis on 'soil security' in Australian agriculture (e.g. USSC 2012). Mitigation of greenhouse gas was another quantifiable outcome of the CRP. Gebhart *et al.* (1994) suggested that the CRP would sequester up to 45% of USA agricultural emissions annually, and Tom Vilsack (2016), USA Secretary of Agriculture, reported that CRP lands had sequestered 44.4 million tonnes of greenhouse gas emissions per year since 1985. Regarding water quality, Vilsack also reported that nitrogen and phosphorus runoff to waterways on CRP lands had been reduced by 95% and 85%, respectively. Long-term assessments of the CRP have concluded that its economic benefits outweigh its cost of funding (Wu & Weber 2012). A critical point concerning environmental-focused programmes such as the CRP is that they have been shown to be compliant with World Trade Organization regulations regarding international trade and avoidance of market distortions (Cain & Lovejoy 2004).

Other USDA-funded farm-based conservation programmes such as the Grassland Reserve Program, the Wetland Reserve Program, the Conservation Reserve Enhancement Program and the Monarch Butterfly Program have also been established to complement the CRP. These offer potentially higher rental payments to farmers for programmes and have more keenly focused conservation goals for achieving higher and more targeted on-farm biodiversity outcomes related to threatened species or communities than the CRP (Haufler & Ganguli 2007). For example, the Monarch Butterfly Program (signed into law in 2015 by President Obama) created considerable interest in the American public to preserve this iconic invertebrate. Many of the growers I met commented that such was demand they were battling to establish milkweed (*Asclepias* spp.) crops fast enough to supply seed for use in the Monarch Program. Likewise, the Grassland Reserve Program (initiated in 2002 by President G. W. Bush) restored over 1.2 million ha to native prairie up to 2012, at which time, it provided a monetary benefit of $9.70 ha per year for improved forage production, wildlife habitat and carbon sequestration on those lands (Bowen *et al.* 2010).

The Bureau of Land Management (BLM) is another government agency that, according to growers and restorationists,

administers programmes creating strong demand for native seed and restoration services (Kilkenny *et al.* 2014). The BLM is embedded within the USA Department of the Interior and administers 99 million ha of public lands. Among many objectives, it promotes the conservation and restoration of native plant diversity (BLM 2017) and so administers many ongoing restoration programmes on BLM lands. It has also developed a national seed strategy to provide support and information for seed collectors, farmers, seed growers and restorationists, so that seed of appropriate quality and quantities are available for restoration on BLM-managed and leased lands (Shaw *et al.* 2005).

While these various government conservation programmes have been achieved through strong leadership and the development of coordinated policy frameworks (Szentandrasi *et al.* 1995), there are future challenges for the CRP and similar acreage retirement programmes because of uncertainty about the degree to which future administrations will continue to support farm bill programmes (Blumenauer 2017). There has also been concern about the CRP in some rural communities where demand for products like fuel and chemicals have reduced due to lowering of conventional farm production (Martin *et al.* 1988; Putnam 2012). There is also pressure to maintain farmer support for farm rental programmes in the face of growing market demand for increased farm production driven by higher commodity prices (Wu & Weber 2012). Hellerstein and Scott (2011) highlighted this point in relation to increased use of ethanol creating the need for more, not less, corn. Rental programmes may have to offer farmers higher rental rates to maintain enrolment targets, which may be politically difficult to achieve in a constrained budgetary climate (Secchi & Babcock 2007).

Despite these challenges, at the time of my tour, CRP and similar government-administered farm rental programmes were viewed by growers and restorationists as major market drivers. They had also created the opportunity to utilise part of the agricultural footprint for conservation allowing enrolled farmers to balance the stewardship of nature with meeting their agricultural production and economic goals.

Roadside restoration

There are over 6 million km of road spanning the continental United States and 29 million ha of roadside landscaping (Quarles 2003). Travelling north from Houston, Texas, to visit the Lady Bird Johnson Wildflower Centre, Austin, I noted regular long stretches of highway where wildflowers flowered in profusion along the roadsides and central verges. Given their presence also seemed intentional (rather than as extensive roadside remnants), I dared not believe these were native wildflowers as such a thing was unthinkable in Australia. Upon arrival at the LBJ Wildflower Centre (a magnificent facility dedicated to community education and research focused on Texan plant communities), I commented on this experience and was informed that these had indeed been plantings of Texan wildflowers. I learnt this remarkable landscaping was not uncommon in the state and more broadly across the United States (I saw similar roadsides in most states I visited). I also learnt such programmes were the legacy of strong leadership and proactive legislation commencing in the 1960s (Anonymous 2002). The roadside wildflower 'movement' was in large part initiated through the passion and advocacy of Lady Bird Johnson, wife of former USA President Lyndon Johnson. She and her husband (residents of Texas) were known to have been dismayed by the condition of roadsides on their long and frequent drives between Texas and Washington DC. After much public advocacy and lobbying by his wife, President Johnson introduced the Highway Beautification Act of 1965, which set in place legislation to limit rampart billboard signage and provided funding for roadside rubbish removal and native landscaping on federally funded highways.

This leadership from the highest office set the stage for other 'native flora friendly' legislation from both federal and state governments in the years that followed. Important milestones were the 1987 Surface Transportation and Uniform Relocation Assistance Act (under President Ronald Reagan), which included a requirement for road agencies to fund the planting of native wildflowers using 1% of the total highway landscaping budget. In 1994, the Memorandum on Environmentally Beneficial Landscaping (signed into law by President Clinton) established clear directions for Departments of Transport (DOTs) to utilise local native species in roadside landscaping (Tinsley *et al.* 2006). These pieces of legislation created huge demand for native seed from DOTs. For example, in 2006 Tinsley *et al.* noted that the Texas DOT used 11.7 tonnes per year of wildflower seed in its 484,000-km vegetative road management programme. Barton and Garcia (2015) commented this figure had increased to an amount of 27 tonnes per year seven years later.

Native plants are viewed as beneficial by DOTs for a variety of reasons. Importantly, many recognise that road corridors represent among the largest pieces of continuous land available for biodiversity habitat if planted to native vegetation (MacDonagh & Hallyn 2010; Sorvig 2011; Conniff 2013; Barton & Garcia 2015). This thinking complements schemes such as the Monarch Butterfly Program which now sees milkweed planted within roadside landscaping to create food resources for a distinctive insect species on its annual migration across the continental USA.

Departments of Transport also recognised that native wildflowers and grasses can provide an important functional role on roadsides. These benefits include stabilising verges and reducing ongoing vegetation maintenance costs (Jacobson *et al.* 1990; Quarles 2003; Tinsley *et al.* 2006; Lulow 2008; Sorvig 2011). The Minnesota DOT publication, *Native Seed Mix Designs for Roadsides* (MacDonagh & Hallyn 2010), lists a range of functional and social goals for roadside management, including maintaining visibility for travellers, withstanding harsh climatic conditions, minimising maintenance costs, reducing soil erosion, improving water quality (by assisting in the infiltration of storm-water runoff) and for maintaining good public relations. MacDonagh and

Hallyn (2010) commented that 'research and experience have shown that native grasslands are especially well suited to accomplish these goals'.

Beyond biodiversity and functional outcomes, roadside wildflower plantings are valued for their tourism potential (or 'wildflower tourism' as it was described to me by several people). States including both North and South Carolina, Iowa, Kansas, Minnesota, Missouri, Oklahoma, Oregon and Texas have all established individual wildflower programmes with a key goal of attracting tourists (Anonymous 2002). For example, North Carolina's Wildflower Program (initiated in 1985) raises funds from the sale of personalised licence plates to support the planting of wildflowers on its roadsides. A North Carolina DOT publication, *Wildflowers on North Carolina Roadsides* (North Carolina DOT 2017), comments that tourism provides US$18 billion annually to the state's economy, and because most visitors arrive by vehicle, the wildflower programme is viewed as important to helping make the state an appealing tourist destination. In central Texas, I drove for several hours along a breathtaking wildflower trail west of Austin (Fig. 8), which at that time of the year attracted tourists from across the country. I was told it was viewed by the community as an important contributor to the local economies of towns along its way during the flowering season.

By making the vegetated spaces on USA road corridors available for the establishment of native herbaceous species, Americans have created a huge footprint for native biota. Their DOTs have also benefited from the functional and amenity attributes offered by these species. The demand for seed and plants created by these roadside programmes meant that the growers and restorationists I spoke to commonly nominated state DOTs as their second most significant market. There are few similar initiatives in Australia, despite our almost 800,000-km road system representing a potential canvas for the restoration of native herbaceous vegetation (with all the associated benefits seen in the United States).

Natives in landscaped environments

I learnt from those I interviewed how, over many decades, the seed and restoration sectors had developed considerable expertise and capacity. Large markets such as farm rental and DOT programmes had helped to create efficient, effective and innovative businesses able to offer a range of products at competitive prices and able to explore and develop new markets in novel areas. One such area, the urban landscaping and landscape design markets, had developed very strongly over recent decades. USA landscape architects and city designers are increasingly embracing the use of native ground-layer species. These emerging urban-based markets are creating large demand for plants and seed. I toured several plant nurseries producing several million plants per year for their local urban markets. This market often generated strong collaboration between the growers and architectural design teams. Many projects were for large private organisations (such as Walmart or Coca Cola) undertaken to create native landscaping around their retail or office developments to meet amenity and social-licence goals. Other works I learnt of were undertaken for municipal councils or similar public agencies (such as hospitals and libraries) and these were also often large in scale requiring many millions of plants from a diverse range of species (e.g. Lake Michigan foreshore, and Patriot Lake, Memphis, Tennessee).

One restoration practitioner described 'the increasing trend in sustainable energy' taking place in his state of Minnesota. Here, tracts of rural land were increasingly being converted to use for large solar arrays to provide clean energy for surrounding communities. He noted how, in some instances, local authorities had negotiated with solar developers to create additional biodiversity outcomes in association with solar arrays. This was being achieved by seeding native grasses and wildflowers under the solar infrastructure. This type of action not only increased plant diversity but also created habitat for birds and pollinator species. Such programmes also create flow-on benefits for the seed and restoration sectors by creating demand for services.

While this increasing use of native herbaceous flora in USA urban landscapes and infrastructure programmes was typically undertaken for functional and amenity reasons, most people recognised that these works also created

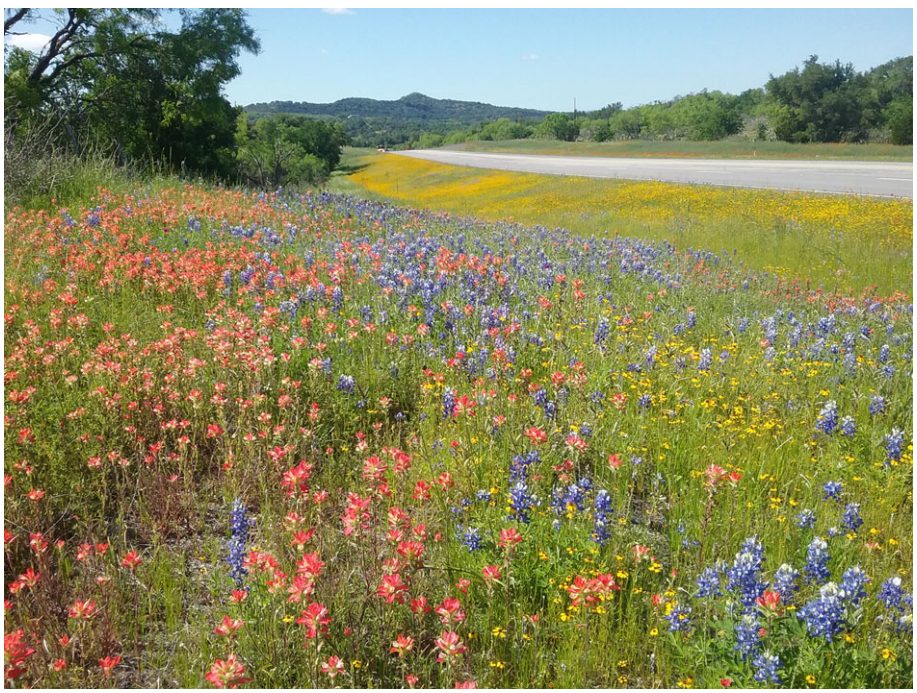

Figure 8. Stunning wildflower roadside, Texas, USA. (Photo Paul Gibson-Roy)

opportunities for preserving native biota in built environments. In Australia's cityscapes or infrastructure works, in contrast, there is very little integration of native ground-layer species apart from the use of a small range of grasses and grass-like species. This is primarily because seed and plants are seldom available from a broad range of species at prices that are competitive with commonly grown exotic species. This would not necessarily be the case if a large restoration sector existed.

Ecological restoration cases

I was taken to see many grassland or grassy woodland (i.e. savanna) restoration projects during my tour. These ranged in composition, complexity and structure depending on the types of goals (functional, diversity, amenity and combinations thereof) and the sources and degrees of funding (e.g. farm rental, development offset, roadside programmes, private/philanthropic and combinations thereof). All of these, however, represented effectively restored native vegetation. Some were relatively small (<20 ha) and others were quite vast (up to 5000 ha). I visited some that used modest numbers of native grass species to create grazing fodder and/or to stabilise soils (e.g. Elk Creek, Missouri; Rockford, Illinois) and others that installed hundreds of species to restore highly complex grassy communities (e.g. Kankakee Sands, Indiana; Franklin Grove, Illinois). Several included threatened species reintroductions as sub-components of overall programmes to great effect (e.g. Golden Paintbrush, *Castilleja levisecta*, at William L. Finley National Wildlife Refuge, Oregon; Fig. 9). The fundamental techniques used to restore grassy communities in the United States were not dissimilar to those in Australia. As in Australia, weeds were a primary focus for practitioners, whether preparing a site or during establishment or longer-term management. Because access to seed for restoration is not the issue it is in Australia (as USA practitioners have access to appropriate quantities and quality of seed), USA restorationists could focus on site preparation, planting techniques and management.

Figure 9. Threatened Golden Paintbrush (*Castilleja levisecta*) reintroduced into a species-rich ecological restoration, Oregon, USA. (Photo Paul Gibson-Roy)

As in Australia, growers and restorationists in the United States are required to obtain special permits to use federal or state-listed threatened and endangered species in restorations (e.g. see http://www.dnr.state.mn.us/nhnrp/endangered_permits.html). I was informed by one grower this usually meant they could only produce seed or plants from a threatened species for set purposes (i.e. a species-specific programme) and not for general sale. Another described how threatened species regulations were unique to each state, which could mean the same species may be protected on one side of a state line and not on the other (where it could be collected and grown in cultivation for sale). From a grower's perspective, for the reasons mentioned above and because some rare species had proved difficult to grow in cultivation, the seed of threatened species was much more expensive than seed of most common natives. Because of these cost considerations, another grower told me he recommended that clients install threatened species as containerised stock as a much less expensive option than using seed (and one that still allowed programmes to establish viable plant populations).

For direct seeding, most practitioners used farm-style seeding equipment such as Truax (4300 Quebec Avenue North New Hope, MN 55428) or Great Plains (1525 E. North Street Salina, KS 67401) seeders or ag-lime spreaders. I was interested to hear how in states with cold winters, seed was spread or sown in late autumn and left to cool stratify over winter (often under snow); and with dormancy relieved, emerged in spring. Some described a technique called freeze-thaw seeding. Here seed was simply broadcast on to fallow soil where the overnight freezing and daytime thawing of ground drew seed into the soil profile.

Most restoration practitioners I spoke to undertook their restorations on fields that had been in agricultural production (especially corn) for periods of up to 10 years (such as CRP restorations). They saw this site history as beneficial because the long-term herbicide management of weeds in those crops meant (in theory) these fields were relatively weed-free at the time of restoration, allowing the native species to establish in the absence of strong competition. Post-installation, weeds were generally tolerated as minor components of restorations where they did not dominate. Where they did, and the cost of long-term management was

prohibitive, I was told by practitioners it was not uncommon to sacrifice work already done by putting restoration fields 'back to corn' for a further period. This typically occurred when restorations had been initiated before a field had been under corn for long enough.

No effort was made to limit soil nutrients on these agricultural fields prior to seeding (as is often the case in Australia). It was explained to me that USA soils are not nutrient-poor in the same way as Australian soils, and so their flora was not disadvantaged by higher nutrient conditions (created by adding fertiliser) in the way that comparable Australian flora would be. I noted that the USA herbaceous flora was typically much taller and more competitive than its Australian counterpart, and this was another factor in enabling it to compete more effectively with non-native species.

I was informed that longer-term management of restoration sites focused on similar factors dealt with by Australian restorationists. This included controlling biomass accumulation, weed ingress, excess tree regrowth (particularly from oaks, *Quercus* spp.), overgrazing, vandalism – the list goes on. However, the difference between the Australian and USA situation is that, with many USA restorations established through adequately funded programmes, USA operators have the planning and budget to support long-term management – wherever and whatever challenges present. This is contrary to the Australian experience where a lack of support for long-term management is something most managers of native grasslands and grassy woodlands accept as a given.

In the end, what impressed me most about the restoration practitioners I met was their quiet confidence in their ability to re-build native vegetation. Even noting that some restoration projects failed to meet expectations, these people had a firm belief and confidence in a sector that had the financial and on-ground resources, knowledge and systems to achieve success at scale. This was demonstrated by most of the restoration sites I visited and indeed in the many millions of hectares of restoration undertaken nationally through programmes such as farm rental or DOT schemes. I was envious of their confidence, because in the absence of similar markets for restoration, it is not something I feel will be a feature of the Australian sector for the foreseeable future.

Conclusions

I had not expected to encounter such a well-established, structured and capable restoration or seed-growing sector as I did in the United States. Nor had I expected to be received with such generosity of spirit by those lovely people whom I met. Many things I saw and learnt about could be applied to varying degrees here in Australia where they would undoubtedly improve the manner and scale at which we restore our ground-layer communities. I have gone into considerable detail on many aspects of my tour, not to present a 'how to' of any sort, but so those who have knowledge of the Australian sector can appreciate just how profoundly different things are between the two countries. We should not feel discouraged by their success, rather we should learn from the knowledge of how their opportunities were created and use it to direct our sector on to a different path to that we now tread.

I do not want to overly idolise the USA situation and certainly do not suggest that all I viewed or learnt of was perfect. I saw much but by no means all facets of the sector. Many of the funding programmes I've written about have both limitations and strengths. It is also certain that some growers are more effective than others and that while many restoration sites are great successes, others fail. However, it is undeniable that remarkable things have been achieved in the United States in relation to the restoration of grassy ecosystems. The degree to which these outcomes have been influenced by inspirational people such as Lady Bird Johnson and through the political leadership shown by successive USA presidents (and other politicians) on both sides are surely important factors.

As previously stated, the Americans I met were 'believers'. I was not exposed to the 'doubt' that I commonly experience in Australia where questions such as 'why don't our restoration projects work?' are commonly debated topics at forums (e.g. the *Restore, Regenerate, Revegetate* conference held at UNE, Armidale, NSW, in February 2017). Here, we doubt whether it is possible to restore diverse native landscapes, whereas in the United States, it was my impression that it is simply assumed that it can (and should) be done (and evidence of outcomes supported that view). Belief of this magnitude is a powerful catalyst for progress and one we sorely need.

Decisive government action (as has been displayed in the United States) will be critical if we are to move from the current situation of continued loss. Whelan (2002) noted that if governments create the right incentives, markets can achieve remarkable things. This is what I think has occurred in the United States. Appropriate legislation (such as farm bills and DOT directives) has created powerful incentives for farmers and landscape managers to implement restoration on their lands. This huge market fostered and enabled the USA restoration sector to develop and eventually achieve remarkable things. Without that government leadership, I find it hard to believe I would have found what I did. Rather, I suspect I would have found something that would have more resembled the situation we have in Australia today.

It was clear to me that the USA seed and restoration sectors and markets are complex and beyond full comprehension of a single fellowship. However, I felt some clear features coalesce as factors underpinning the successes I witnessed. These are

- Individuals with great passion and vision helped shape the USA people's perception and acceptance of the need to restore its native flora
- Political leadership (to the highest level) promoted legislative and regulatory processes that created impetus and support for the uptake and implementation of those ideals at a national scale
- Implementation at national scale fuelled the development of a viable, innovative and forward-thinking sector

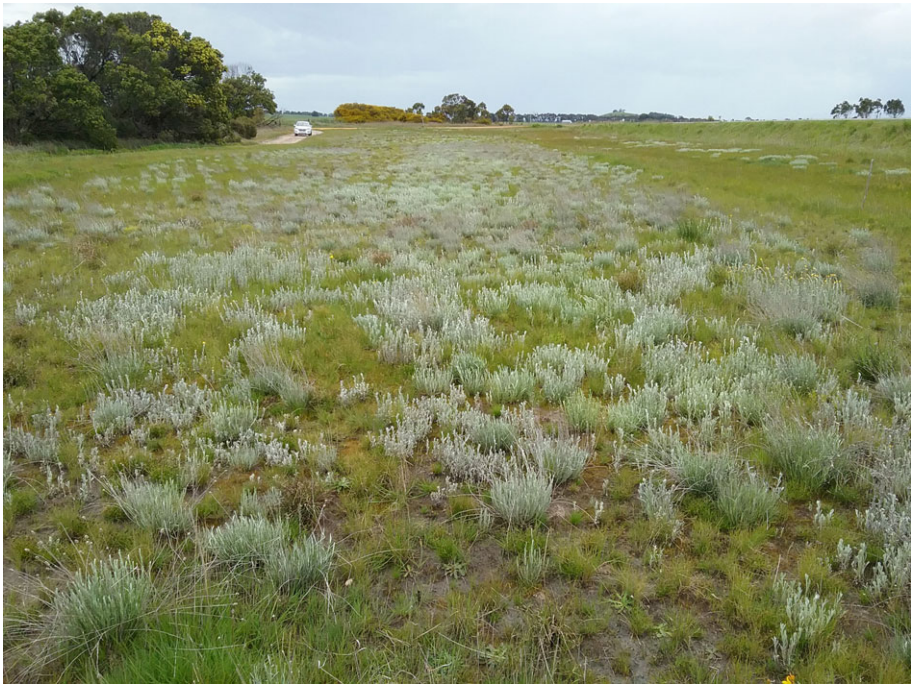

Figure 10. An established roadside grassland restoration in early spring 2017, Wickliffe, Victoria, Australia. (Photo Paul Gibson-Roy)

- This culture of success and belief is taking the sector into exciting new areas of opportunity.

I feel in Australia we too often look to government departments for grand leadership and support. However, it is unfair to expect such agencies to offer grand vision when their role is to implement and administer government policy. Grand vision must first come from our elected representatives. I believe we need prime ministers, premiers, governors and the like to take on a true leadership role in forming policy and legislation that supports the preservation of native species through restoration. But our leaders cannot be expected to have the background or knowledge to form grand visions if they are not informed and inspired by others. For this task, we need passionate and articulate advocates from research and practice to inform, guide and challenge leaders to use their positions to create transformative change. It will require researchers to focus less on 'publication output' and more on advocacy; it will require practitioners to focus less on whose methods are 'best practice' and more on building our sector. None of this will be easy or straightforward – but it has been achieved in the United States.

There is no technical reason why in Australia we must watch as our native grassy ecosystems disappear forever. My own work has shown they can be rebuilt on farms, roadsides and in urban areas (Gibson-Roy & McDonald 2014). Indeed, while I finalised this manuscript, I also spent several weeks touring and monitoring many old Victorian grassy groundcover restoration project sites (Gibson-Roy *et al.* 2010). These are now approaching 15 years in age and I found most comparable in quality and condition to the best remnant grasslands I know (Fig. 10). At the same time, I found precious remnants maddeningly degrading seemingly through neglect and inertia. Standing as I did during these surveys in beautiful, resilient, functional and species-rich restoration sites, I found it hard to fathom why some in our sector are so resistant to the notion of 'redemption through restoration'. Why does our sector not have the confidence to embrace these approaches? Why do we not offer farmers the incentives they need to return native grassy ecosystems to part of their holdings? Why do we not expect our road agencies to replace roadsides covered in exotics with natives? Why is our native ground-flora not more commonly integrated into our urban landscapes? The feasibility and benefits of all these actions have been demonstrated in the United States – why not here?

As a sector, we must dispense with doubt and embrace belief. We can no longer afford to create the illusion of activity (as has been the case for decades), when there is so little progress and so much loss. We must put our shoulders to the wheel and grow seed and restore complex vegetation to create change for the good. We must stop fearing failure. Where it occurs, we can learn and move forward. All this can be done. And meanwhile, across the Pacific in the United States, year on year, seemingly astronomical quantities of native seed and plants are distributed across the broad American landscape, creating ever increasing environments of diverse, functional and resilient native vegetation. Surely our goal must be to strive for the day when a similar thing can be written about Australia.

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