PROJECT PHOENIX

HOW DOES THE NATIVE SEED MARKET WORK?

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Across all of our Project Phoenix activities and actions we pay respect to the Traditional Owners and Custodians of the lands and waters on which we work. We honour the resilience and continuing connection to country, culture and community of all Aboriginal and Torres Strait Islander people across Australia. We recognise the decisions we make today will impact the lives of generations to come.

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1 PREFACE

1.1 Comment

This report relies on the insights and understandings gleaned from extensive discussions with people involved in the native seed sector in Australia. The broad methodology has been to survey a diversity of perspectives and different parts of the native seed sector from different parts of Australia through informal communication. Due to COVID-19, discussions were not held in person but instead through phone calls, video calls and conference calls. These calls served as a critical component of the research. An indicative list of those contacted is attached, several of whom were contacted on multiple occasions for greater detail.

A combination of top down and bottom up research, using both secondary and primary resources was utilised, along with the 2020 *Australian Native Seed Survey Report*[1] that provided a recent snapshot of the sector as a backdrop.

Relying on extensive academic literature and engaging in follow up discussions with the authors of the research, this report attempts to ensure pertinent scientific perspectives are incorporated.

Alongside such academic perspectives, extensive discussions with a cross-section of operators in the sector have helped to ensure the information or evidence for thinking is grounded in fact and experience, rather than supposition. Research from abroad and in-depth discussions with native seed growers, purchasers and policy makers internationally were also undertaken.

One similarity across the country is that the vast majority of seed collected or grown is done so for the mining sector. This sector's requirements have continued to grow, and without the mining sector, the commercial native seed industry today would be significantly smaller. The way in which the mining sector has been integral in driving commercial seed collection and how its role may evolve is thought to be pertinent to the seed sector's future.

1.2 Issues and assumptions

One of the notable challenges in analysing the native seed sector is the difficulty of finding data where:

- no clear forward expectation is provided by government for restoration project seed requirements — funding is variable and uncoordinated
- mining sector demand schedule is generally not publicised.

The native seed sector's collectors and merchants are famously secretive, small and location specific, and as such it is not readily possible to collect data on activity in the sector without creating concerns around sharing commercial and confidential information with competitors in the sector. Data revealing the extent to which shortfalls exist in the supply are therefore not available.

[1] Hancock *et al.* 2020.

From research into the native seed sector, stretching back over 20 years, the issues affecting the market, such as the lack of visibility on demand, remain the same. Market failures also emerge as a function of the secrecy on prices in the sector.

An underlying assumption in the report is the importance of the trading system for seed. This assumption relies on historical interpretations from past seed surveys which revealed that on many occasions, supply shortfalls were avoidable. The systems to communicate seed demand need to sync with collectors and the natural systems on which we depend for seed. Seed collection requires considerable planning and luck with weather. Seed orders are also highly specific and not widely substitutable.

The absence of a public mechanism to communicate gaps and facilitate syncing demand and supply through prices has precluded the emergence of efficient market processes from taking hold and addressing the issues on a for-profit basis. This report assumes that were such market processes to be activated, they would significantly alleviate the constraints on seed and make salient the opportunities that exist for investment in the sector. Lack of transparency limits the capacity of the system to respond.

For this reason, among others, this report is not a statistical survey of the native seed sector, nor a quantitative modelling of the seed sector's commercial capacity, but instead an investigation of the economic, regulatory and institutional factors shaping the sector's productivity and affecting its ability to supply native seed for revegetation projects.

Through consultation and conversations with sector participants, an array of information has been gleaned to construct a mosaic of the sector's history and current state. There are definite limits to making generalisations on the sector; there is such a diversity of seed varieties and such a diversity of ecological regions that experiences differ significantly.

At this stage, detailed data on the availability of seed or stands in the wild is not available. Spatial analysis from satellite photos promises to change things in the future. The Habitat Condition Assessment System (HCAS) will provide much needed insight on where pinch points exist in the availability of supply on a biophysical level. Subsequent work with this system will be required to ensure the sector is in a position to address the public interest requirement maintaining and increasing our native biodiversity.

The secular trend worldwide is for a growth in the demand for native seed, not only in volume but also in diversity, driven not only by the need to achieve species-rich ecological gain but also by the need to increase diversity of species available to ensure establishment and persistence in the face of climate change. An additional source of demand for seed has been for rehabilitation of areas affected by environmental events, such as fires. A large and growing proportion of seed in the United States (US) is dedicated to projects rehabilitating fire affected land to prevent weeds from establishing.

2 EXECUTIVE SUMMARY

This report represents a part of a larger project to address capacity constraints of the native seed sector and improve its efficiency and capability to underwrite critical ecological restoration within Australia. There is incredible diversity of seed varieties across landscapes and some are in chronic shortage, putting a chokehold on the manner and rate with which habitat restoration can be undertaken to maintain ecological biodiversity. Without an adequate volume, direct seeding is not feasible, and where direct seeding is not an option, the capacity to arrest and offset biodiversity loss is forfeited.

The 2019–20 Black Summer bushfires highlighted the vulnerability to source seed after environmental shocks and have helped make salient the challenge that lies in scaling an increase in both the diversity and volume of seed and will hopefully be a catalyst for improving the responsiveness and resilience of the system upon which we rely for the provision of seed for restoration. However, the fires were largely in areas where seed is either not required or where seed is not chronically scarce. Where extensive clearing has occurred on highly productive land for farming, the biophysical availability of seed for certain species and vegetation types is chronically limited. The quantities available in the wild are inadequate to allow for direct seeding projects, affecting the economic feasibility of repairing ecosystems in these needy landscapes.

Because different areas have different requirements for seed, no one generalisation fits all. Yet, native seed is a *sine qua non* for ecological restoration, a fundamental building block. Unbeknownst to many, there is a range of complexities that can lead to failure in the capacity of the current market to provide seed, aside from overcoming chronic shortages in the wild. This report provides a review of the market and supply chain for native seed and discusses the market failures along with proposing practical actions and steps to redress these failings.

For some obvious reasons, there's considerable opacity in the operations and pricing of native seed. This may be a satisfactory state of affairs for a number of players in the sector since it may reduce competition, but a lack of information on prices fundamentally limits the extent to which we can economically solve the problem of limited resources as a society. It introduces a market failure.

Establishing a public centralised seed market to coordinate and reveal orders and price information at the ecoregional level is a key recommendation of this report. A well-designed market mechanism will do much to attract the level of investment required in the sector by distributing the critical kind of information that enables informed investment decision making. Developing a mechanism to incentivise trade will provide confidence to investors or other actors to engage in the sector. Greater participation will over time reduce inefficiencies and unlock underperforming land, labour and capital assets to more productive use.

The vast majority of landholders in this country, understandably but unfortunately, do not yet know what native vegetation they have nor the tradable value of its seed. When landholders allow seed collection on their property for shrubs and trees, they more often than not go uncompensated. Without any incentive, landholders are unlikely to invite seed collectors to collect seed from their properties but, we argue, such an invitation is just what is required if we are to better utilise the existing wild resources.

Presently, many landholders are unaware they could benefit by engaging seed collectors to collect seed from their native vegetation; they ecosystem service they are providing goes unremunerated.

The idiosyncratic nature of many native seeds, being as they are often locationally specific, means that there's a greater need for wider participation in the sector at the local level, especially among landholders. Good seed collectors require botanical expertise and exquisite spatial and temporal awareness of where to pick what when. Increased codification of such tacit knowledge could combine with citizen science to document where to find sought after species.

While greater coordination may not overcome the supply constraints for all species of seed, it is believed that greater coordination of existing seed resources will reveal where the market opportunities exist for alternative seed production measures, such as seed production areas.

The mining sector, being the largest most significant and organised industry relying on the native seed sector, can help use its market 'pull' through procurement to establish best practice and support a model standard for how seed can best be collected and transacted.

This report proposes that through coordination with state minerals councils and resources regulators, some key organisations could be encouraged to pilot a procurement auction for seed through a centralised marketplace for a given ecological region.

Working with market design principles, the market could drive more efficiency in transactions, and legitimacy in the market while simultaneously generating the public good of price information. A transparent market could not only broaden the economic realisation of seed's role as an ecosystem service but also incentivise sellers to demonstrate sound collection conventions and proper communication of seed provenance.

The seed supply industry lacks clear market-based signals in the form of forecasting information that has significantly impeded private investment in seed supply for revegetation. By giving clear information of wait times for seed and prices, planning both from a supplier and purchaser side of the market could be improved.

Revegetation is expected to remain a key component of most regional and catchment plans and the scale of revegetation work required will in certain regions create unachievable demands on existing seed supply systems but without such information being made public, coordination for investment to meet the demand for appropriate native seed is unlikely to emerge.

Recognising the power of incentives to drive action and solve problems in clever ways, this report advocates leveraging market design methodologies and improved network coordination among key bodies to make a steep improvement in the native seed sector's capacity to address demand. Enabling clearer communication of seed requirements well in advance is critical to reducing risk and inviting investment into the sector.

Confidence is critical to the market place. Publicly accessible figures on the demand and supply of native seed, publication of successful commercial native seed ventures and projects, consumer feedback and auditing and monitoring of seed supply operations are all components of a system that builds capacity and confidence.

The capacity of regions and institutions to adequately assess seed demand and supply requirements needs to be assured. Unlike other commodities such as fertiliser and fencing materials, native plant seed is a highly variable resource with specific applications and capabilities. It is the product of natural processes and cannot be manufactured in larger quantities at will. As such, there's less room for error in ensuring seed orders are made with enough time. Seed planning is a critical pre-requisite of restoration planning and restoration success.

Once a centralised market is established, it would be easier to drive greater participation by other organisations such as government bodies (e.g. NRMs, or infrastructure services) to participate in the market.

To help remove impediments to cooperation and partnership development, a peak body or broadly based national association to represent the interests of the native seed industry could also assist in driving improvements in the coordination of industry financial interests. Aside from helping coordinate investment in the sector, a peak body could provide the leadership to:

- consult on and establish a quality assurance system
- document and publish marketplace development and activity
- assist with policy priorities for areas unable to attract investment interest
- coordinate industry resources and accredit training.

Improved native seed management for revegetation firstly requires a significant increase in awareness at the policy level and some form of national leadership. It then needs a coordinated and collaborative approach from all levels of government, industry and the broader community. It will also require a well-defined market that is markedly different from that operating today.

3 PURPOSE

This report seeks to:

- identify and address the economic factors affecting the capacity of the native seed sector and generating supply chain risk in the availability of native seed and plant material for large scale commercial and/or non-commercial seeding projects with a view to guiding future investment and funding strategies in developing sustainable sector outcomes
- review mining sector demand for native seed with a view to understanding more about the market for native seed and how it functions and what steps can be taken to improve its efficiency
- introduce a progressive set of strategies over the short and longer term to raise the sector's productivity either through investments in science (public and private) to fill knowledge gaps or by undertaking steps to improve market efficiency.

As information emerges subsequent to the implementation of the strategies, investment opportunities should become evident.

The strategies proposed tie back to **Strategic Goals 3, 4 and 5 of Australia's National Vegetation Framework (NVF)** which guide government, the community and the private sector in vegetation management across the nation. The five goals of Australia's National Vegetation Framework (NVF) are to:

1. Increase the national extent and connectivity of native vegetation
2. Maintain and improve the condition and function of native vegetation
3. **Maximise the native vegetation benefits of ecosystem service markets**
4. **Build capacity to understand, value and manage native vegetation**
5. **Advance the engagement and inclusion of Indigenous peoples in management of native vegetation**

This report is a first pass at using a lens from economic theory to understand the dynamics affecting the commercial availability of native seed in Australia and makes several observations which cannot be fully substantiated because of insufficient data. It relies largely on economic arguments to develop a range of policy proposals.

Through extensive research of peer-reviewed journals, government publications, and in-depth discussions with restoration practitioners, seed collectors, seed merchants, seed growers, bureaucrats, ecologists, economists, lawyers and botanists in Australia and abroad, a mosaic approach has been employed to build up an understanding of the sector's dynamics.

A working assumption in this report is that notwithstanding significant differences in vegetation, Australia can draw on the US's decades-long experience in developing commercial capacity in native seed and explore steps we might look to replicate (e.g. seed zones) or avoid (e.g. cultivars). Some practices are readily transferable to Australia. There are also practices from other industry sectors that are in part transferable to the native seed sector e.g. fisheries management, plantation timber.

The mining sector accounts for the greatest share of demand in seed sold commercially and is considered the prime mover in the sector and a mainstay for the majority of seed merchants. Because the demand from the government sector is so unpredictable and inconsistent, it provides less certainty from a business risk perspective for seed collectors or merchants to remain a going concern.

Lack of real-world data makes a study of the native seed industry using conventional statistical analysis difficult (Mock *et al.* 2016, p. 697). Significant data shortcomings prevent the possibility of developing any meaningful quantitative models of the sector at this point. A survey is proposed where, by surveying some key industry operators, we could develop a provisional industry sector model showing the functional relationship between the native seed industry and other industry sectors, such as mining and construction, by constructing an input-output table. Simulating the removal of the seed sector would give a sense of how vital the seed sector is to the nation's economic productivity.

It is believed a large part of the reason the sector is not larger or more widely recognised than it is, is because there is an incentive not to divulge or disclose information and instead keep it secret. A lack of market transaction data restricts how declarative we can be about the sector's financial economics and returns. By designing and piloting the proposed centralised market/exchange for seed, actual market data and behaviour will emerge with which we can iteratively test assumptions and fine-tune the market's efficiency. Such information will also provide a more meaningful and defensible base from which to model and develop longer-term policy options for the sector.

A core argument in this report is that information flows play a critical role in driving participation and efficiency in the market. Information helps efficiency (productivity) by reducing uncertainty for all participants, monetising latent assets, and increasing productive competition among both sellers and buyers.

A number of market failures that exist in the market for native seed are listed below (Table 1) and will be discussed throughout.

TABLE 1. MARKET FAILURES

MARKET FAILURE	EXAMPLE IN THE MARKET FOR NATIVE SEED
Informational asymmetries	• Demand requirement, especially from government projects, is not communicated with enough lead time to collect or grow seed supply. • Seed lots are not tested to an agreed standard so purchasing seed lots is a dice roll. There is no quality control in the market, nor certification system or purity testing required in the current market for seed. • Strategic misrepresentation — unsophisticated buyers may be sold seed by unscrupulous or untrained pickers only to discover it is not the seed they required or is of different provenance undermining confidence amongst buyers (organisations such as RIAWA are acting to address this). • No centrally formed standard price data precludes the process of assessing investment opportunities with expected rates of return. • Landholders are by and large unaware of the value of their permission to allow seed collectors to harvest seed from their remnants leading to probable misallocation of resources.
Monopolies	• Some collectors may have near-monopoly on some access to seed and may seek to corner the market.
Allocative efficiency	• Absence of a futures market. Contractual advance orders, which could support the establishment of seed production areas, are not occurring frustrating the ability of the sector to undertake capital expansion and address future and diverse requirements for native seed in an efficient manner.
Negative externalities	• Over-harvesting by inexperienced or unscrupulous operators: unlicensed operators not collecting in line with voluntary *FloraBank Guidelines*, the most recent significant achievement in structuring sustainability into the seed sector. • Findings from the *Australian Native Seed Survey Report* show that a significant proportion of seed sold is likely collected without a licence. Licensing is established to help with resource management. • The cost of the extraction of seed from remnants may exceed the sustainable rate and deplete the resource at a rate that exceeds its renewal rate or affects other ecosystem interactions e.g. bees, birds or other fauna seeking flowers or seeds. The actual cost of production is not reflected in the price of the seed.
Transaction costs	• Search costs involved in finding and coordinating buyers with sellers is high, sometimes resulting in substitution of species or no purchase • Information about what requirements are and who may have the capacity — and the licensed authority — to satisfy the requirements is not always available. The costs of pulling information together to facilitate trade are called a transaction cost.
Non-excludability	• Since the seed (ecosystem service) being derived from remnants being considered de facto open access, it leads to an under-investment in the maintenance of remnants because their asset values, as a function of their income, are being understated. The consequence is less incentive for owners to conserve or grow the resource.
Homogenous goods	• Seed batches are not fungible — quality varies and therefore price should also, but unless markers of certification or standards are made available prices may not reflect the correct value. The Bureau of Land Management (BLM) in the US uses metrics such as Pure Live Seed (PLS) to discern price information and a colour tagging system to discriminate provenance.

4 INTRODUCTION

Ecological restoration activity is growing worldwide. Commitments to restore degraded landscapes have been made across the globe by governments, companies and philanthropic foundations alike. Businesses are funding 'Nature-Based Solutions' (NBS) both in an effort to offset their carbon emissions or biodiversity impacts and maintain their social 'licence to operate' which is driving demand growth in the ecological restoration sector and those factor markets linked to it, such as the native seed sector.

While commitments to *proactive* restoration are being made, there is also an increased requirement for *reactive* restoration, brought about by environmental degradation following stochastic events such as fires or floods.[2]

The increasing incidence and intensity of these stochastic events, also including droughts, is increasing the need for restoration to maintain ecological resilience at the landscape level (Oldfield 2019, p. 380).

Notwithstanding the fact that Australia has a large proportion of its landscape adapted to fire, the impact, frequency and intensity of fires threatens some species and ecosystems creating knock-on ecological issues such as land erosion.[3] Reseeding is a key management practice to counter land degradation and disturbance in semi-arid ecosystems (Knutson *et al.* 2014).

To safeguard against environmental degradation and biodiversity loss, we need to ensure we have the capacity to restore or rehabilitate degraded areas. One of the key techniques we have to rehabilitate or restore degraded land is through native revegetation, yet the capacity to do so is fundamentally limited by the quantity and diversity of seed available. Reforestation of heavily degraded sites requires significant volumes of seed and should include rare, endemic and endangered species to maximise biodiversity and ensure ecological resilience.

[2] Proactive restoration efforts usually have a lead time for completion and are diverse in geographic location and scale, while reactive projects are unexpected or stochastic (random) in nature. Consequently, seed requirements for reactive projects are harder to accommodate.

[3] Some species such as Mountain Ash are known as 'obligate seeders' and can only regenerate from seed. If fires become too frequent obligate seeders won't have time to reach their sexual maturity and reproduce before being burnt, imperilling their genetic survival and possibly wildlife or organisms that interact with them. We need to improve our understanding of how recurrent fire impacts annual plants. Fire often leads to significant land erosion issues that require immediate attention.

Finding ways to improve availability of native seed through capacity building in the sector and improving market efficiency will require unprecedented levels of coordination between public and private, and the non-profit sectors. Leveraging economic incentives to increase stakeholder participation in environmental markets can be expected to generate greater productivity and support higher quality biodiversity and conservation outcomes through supporting improved resource management.

For Australia to benefit from the massive investments in nature-based solutions, it must ensure it has capacity in its native seed sector to provide the variety and volume of seed when and where it is required, otherwise some projects will not proceed. While we can generally rely on markets to signal opportunity to entrepreneurs and incentivise action, the pseudo-market for seed in Australia does not yet function as smoothly as others for reasons which will be explained in the chapters which follow.

Without developing institutions to enable a market to reveal information on the availability of seed, and signal opportunities for entrepreneurs, the threat of more projects being scuppered for want of seed will remain.

It is hoped this report will help policymakers recognise the urgency of ensuring adequate coordination among our ecologically diverse regions, and the remarkable opportunity we have to gain from ensuring we have adequate seed to supply NBS projects.

5 BACKGROUND

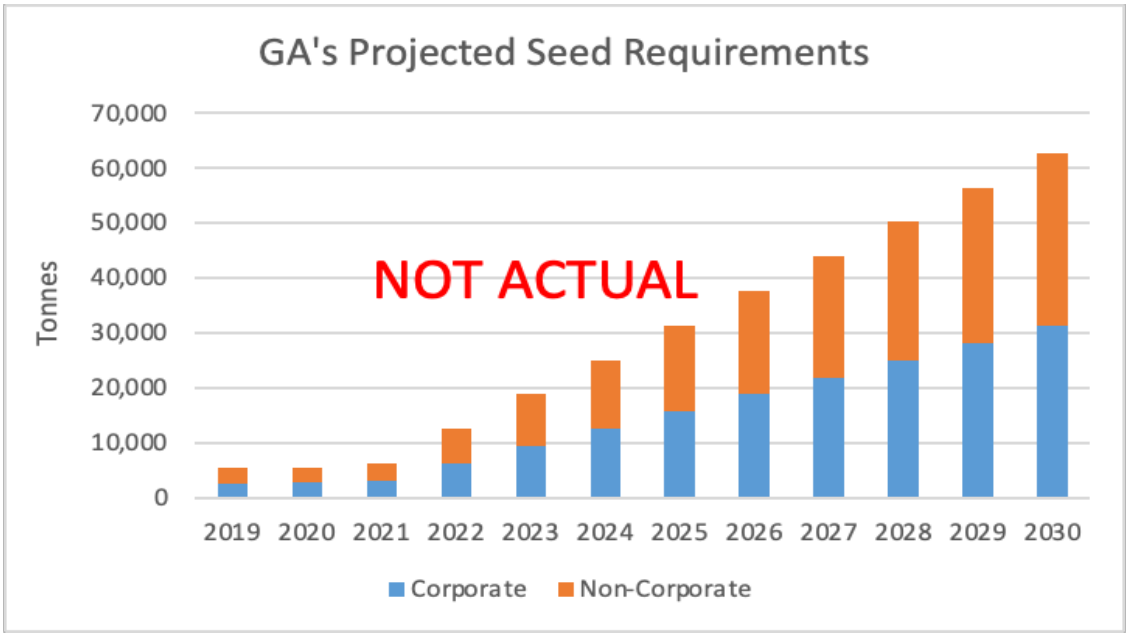
While the native seed sector or its supply chain is not tracked by the Australia Bureau of Statistics (ABS), it is recognised as a key factor for the broader ecological restoration sector and providing critical input for the mining sector during rehabilitation of mine sites closure. The mining sector is estimated to consume around 70–80 per cent of native seed collected or grown for commercial sale (Mortlock 2006; Broadhurst *et al.* 2015, p. 30).

The emergence of several investable environmental markets where income or 'offset' credits can be earned from trading with organisations willing to pay for them (e.g. for biodiversity or carbon bio-sequestration), whether to satisfy regulatory obligations or to provide a public good, is starting reveal the limit seed availability places on project feasibility.

Many factors drive growth in ecosystem markets. The growth in demand for assets that burnish green credentials and demonstrate commitment to non-financial metrics and social licence is growing rapidly and is widely publicised in annual reports and media releases.

According to Greening Australia, a significant increase in seed demand will be driven by that coming from nature-based solutions — the corporate sector seeking green offsets on a voluntary basis.

FIGURE 1. SAMPLE PROJECTED SEED REQUIREMENTS



Lack of native seed availability represents a significant threat to the development of Nature Based Solutions (NBS) or Natural Carbon Solutions (NCS) because without seed the projects cannot move ahead, and potential clients end up avoiding the space altogether and maybe investing their offset dollars offshore (cf. Telstra). A common refrain is that there is a desire to move away from purchasing offset projects abroad and 'importing credits', and instead purchasing offsets closer to a corporation's operations.

> *'Our experience has been that it is extremely difficult to purchase carbon offsets from projects located in Australia. This is something that needs to be addressed because what it says is that there are not enough projects contributing to a reduction in greenhouse emissions.'*
>
> Andy Penn — Telstra CEO — 2020

It has been said there has been a 'race to the bottom' in the ERF scheme with methods that generate cheaper carbon credits but are controversial ecologically. It is an order of magnitude more expensive to undertake a biodiverse carbon offset versus a project with a few species. Many companies are reportedly looking to invest in higher quality carbon offsets projects that 'tick other boxes', supporting say, biodiversity or social impact because these 'co-benefits' generally return non-financial rewards such as raising staff morale or improving the companies' standing as corporate citizens.

Environmental policies or regulations can change quickly, but to supply companies with a hedge to their compliance liabilities using nature-based solutions takes time to 'ramp up', especially where factor markets such as seed are capacity constrained.

As more large-scale compliance-driven restoration projects look to be undertaken, the importance of a rapidly functioning market for seed will become increasingly critical. Meanwhile, demand from the mining sector is expected to remain high with at least 30 mines of the major companies to be closed before 2045.

6 THE MINING SECTOR AND THE SEED SECTOR

Mining companies are obligated to rehabilitate disturbed land, yet not necessarily ecologically restore it. While ecological restoration might be a preferred objective, it is also clear this may be practically impossible at many mine sites and that less stringent targets will often be necessary, meaning that a lower level 'rehabilitation' is the more common practice (Glenn *et al.* 2014; Lamb *et al.* 2015, p. 187).

A review of some of the experiences of rehabilitating post-mining landscapes in Australia concluded that problems have arisen because of:

- the inherently difficult task of restoring ecosystems at highly modified mine sites
- institutional and management weaknesses and
- loose regulatory frameworks that allow a high level of company self-regulation (Lamb et al. 2015, p. 186).

Mining companies deposit a rehabilitation bond to the state resource regulator as a surety that can only be relinquished once the resources regulator is satisfied that the mine closure and rehabilitation conform with the original terms negotiated when the lease was established. In the past, this often simply meant rehabilitating to exotic pasture. However, over time, with rising expectations of the proper closure of mines, rehabilitation standards have increased. Rather than simply using exotic pastures as a cover crop, the complexity of rehabilitation projects and seed requirements has now changed significantly.

In an effort to improve rehabilitation outcomes, the New South Wales Resource Regulator recently developed a new policy for mines where progressive rehabilitation of the mining lease is required, in line with best practice. Progressive rehabilitation is recognised as more successful and cost effective because it more effectively maintains on-site seed and soil biota which leads to improved revegetation prospects.[4]

[4] Topsoil seed banks usually contains much of a site's nutrient resources as well as mycorrhizae and seeds and it is important to conserve these to facilitate plant establishment and growth. But long-term stockpiling (>6 months)

Further regulatory changes in New South Wales also provide an incentive to mining companies to go above and beyond rehabilitation and be rewarded 'offset' credits if they can show their restoration is responsible for 'additional' ecological gain. Consequently, demand for diversity of seed is likely to see some significant growth, especially as other states move to increase their expectations of mining corporations' efforts in restoration.

Some mining companies, especially in Western Australia, have been involved for some time in research collaborations with academic and public research bodies. This practical work has helped drive forward the science of successful restoration. Research has helped improve knowledge of how to germinate seed and rehabilitate successfully in the field, as well as restoration planning, and improving systems to ensure seed availability from seed ordering through to seed production. More mining companies have systems that allow them to pre-order seed by retaining seed collectors on rolling contracts which allows collectors to support seed requirements as and when required.

Seed collectors who provide much of the seed for mine site rehabilitation are networked and may work with a merchant who contracts to a mining company, or as a 'picker direct' who contracts with the mining company themselves.

The adoption of best practice within the mining sector is, however, uneven. Instances are reported where seed orders are made so late that inappropriate collection methods become incentivised.

When legitimate collectors decline an order, declaring an inability to satisfy a mining company's order in terms of volume (because only 10–20 per cent of seed should be collected from any one plant), it has created openings for illegitimate seed collectors to satisfy orders by chopping down plants altogether (taking 100 per cent of seed). Stories abound of seed being sold which is non-viable or of a completely different species. Mining companies, as with lots of other seed purchasers, typically have no recourse for seed purchases. Concerningly, however, mining companies just as often as not do not check to see whether a collector has a licence to operate.

This supply chain risk provides a significant downside to mining companies where a social licence to operate is growing in its importance. Minerals Councils exist at the state level and each has an environmental and sustainability committee. It is thought that through coordination of communication with these committees and the resource regulators, a centralised reputable marketplace could be scaled to support broader ambitions for landscape scale restoration projects and ensure that the seed which is sourced is genetically suitable and sourced sustainably.

results in a loss of mycorrhizae and native seed stores and often leads to an accumulation of weed species seeds (Lamb *et al.* 2015, p. 188).

While the mining sector creates significant demand and a market for the collection and production of a variety of native seeds, the positive 'spill-over effects' of this market are currently small because mining is generally concentrated in areas of land with little overlap on the general landscape that has been degraded by humans (Broadhurst *et al.* 2015, p. 30). A significant opportunity to generate spill-over lies in establishing more broadly some of the more sustainable and sound market conventions that have been adopted within the market sector. According to the last State of the Environment report, the proportion of land used by the mining sector represented only 2 per cent.

Australia has over 26,000 flowering plant species, many with several sub-species, unevenly distributed across a significant number of ecological regions (ecoregions). The regions in which carbon projects are undertaken, or biodiversity offsets are created, can and do vary as a function of a range of factors, not least land prices and seed availability.

The availability of seed in Australia's various ecoregions varies depending on how heavily cleared it has been in past decades. The status of seed availability by region (e.g. at the Natural Resource Management (NRM) level) is neither actively monitored nor reported. Such information, however, critically affects the eligibility of regions for nature-based solutions projects.

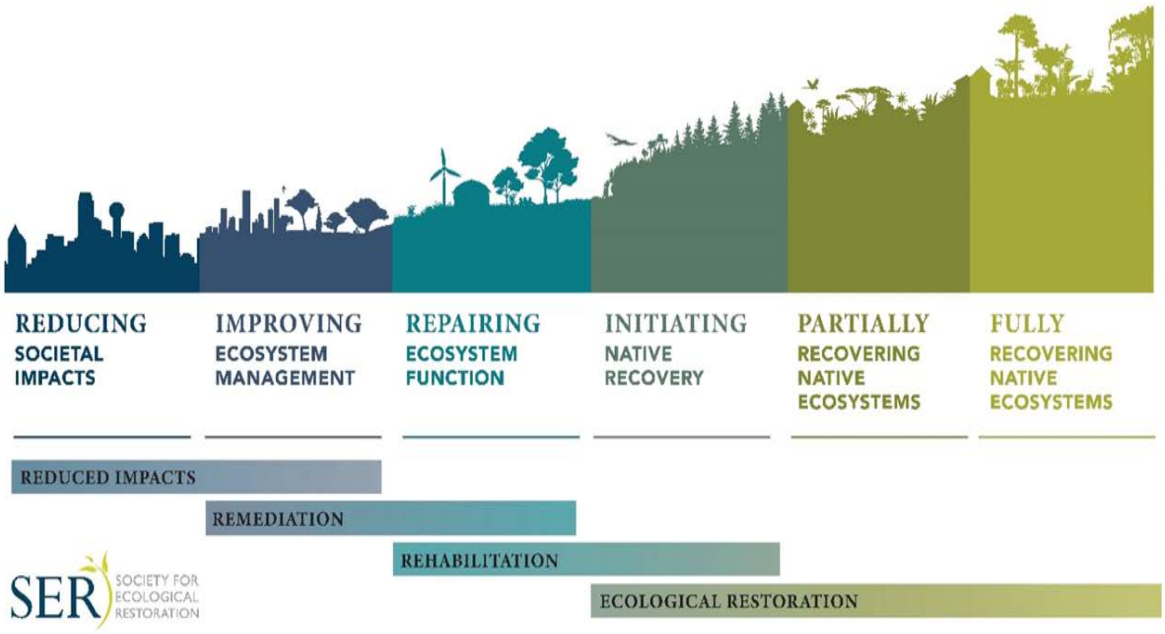
There are millions of hectares requiring restoration in Australia. Some of those are hectares will be restored under legal obligation, in the case of mining, while the remainder will rely largely on voluntary initiative.

Some back-of-the-envelope calculations for seed can made using estimates of the areas requiring rehabilitation or restoration for mining, carbon, ecological restoration commitments etc by governments and other organisations. For example, with commitments to restoration challenges at the landscape scale, the quantity of seed that will need to be sourced will dwarf current levels. Current volumes of seed in the market are estimated to be circa 6–10 tonnes annually which, as a rough guide, provides for around 11,000ha.

CSIRO modelling suggests that by 2030, around half a million hectares will be required for carbon projects using vegetation. This is vastly more revegetation than is happening at present. At this stage, many areas will not qualify for large scale native revegetation projects because the biophysical availability of native seed appropriate to the area is not available in adequate supply. Closer assessment of the capacity of various regions to accommodate large scale revegetation will be able to be estimated following the release of the Habitat Condition Assessment System (HCAS).[5]

[5] https://research.csiro.au/biodiversity-knowledge/projects/hcas/

FIGURE 2. THE RESTORATIVE CONTINUUM — IMPROVING BIODIVERSITY, ECOLOGICAL INTEGRITY AND ECOSYSTEM SERVICES



Source: Society for Ecological Restoration

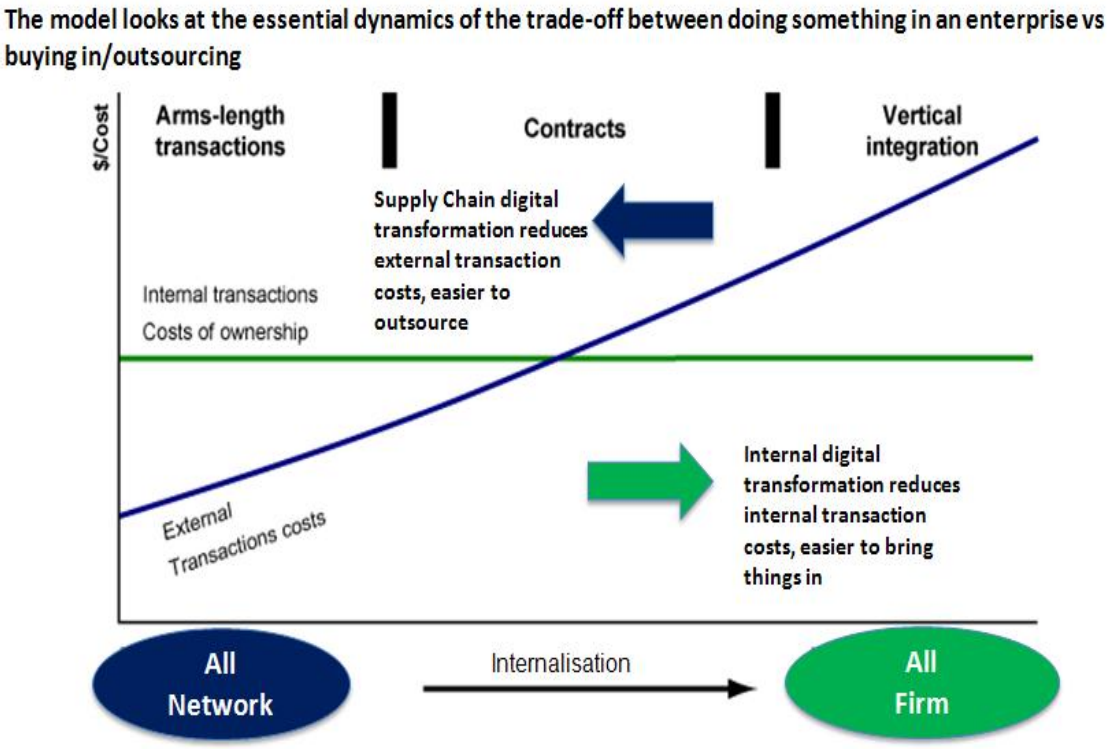
Even with adequate foresight of seed demand as is the case with mine operations, obtaining seed of desired species in the quantities required can be difficult (Lippitt *et al.* 1994; Mortlock 2000; Merritt & Dixon 2011, 2014; Tischew *et al.* 2011; Broadhurst *et al.* 2015; Kildisheva *et al.* 2016, p. 38). Some ecoregions have fewer remnants available than others, and others may simply have fewer seed collectors to contract.

It is often impossible to make a satisfactory collection from a given species population in a given year, especially if large quantities of seed are required, as collecting from wild populations is fraught with difficulty due to flowering, pollination and seed crops being spatially and temporally variable from year to year (Broadhurst *et al.* 2015, p. 30). Seed crops may be negligible owing to seasonal climatic factors, seed predation by insects and fauna, poor pollination, irregular seed set, over-harvesting, etc. It can be difficult to find seed of a certain species locally, and if found, there may be an insufficient quantity (Mortlock 1999). Certain species of Eucalypts may go several years without flowering.

Furthermore, the schedule of seed release for some plants is not periodic but triggered by events such as fire which may mean collectors could provide more value on a retainer in order to collect such serotinous seed.

The emergence of in-house collection, nurseries and seed production areas on mining sites reflects the presence of material transaction costs and inefficiencies for mining companies when engaging in the market for native seed. In economics, the costs of engaging in trade are defined as 'transaction costs', and such costs can be so substantial that they can erode the profits generated through trade, in which case buyers and sellers may withdraw from the market. When transaction costs are high, some tasks are more profitably handled internally because the costs of using the market exceed the costs of retaining those competencies in-house.

FIGURE 3. MARKET COSTS V IN-HOUSE COSTS



Apart from some NGOs and governments, few other organisations are in a financial position to develop seed production at scale and must rely on the market for native seed, regardless of the transaction costs involved. Improving the efficiency of the native seed market is, therefore, a critical priority for the government because unaddressed, it could continue to undermine economic activity and forfeit opportunities to repair ecologically degraded areas.

A golden rule of Australian revegetation practice has been: 'The Right Tree in the Right Place for the Right Reason'. The US Native Seed Strategy's motto is: 'The right seed, in the right place, at the right time'.

'Australia is a substantially market-based economy. The more efficiently markets function as an allocation mechanism in the economy — by setting prices that align demand and supply and facilitate exchange — the closer Australia can get to peak productivity.'

Productivity Commission

A range of unique attributes and transaction complexities characterise the market for native seed and make it a challenging transaction space. Australia has more than 26,000 flowering plants, and many of those species have a number of variants (or local adaptations) suited to certain environments but not to others. As such, many species cannot be purchased based on species type alone. With so many different markets for various seeds, the markets can suffer from thinness, where there are too few buyers and sellers leading to very volatile prices.

The limitation of the suitability or applicability in an environment reflects a distinct characteristic of the market for seed. It is more like a matching market. As the late Nobel Laureate of Economics, Alvin Roth, explained:

'A matching market is a market in which prices don't do all the work… matching markets are markets in which you can't just choose what you want even if you can afford it — you also have to be chosen.'

Most plant species are represented by an array of genetically variable populations, reflecting different adaptations to varying soils, climates and biotic factors across their geographic ranges.

An ecotype or variant is a genetic sub-category within a species of plant that is adapted to certain environmental conditions. If seed is not adapted to an area, the plant's establishment and longer-term survival will be in question. Provenance-specific or local ecotypes will not only have better establishment and persistence rates, but also support the local biodiversity.

For a merchant to provide seed across all the species and sub-species on a just-in-time basis would be beyond what any one firm could achieve; the number of stock-keeping units (SKUs) would be overwhelming and too expensive to maintain. In economics, where the costs of providing a service are not more than offset by the demand for the service, the market for that service is said to be 'missing'. In such circumstances, transaction costs increase and institutions to help coordinate are required to enable trade.

An example of another market where inventorying is uneconomic and institutional coordination is critically required, is that for organ transplants.

Presently, the systems to accommodate the existing demand is limited, and without considerable planning, the capacity to source seed for larger landscape scale projects will not be possible in some places. Having a plan will require greater information which we believe can be revealed through a market.

7 THE NATIVE SEED MARKET — DEMAND

One of the persistent challenges in the market for native seed lies in sourcing seed which matches the provenance requirements of the restoration site. Plant seeds that originate from the same site or from environmentally similar locations are likely to have similar characteristics, and thus are more likely to establish and enhance ecological relationships than seeds from environmentally distant plants.

If the market cannot furnish the requisite range and volume of seeds to undertake restoration projects in line with expectations, projects may proceed with undesirably low levels of biodiversity or not proceed at all. Some infrastructure projects (e.g. roads), where native seed is preferred, end up using non-native species due to a lack of available supplies. This fall-back solution introduces moral hazard[6] in sourcing plant material. It can be cheaper and easier to establish non-natives, and as a consequence, ensuring the availability of native seed in advance is not prioritised.

The Society for Ecological Restoration Australia (SERA) could help provide reference ecosystems in collaboration with organisations such as Greening Australia who could oversee seed availability to match and meet requirements. Quantitative surveying methods could be employed to estimate seed requirements based on anticipated project sites ahead of time.

At landscape scale, the consequence of the inability to source adequate quantities of seeds or sufficient species diversity to meet basic biodiversity and genetic provenance standards, compromises restoration outcomes (Kildisheva *et al.* 2016, p. 38). Obtaining sufficient quantities of appropriate native seed is one of the greatest barriers to revegetation (Mortlock 2000; Broadhurst *et al.* 2008, 2015; Rowe 2010; Tischew *et al.* 2011). Commercially available seed rarely offers sufficient variety in native plant species or regional genotypes to restore locally adapted, biodiverse stands of vegetation (Smith *et al.* 2007;Meissen *et al.* 2017, p. 2).

Many restoration programs are biased toward a few core species that can be reliably and readily sourced, stored at ambient conditions, and easily germinated. Although these 'workhorse' species do deliver environmental outcomes in a cost-effective manner, they represent just a fraction of the species required to reconstruct diverse and resilient ecosystems (Broadhurst *et al.* 2016, pp. 74–75).

[6] In economics, 'moral hazard' occurs when an entity has an incentive to increase its exposure to risk because it does not bear the full costs of that risk.

Restoration relies on species and functional diversity (Standards Reference Group SERA 2017) and while some ecosystem services can be generated with relatively few species, when higher levels of ecosystem function are required, such as for wildlife habitat, multi-species plantings are necessary (Lamb 2018).

Grasses and trees typically comprise the core of restoration and revegetation seedings, while other functional groups, especially native forbs, are under-represented due to limited availability and/or high seed costs (Richards *et al.* 1998; Walker and Shaw, 2005).

Diversity is critical for ecosystem resilience yet current structural biases in the availability of seed, in part due to past under-investment in seed and restoration science, is currently limiting our capacity to deliver on this.

Our limited knowledge of dormancy and germination requirements already constrains our ability to successfully restore complex plant communities and this will be exacerbated in the future, thereby compounding imbalances by planting more of those available and neglecting those which are not (Broadhurst *et al.* 2016).

An undesirable feedback loop can emerge if restoration projects are biased toward easier-to-restore grasses and trees, rather than including forbs and shrubs which are also critical plant types for ecosystem health.

Long-term ecosystem health is dependent on maintaining the adaptive variability found within and among local populations, and on maintaining critical ecological relationships among plants and animals.

'The more species there are, the more it increases ecosystem functions.'

Eminent ecologist Bernhard Schmid
Professor of Environmental Sciences
University of Zurich and Peking University

In Sao Paulo, the richest state in Brazil, legislation covering topics from the required restoration technology to minimum levels of native plant diversity (Aronson *et al.* 2011) has benefited directly from the experience gained and reported in the scientific literature by Atlantic Forest Restoration Pact (AFRP) restoration scientists and practitioners. Such official guidelines for restoration now prescribe a minimum of 80 native tree species per hectare in restored forests and require the use of seedlings originating from the same vegetation type, collected as near as possible to the actual restoration site, along with a rigorous monitoring program (Melo *et al.* 2013, p. 399).[7]

[7] The Atlantic Forest Restoration Pact (AFRP) is a coalition of 260+ stakeholders, including governmental agencies, private sector, NGOs and research institutions, aimed at restoring 15 million hectares of degraded and deforested lands by 2050. The AFRP tracks information related to restoration technology, successes, and failures to date, and

While the cause of the shortfalls in seed availability can be attributed to different factors in different places, inadequate species variety in a restoration project undermines outcomes, and worse, reduces rather than increases, biodiversity and ecosystem interactions. This underscores the importance of advanced ordering in order to achieve planned objectives.

Some large-scale revegetation projects can, if not properly planned, have catastrophic effects on ecosystems. For instance, China's 40-Year Billion Tree Project had an excessive reliance on poplars because they were easy to source, but this led to problems with pests and disease and the ultimate removal of a lot of infected trees.

Given the long lifecycles of trees, building seed supply to meet the demand from large scale restoration typically takes years. Overly ambitious targets and short funding cycles can result in selecting species and seed sources based on what is readily available rather than what best meets project objectives (Stanturf *et al.* 2015).

> *'Commitment can replace complacency, urgency can become opportunity. Because of the challenge of shifting our economies to net zero is an enormous opportunity, and it's one that will have to involve every company in every sector in every country. Building a sustainable future will be capital-intensive after a long period when there's been too little investment. It will be job-heavy when unemployment is soaring.'*
>
> Dr Mark Carney, former Governor of the Bank of England

8 THE NATIVE SEED MARKET — SUPPLY

Australia's native seed market operates by and large as a function of the merchants and pickers collecting to order or speculatively, with seed growers contributing an estimated 10 per cent of seed volume in the market. Most seed collectors, including smaller commercial collectors, tend to collect much of their seed in their local area so, the nearer a seed user is to the home base of a commercial collector or supplier, the easier it will be to obtain local indigenous seed from them. The further away a seed user is, the less likely it is that speculatively collected seed is available and the higher the cost will be for collection to order (Mortlock 1999). As mentioned earlier, this in part explains why more seed varieties required for restoration are not speculatively collected for the mining sector — mines and restoration locations are generally in different areas.

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has made available a practical, comprehensive and field-tested framework for forest restoration in the Atlantic Forest (Rodrigues *et al.* 2009a). http://www.pactomataatlantica.org.br (Melo *et al.* 2013, p. 398).

As mentioned, there are 26,000+ flowering species in Australia and for many of these there are several ecotypic variants which means there are multiple seed varieties in Australia. Reports from key merchants (intermediaries who engage multiple collectors) state they can in most cases source the variety and volume of seed but only with adequate notice. Many purchasers mistakenly assume merchants will have their variety of seed on-hand, but this is not feasible because the costs and risks associated with seed inventory are too large.

Nevertheless, merchants do carry some inventory, and where unable to provide stock immediately, will look to convert an order into a contract to collect. Seed merchants can generally fulfil any orders within a year in terms of the variety of seed being sought. However, in cases where they cannot source the seed within the year, it may be a case of requiring greater time because seasonal factors, such as temperature and rainfall, affect seed crop yields. In extreme cases, after a fire for instance, their source may have been destroyed and it could take time for the merchant's seed collecting team time to find another quarry.

In terms of volume, seed merchants also indicate confidence they can service the market, but again, they need greater notice to collect. For especially large volumes, it may be necessary to undertake a seed-increase project where farmers or other experts can be contracted to 'grow-out' which can take from 2 to 5+ years depending on plant type. Importantly, these contract grow-out opportunities only exist for species where we have knowledge of the propagation protocols.

The future sector challenge will not just be overcoming the need to efficiently coordinate the diversity of seed required, but also sourcing or producing the volumes required, especially with project sizes being governed by offset obligations which can be huge.

There is no central clearing house or exchange for native seed from which information can be drawn about the mismatches that exist in supply and demand for seed. Such information collected over time could provide a useful barometer on whether any seed shortages are acute or chronic in nature and help manage the resource. Publicising such information should also help reform buyer expectations and trigger more appropriate planning processes.

With any fast-growing or volatile sector, there are execution risks around the supply chain, which may take the form of capacity constraints and cost inflation. In a matching market, as is the case with native seed, demand tends to be inelastic to price. 'Inelasticity' refers to the sensitivity of demand or supply to changes in price. For example, if the price of a commodity increases 25 per cent, but demand only decreases two per cent, then demand for that commodity is said to be 'inelastic' relative to price. Yet seed is one of those commodities where an increase in price does not necessarily yield an increase in supply.

Some ecotypes, i.e. provenance-specific seed, may sell for five times their average price, but within the same year another ecotype of the same species may sell for a mere fraction of its market average. This introduces a conflict of interest for the collector or merchant to declare they are what the purchaser wants them to be, because there is no practical way to determine seed origins or their genetic quality and seeds of many species look very similar.

From an economic theory perspective, transactions where one party has information the other lacks will prevent the price mechanism from allocating resources efficiently, leading to a market failure. In this case, the specific kind of information asymmetry between the buyer and the seller leads to what is known as 'adverse selection'. Adverse selection leads to 'bad' products or services being selected. In the words of one seed market participant, 'It's like transacting on the dark web.'

For a market to function properly, the market must lead market participants to truthfully reveal private valuations for their seed in the face of incentives to misrepresent these values. This can be addressed only through market design, which will be discussed in a subsequent chapter.

Generally, seed purchasers must trust that seed obtained from their supplier is of the species and from the locality claimed (Mortlock 1999). Unlike in the US where state authorities can provide certification of source-provenance, there is no official tagging system operating in Australia for native seed. Services exist to clean seed and certify its purity, but generally purchasers in the native seed market are price takers and would need to run the testing on their own account.

In the US, 90 per cent of the demand for native seed is driven by three major buyers, the Bureau of Land Management (BLM), US Forestry Service (USFS), and the US Fish & Wildlife Service, with the BLM, the largest federal land manager, alone purchasing three million pounds (1.4 million kg) of seed per year. With such market influence, it has been responsible for instituting certification and standardisation measures that have raised the quality of the plant material available.

For example, the BLM requires a Pure Live Seed (PLS) rating and a noxious weed rating above a set threshold, as well as a tag which certifies its source, as overseen by state level seed certifying agencies.

Requirements to use only accredited seed in publicly-funded restoration projects and programmes should be introduced in Australia as they are in the US. Presently, however, there are no commonly held services or certification protocols around seed standard purity or viability being enforced.

Because mining companies are the biggest buyers of native seed in Australia, their procurement rules play an over-sized role in the seed market. By working with sustainability committees of state level Minerals Councils, the opportunity to establish good protocols could

be instituted at a strategic level. With standards being prescribed by such a large segment of the market, collectors and growers would be incentivised to provide assurance on seed purity and source to the market.

The Restoration Industry Association of Western Australia (RIAWA) has recently introduced some standards to be upheld among their members to ensure collectors are following sustainable picking protocols and purity measures for seed (cf *FloraBank Guidelines*).

The *FloraBank Guidelines* remain a recognised standard in the Australian native seed sector today. The *FloraBank Guidelines* establish protocols for wild collections around how much to take from any one plant, and the need to collect from across as many different plants as possible to mitigate the risk of seed being collected from the weakest plants within a population.

Native seed collectors, in common with beekeepers, are secretive and guard their harvesting sites fiercely. So, while the *FloraBank Guidelines* instruct collectors to harvest no more than 10–20 per cent of the seed crop from any one plant, no mechanism exists to ensure seed is not collected from the same plant by different collectors (e.g. a state-based licensing regulator).

A key challenge for the native seed supply chain in Australia is its reliance on wild stands, or remnants, for seed.

There exists widespread concern that the environmental sustainability of the sector's primary approach to sourcing seed (i.e. wild harvesting) may not be sustainable. Vast quantities of native seed are required for large scale restoration yet relying solely on wild resources may not be possible (Merritt & Dixon 2014; Abbandonato *et al.* 2018, p. 820).

Identification of sustainable seed harvest and management strategies will better equip conservation practitioners to make decisions to ensure a reliable and steady seed supply for restoration while also conserving the integrity of remnant ecosystems and seed sources (Meissen *et al.* 2017, p. 3).

Through the forthcoming Habitat Condition Assessment System (HCAS), a better reckoning of sustainable seed harvesting practices will need to be more closely monitored. Biophysical constraints compound the market failures that already exist in the market and closer attention will enable more targeted responses which will be required given the diverse nature of seed.

8.1 Licensing and access: the economics of the market for access and the 'activation opportunity'

Presently, the licensing and permit regime for seed harvesting is managed at the state/territory level. The information available and systems used to aggregate and manage the flora resources are most comprehensive in Western Australia (WA), reflecting the importance of the flora industry economically, and where the perils of unchecked harvesting were experienced during a boom in wild-harvested wildflower exports.

Strict controls exist in WA where seed collections for commercial purposes require a wildlife licence (the licence which covers seed collectors among other activities) to collect seed. In most other states, a licence is not required to collect from private landholdings in part because in Australia, trees and seed, unlike birds and fish, belong to the landholder.

WA collectors require endorsement from their district along with their licence to collect seed, as well as land manager or owner approval. This additional layer of permission or approval works to improve monitoring of flora resources and collector activity.

While the WA government collects more information on seed collecting activities than any other jurisdiction, it cannot attest to the status of the remnants from which seed is harvested, nor facilitate access rights.

A key competitive edge for native seed collectors is their knowledge of seed sources. An interesting finding from the *Australian Native Seed Survey Report* was that seed in Australia is most commonly taken from private land and roadsides. Collectors negotiate with landholders to access and collect seed and often explain that they request permission after seeing a species from the roadside, by chance. Generally for seed collecting, unlike in agistment agreements, no payment is made for any seed collected although on occasion some in-kind payment may be given.[8] Interestingly, landholders often do not have knowledge of the species varieties available on their properties, nor the prices the seed would command in the market. The market value of the seed is therefore generally wholly appropriated by the collector.

With greater transparency, economic theory suggests landholders would request some remuneration, as they generally do in the case of agistment. Instead, the lack of transparency on the seeds' value leads to suboptimal investment in seed sources.

Seed, if thought of as an ecosystem service, would receive a greater level of attention than it currently does. With a payment for ecosystem services (PES), landholders would be incentivised to audit their vegetation botanically, and lease or lend out access to seeds through some brokering service as they do with agistment.

[8] Interestingly, when it comes to access to harvest grasses, contracts with payment are more likely to exist, but that's because that requires control over the land resources and the landholder must sacrifice feed for livestock for example.

Returns from such services could help cover costs of fencing and other management needs. Such services could be further incentivised through tax credits if the seed is used for the public good. No brokering mechanism to facilitate access to private land is known.[9]

The informational asymmetry wielded by collectors is problematic where it comes to driving greater supply in the market and limiting the competition for collection in the market.

8.2 Seed cycling

Unlike inanimate products such as an iPhone that can be traded, a unique property of a biological resource like seed, is its ability to reproduce. For this reason, seed could actually be leased to landholders or growers on condition of in-kind repayment at some future date, similar to the way a financial repurchase agreement works.

In Europe, where rewilding projects are becoming more common, an initiative to lease livestock has emerged through an organisation known as the European Wildlife Bank (EWB). The EWB is a pioneering mechanism that builds and 'lends' self-breeding herds of grazing wildlife species (wild horses, European bison, deer species) for reintroduction into the natural landscapes. On maturity of the loan, part of the herd is returned to the bank plus 'interest' thereby increasing the bank's underlying 'wildlife capital' and the remaining animals are retained within the landscapes that the bank and its partners are working to repopulate.

A similar system could be used for seed. Many revegetation projects have relied on seed from prior revegetation projects.

Numerous seed collectors from New South Wales have explained that without the right to harvest seed from offsets on mining leases, their costs and risks for restoration would have increased significantly. Collectors in WA have explained that changing land use has led to significant reduction in the areas from which they can harvest seed. Carbon offset projects following the Environmental Planting Method are prohibited from having their seed commercially harvested. This is because permitting it could be regarded as violating the principle of 'additionality', wherein a project can only be funded with carbon offset credits where it is in addition to what would happen without the scheme.

Given we are aiming to increase both the availability and access to quality seed, policies which constrict supply warrant review. Allowing seed collection on carbon projects using the Environmental Planting Method could keep seed stocks higher and incentivise the more expensive, but also more sought-after species-rich plantings which offer biodiversity co-benefits.

[9] Similar in some ways to the way mini-grids reticulate access to cheapest power across a range of different properties to coordinate resources efficiently.

Presently the policies prohibiting seed collection under the Environmental Planting Method disadvantage the method relative to other methods and possibly create a perverse incentive to reduce the species diversity in a planting.

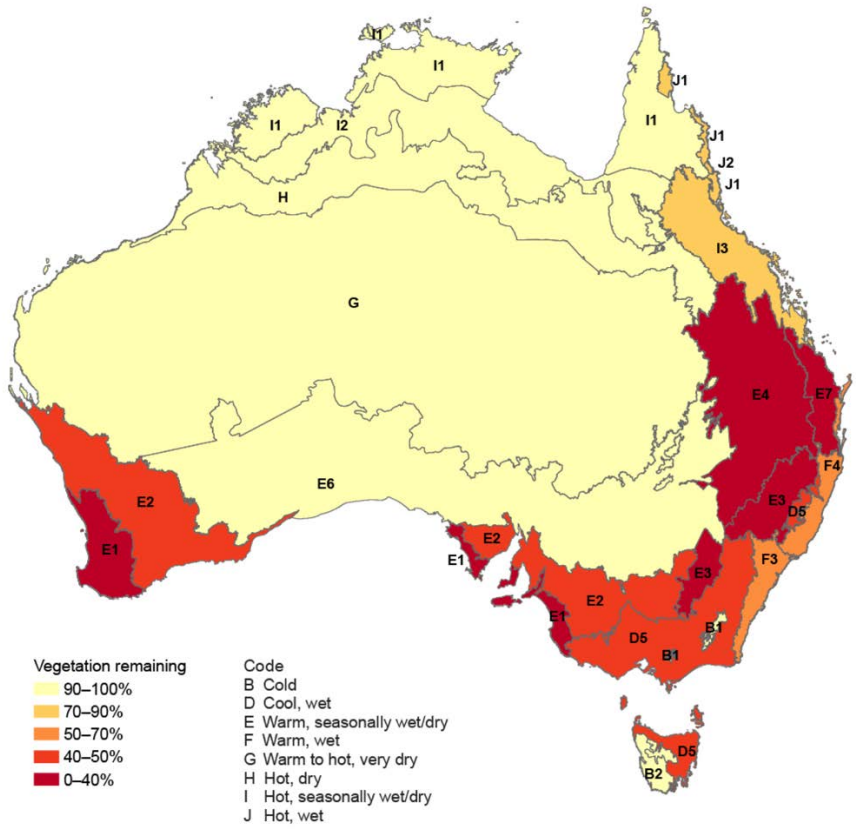
In areas where there has been significant clearing, the importance of seed cycling is greater still. The less that seed is capitalised upon, the greater the risk of biodiversity loss in that ecoregion.

9 STOCKS AND FLOWS — SEED AS AN ECOSYSTEM SERVICE

When it comes to wild harvesting of native vegetation, stock assessments would be helpful as are done for fisheries. Developments in spatial analysis are beginning to show promise in their ability to reveal regions where the carrying capacity of remnants may require closer scrutiny to understand sustainable harvesting rates.

Concepts of 'Natural Capital', and newer methods for accounting for environmental assets, such as the System of Environment Economic Accounting (SEEA), promise to improve our ability to recognise and quantify the impacts, both positive and negative, we are having on the environment. Presently however, there is no clear data on our native vegetation.

FIGURE 4. PERCENTAGE OF AUSTRALIA'S NATIVE VEGETATION REMAINING, BY AGROCLIMATIC REGION, 2011



Note: Numbers on the map after the agroclimate letter codes indicate subcategories for each region (after Hutchinson et al. 2005).
Source: Environmental Resources Information Network, Australian Government Department of the Environment and Energy, 2011

Australia's present native seed supply chain lacks safeguards to prevent over-harvesting. While not a 'tragedy of the commons' because seed is privately owned, the absence of transparency on the economic value of the seed source means the risks of over-harvesting are not being managed and mitigated by the landholder. In accounting terms, over-harvesting impairs the value of an asset by jeopardising future yields. If landowners are able to recognise income from natural capital (asset), they are more likely to safeguard and prevent over-harvesting.

In fisheries management, the concept of 'maximum sustainable yield' (MSY) is typically thought of as the largest average catch that can be continuously taken from a stock under existing environmental conditions. That is, maximum sustainable yield is the greatest number of fish that can be caught each year without impacting the long-term productivity of the stock.

This approach may be largely transferable to vegetation management, but ideally would also take into account genetic diversity.

Over-harvesting from wild populations, both in scale and frequency, can lead to altered regeneration dynamics and population declines (Nevill *et al.* 2018, R1379). Population modelling has confirmed the importance of life history in determining response to seed harvest, with elevated extinction risks for non-clonal species under intensive harvest regimes (Meissen *et al.* 2017).

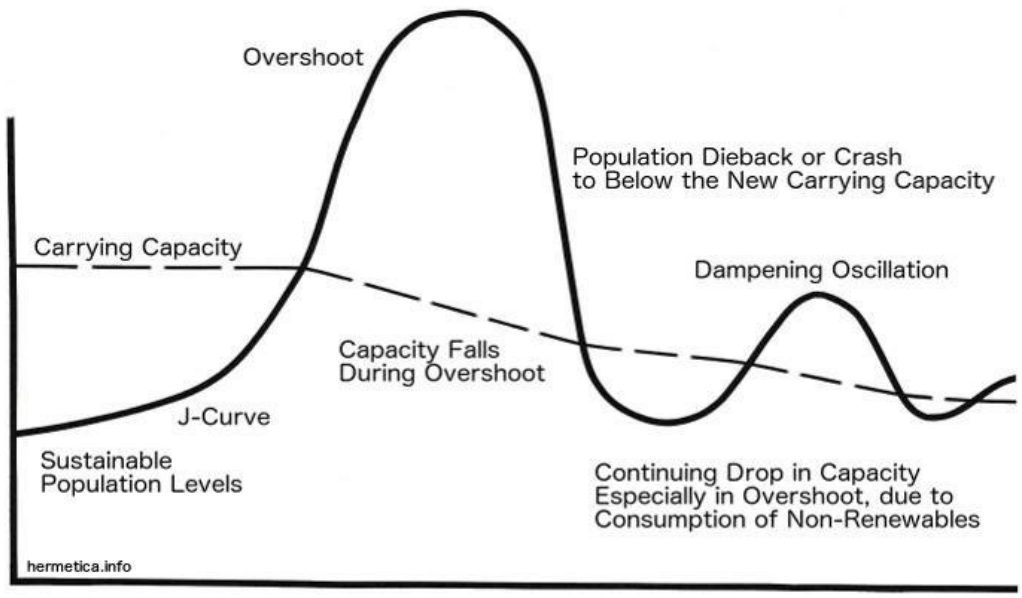
For most plants, seed production represents the culmination of investment in a long series of high-risk events (i.e. flowering, pollination, seed maturation), and plants may be unable to compensate for sudden losses in seed outputs as a result of harvesting.

Without a clear understanding of the impacts of wild seed harvesting, natural areas may face a similar scenario to the collapse of the Atlantic Cod fishery as already depleted 'breeding stock' is removed from the population (Nevill *et al.* 2018, R1379).

A sustainability certification scheme such as exists for the Forest Stewardship Council (FSC) and the Rainforest Alliance could help differentiate collectors in the native seed sector. RIAWA has recently developed a scheme to verify the standards of its collectors.

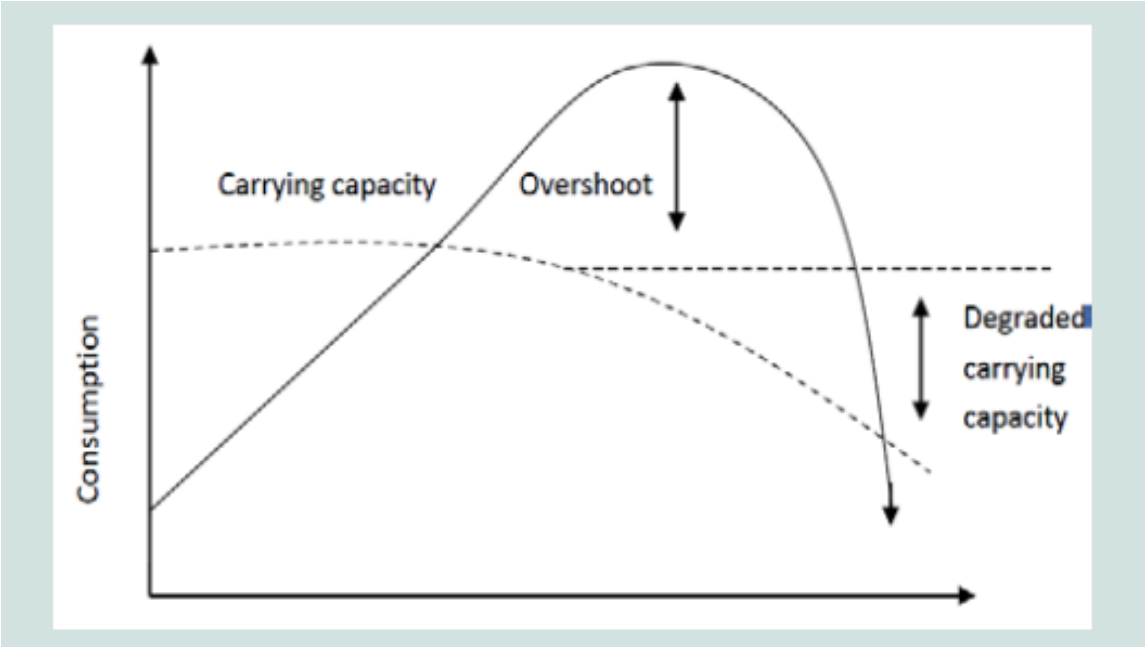
In his book, *Collapse,* UCLA Professor Jared Diamond[10] identified patterns of excessive harvesting leading societies into ecosystem collapse as the rate at which they consumed resources outpaced the rate at which those resources could be regenerated.

FIGURE 5. POPULATION OVERSHOOT AND DIEBACK



[10] J Diamond, *Collapse: How societies choose to fail or survive*, Penguin Press, 2011.

FIGURE 6. CARRYING CAPACITY AND OVERSHOOT



In the context of seed availability in the wild, the 'carrying capacity' for an ecological region can be understood to mean the capacity of the native vegetation to yield enough seed to meet 'demand' for seed in that ecoregion. In ecoregions where extensive clearing has taken place, the carrying capacity will be proportionally lower.[11] In such areas, demand for seed for large scale Nature-Based Solution (NBS) projects can be impossible to satisfy without longer collection lead times, or having supply augmented through dedicated Seed Production Areas (SPAs).

Going forward, the Habitat Condition Assessment System (HCAS) will be a critical framework through which a region's carrying capacity may be gauged. Such information is expected to become available in the near term.

Areas or ecoregions where seed production is likely to be required are those areas where organisations such as the Biodiversity Conservation Trust are purchasing land for conservation to maintain or re-establish ecological diversity. The rate at which the carrying capacity in an ecoregion may be raised is likely to be a function of the financial returns of alternative land uses. This is another reason that the market value of seed needs to be known by landholders as well as seed collectors. Were landholders to know the future seed requirements, they could reasonably be expected to respond to these market incentives and invest in their property's carrying capacity and ensure collection practices were sustainable, not destructive.

[11] Assessing the carrying capacity of remnant vegetation is complex and nuanced because in heavily cleared or degraded areas for example, risks such as inbreeding affect carrying capacity.

It is fair to assume landholders will respond to economic incentives/market signals. Without information on the price of seed and expected future demand, they will systematically misallocate their resources and underserve their market. If the set of alternative land uses is not fully understood, landholders cannot be expected to make the correct trade-offs and respond to environmental markets efficiently.

Through the Biodiversity Conservation Trust, the New South Wales Government is funding the creation of nature reserves in the highly productive landscapes where they are lacking, such as the sheep belt, providing space for locally specific vegetation types and/or ecological communities decimated through clearing, such as Grassy Box Woodlands, to re-establish. This Comprehensive, Adequate and Representative reserve system (CAR) is happening in other states also, under the National Reserve System.

Linking landholders of conservation areas with seed collectors aiming to expand seed collection or undertake local ecological restoration could have the twin benefit of incentivising a threshold level of conservation at the same time as supporting ecological restoration more broadly.

Presently, it seems there is a perverse incentive for many landholders to clear rather than steward those areas providing ecosystem services, such as biodiversity, carbon bio-sequestration, and seed, for which they are not being compensated. Such perversities are identified by the Clean Energy Regulator, the author of the approved methods for carbon bio-sequestration, but the solution developed so far does little to assist those landholders with an incentive to clear.

World-renowned ecologist, Aldo Leopold, summed this up succinctly as follows: 'Conservation will ultimately boil down to rewarding the private landowner who conserves the public interest.'

Another Nobel Laureate in Economics, the late Elinor Ostrom, identified social institutions that enable us to manage collective action problems. A 'collective action problem' or social dilemma is a situation in which all individuals would be better off cooperating but fail to do so because conflicting interests between individuals discourage joint action.

In her Nobel lecture, Ostrom explained:

> *'Designing institutions to force (or nudge) entirely self-interested individuals to achieve better outcomes has been the major goal posited by policy analysts for governments to accomplish for much of the past half century. Extensive empirical research leads me to argue that instead, a core goal of public policy should be to facilitate the development of institutions that bring out the best in humans'.*

Leveraging models perhaps similar to citizen-science could be one way to inform landholders of the value of their botanical resources and provide a channel for them to engage with the seed market more meaningfully. Landholders have a critical role in the native seed supply chain, and without having them and their assets properly 'networked' or 'plugged in' to the chain, the full capacity of the native seed sector will not be realised.

The carrying capacity of the landscape to supply suitable seed for landscape scale restoration will vary from region to region. Understanding how to incentivise landholders to opt for seed production or conservation over other land uses will require communicating the benefits and opportunities. Landholders are a critical stakeholder in the supply chain for seed, yet the existing value chain doesn't reward them in a manner that could incentivise them to grow more plants for seed collection or protect the existing seed sources.

9.1 A role for citizen science?

In areas with low carrying capacity, local NRMs may be required to play a key role to facilitate and coordinate information to improve seed availability.

Citizen science is well developed in the environmental domain, and is used extensively to collect data to help monitor the environment which needs to be collected locally, such as air pollution, the state of nature and biodiversity, water quality etc.

Citizen science often represents a cost-efficient additional source of knowledge and feedback in the monitoring of the environment and the implementation of environment policies widening the evidence base for policy making, by providing new or complementary evidence at the right scale.

The data can be used to validate and calibrate existing data or provide greater granularity. It can help bring local problems or opportunities to light. The vast volume of data that can be collected in a cost-efficient manner by such a large number of volunteers, dwarfs the capacity for professional monitoring.[12]

In Europe, data collected via biodiversity monitoring schemes involving individuals or networks of volunteers have been used in the context of official environmental monitoring and reporting for many years.

Leveraging this intelligence for landholders could sharpen our focus on what the status of our native vegetation is at the ground level and help communicate its relevance to systems outside a landholder's property to coordinate natural resources more efficiently.

[12] https://apple.news/ARak0fISaR9WKn92EtfFYow

10 THE MARKET FOR NATIVE SEED IN AUSTRALIA

Markets are transformative mechanisms that maximise value created from transactions and they are defined by specific conventions and processes that shape the way buyers and sellers transact. They often evolve organically, however, as noted by Nobel Prize Laureate Alvin Roth, '… markets do not always grow like weeds, some are hothouse orchids' that need to be engineered into existence.

A range of complexities, often referred to as 'market failures', need to be addressed before some markets can function efficiently. This is the case with native seed.

The Australian seed market suffers from a number of market failures, some of which are identified in the next section, which is crimping the productivity of the sector, reducing both the variety and volume of seed available and also jeopardising the environment.

In some instances, these market failures reflect the absence of an adequate regulatory framework that would underpin a 'fit-for-purpose' seed market where distribution and variety of seed could be maximised while simultaneously being regulated to ensure a competitive market.

Where market failure exists, governments have a fiduciary duty to intervene to promote effective competition. Regulatory frameworks could help ensure that seed quality and supply certainty are managed appropriately and incentivise purchasers only to trade with licensed collectors and purchase sustainably sourced seed.

> *'Governments play a major role in making the rules that are essential to establish confidence and thus make markets work well. These market rules — providing consumers and workers with necessary protections, managing market power (particularly that inherent in public infrastructure), determining the incentives for innovation, and for skill formation and factor mobility — are not set and forget. They need regular attention to ensure that the system remains competitive, while at the same time providing the coordination needed where collective action is required to address common problems such as setting standards'.*
>
> Productivity Commission

Several key institutional bodies already exist to oversee the smooth and fair functioning of markets in Australia, and examples include the Australian Competition and Consumer Commission (ACCC) and the Independent Pricing and Regulatory Tribunal (IPART). However, the regulatory architecture the seed sector has seen to-date has been one more focused on flora conservation than maximising seed availability, industry development or competitive markets.

Yet, since legislation prescribes the use of native vegetation for restoration or roadside landscaping etc, it is incumbent on government to address any issues bedevilling the market's ability to supply seed if caused by recognisable market failures or information problems.

Uncertainty due to information problems undermines opportunities for exchange and retards the development of an industry, viz today's cottage industry for native seed. With greater certainty of demand being communicated clearly by a committed prioritised revegetation plan, seed collectors or growers could undertake the necessary investment to provide seed when and where required.

It is in the public interest that the market for the right seed is made as economically efficient as possible. A mature and efficient market for native seed will also create incentives for remnants to be maintained more appropriately while driving investment in seed production when and where required. The demand for seed over time is not falling. Restoration work is increasingly calling for greater species diversity and complexity which means seed demand is not just for trees, but forbs, grasses and shrubs also.

By stimulating landholders' recognition of the value of seed, economic theory suggests the range and volume of seed being brought to market would improve.

> *'An adequately regulated system of flora harvesting provides a useful economic incentive for active conservation of flora resources, far and above the threats of penalties for clearing native vegetation.'*
>
> WA Department of Biodiversity Conservation and Attraction (DBCA)

11 MARKET FAILURES

Market failures exist in imperfect markets where the price does not serve to drive coordination among buyers and sellers in a manner which is welfare-maximising. This occurs essentially because the price signal becomes mis-informative. In the seed market, the classic case is where a buyer treats the 'price' of a seed lot as though that was enough information, neglecting critical data on purity (vs weed content, chaff), and viability, or provenance. This leads to a perverse outcome whereby good quality seed product is undercut by poorer standard product which leads to welfare loss for all in terms of ecosystem outcomes.

As mentioned earlier, matching markets requires more information than price alone can communicate. In matching markets, institutions are required to support transactional efficiency and eliminate market failures.

Some of the market failures which exist in the market for native seed are listed below.

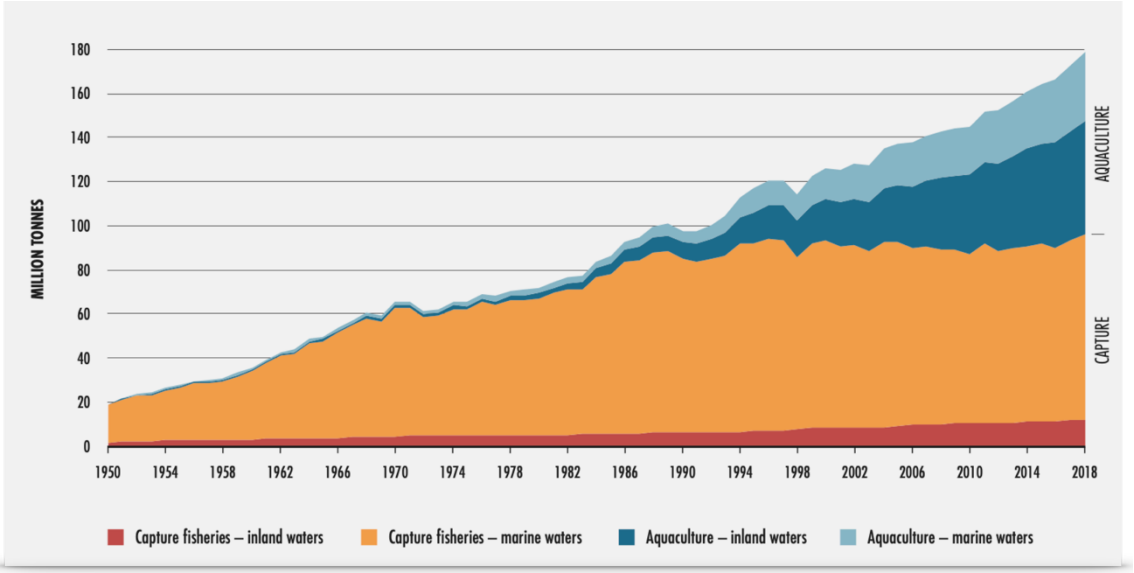
TABLE 2. MARKET FAILURES

MARKET FAILURE	EXAMPLE IN THE NATIVE SEED SECTOR	MITIGATION AVAILABLE THROUGH IMPROVED CENTRALISATION AND GOVERNANCE OF MARKET
Informational asymmetries	• Seed lots are not tested to an agreed standard so purchasing seed lots is a dice roll. There is no quality control in the market, nor certification system or purity testing required in the current market for seed • Strategic misrepresentation — Unsophisticated buyers may be sold seed by unscrupulous or untrained pickers only to discover it is not the seed they required or is of different provenance undermining confidence amongst buyers (organisations such as RIAWA are acting to address this). • No centrally formed standard price data precludes the process of assessing investment opportunities with expected rates of return. • Landholders are by and large unaware of the value of their permission to allow seed collectors to harvest seed from their remnants leading to probable misallocation of resources.	• Market access for collectors/merchants could be predicated upon their disclosing greater information on: – seed purity – seed provenance – geo-location – licensing etc • Market could provide publicly accessible current prices (and over time historical prices) to assist collectors plan work and also help landholders recognise and capitalise on the resources they possess in a sustainable manner and maybe invest in expanding their natural capital • The market could provide key scientific information to reduce risk of incorrect provenancing decisions by purchasers
Monopolies	• Some collectors may have near monopoly on some access to seed and may seek to corner the market.	• Through greater visibility on prices, monopolistic activity could be targeted by authorities
Allocative efficiency	• Absence of a futures market. Contractual advance orders, which could support the establishment of seed production areas, are not occurring frustrating the ability of the sector to undertake capital expansion and address future and diverse requirements for native seed in an efficient manner.	• A market could provide an opportunity to develop future contracts and an agricultural finance intermediary could assist with factoring or supply chain financing
Negative externalities	• Over-harvesting by inexperienced or unscrupulous operators: Unlicensed operators not collecting in line with voluntary *FloraBank Guidelines*, the most recent significant achievement in structuring sustainability into the seed sector. • Findings from the *Australian Native Seed Survey Report* show that a significant proportion of seed sold is likely collected without a licence. Licensing is established to help with resource management.	• Unlicensed collectors could be excluded from the market, incentivising them to adopt more sustainable practices • Greater detail on the source of seed should reveal whether picking behaviour is in line with FloraBank Standards or collecting no more than 10 per cent.

MARKET FAILURE	EXAMPLE IN THE NATIVE SEED SECTOR	MITIGATION AVAILABLE THROUGH IMPROVED CENTRALISATION AND GOVERNANCE OF MARKET
	• The cost of the extraction of seed from remnants may exceed the sustainable rate and deplete the resource at a rate that exceeds its renewal rate or affects other ecosystem interactions, e.g. bees, birds or other fauna seeking flowers or seeds. The actual cost of production is not reflected in the price of the seed.	
Transaction costs	• Search costs involved in finding and coordinating buyers with sellers is high, sometimes resulting in substitution of species or no purchase. • Information about what requirements are and who may have the capacity — and the licensing authority — to satisfy the requirements is not always available. The costs of pulling information together to facilitate trade are called a transaction cost.	• Enabling a centralised exchange at the ecoregional level will enable a broader access for both sellers and buyers to find one another. • Through reputation building measures available in a market, the scope for identifying legitimate players in a market are improved — reduces time spend searching.
Non-excludability	• Since the seed (ecosystem service) being derived from remnants being considered de facto open access, it leads to an under-investment in the maintenance of remnants because their asset values, as a function of their income, are being understated. The consequence is less incentive for owners to conserve or grow the resource.	• Greater awareness from landholders of the value of seed being generated should engage greater incentive to protect and grow such resources for economic returns.
Homogenous goods	• Seed batches are not fungible — quality varies and therefore price should also, but unless markers of certification or standards are made available prices may not reflect the correct value. The Bureau of Land Management (BLM) in the US uses metrics such as Pure Live Seed (PLS) to discern price information and a colour tagging system to discriminate provenance.	• Improvement in the disclosure of seed quality through measures of viability for example will reduce the possibility of a seed lot with only 50 per cent viability commanding the same price as the lot with 90 per cent viability. • Opportunities may emerge to provide genetic or other testing to facilitate even greater transactional efficiency in the market.

The sooner we can establish where wild harvesting is not sustainable, the sooner we can develop alternative farmed sources for the seed through 'seed increase' projects. A loose analogy may be drawn with the market for fish where aquaculture accounts for a significant and growing proportion of fish that is sold to ensure populations in the wild remain sustainable. Where demand outpaces capacity of the wild to supply, supply has been augmented through 'farming'.

FIGURE 7. WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



Source: FAO

While the need to augment supply will not always exist, the critical challenge at the moment lies in developing the expertise to produce wild seed. As mentioned already, we are not at the stage of being able to grow all the species we may need.

It is widely held that the increase of native species through agricultural-style production systems is an area in need of significant development (Merritt & Dixon 2011; Tischew *et al.* 2011; Kildisheva *et al.* 2016, p. 38).

12 SEED PRODUCTION PROTOCOLS FOR SEED ORCHARDING AND SEED PRODUCTION AREAS

12.1 Cultivated natives — 'Improved varieties'

Efforts to increase seed availability by using agricultural production systems have been happening in the US for many years.

The US Department of Agriculture (USDA), specifically the Agricultural Research Service (ARS), underwrote the development of native cultivars (nativars) for those species likely to be the most useful in restoration and also adapted to be easy for the agricultural industry to produce (e.g. synchronous flowering).

These nativars, sometimes called 'improved plant materials', were developed through a variety of plant breeding and selection strategies to achieve rapid emergence and establishment, high forage production, and good seed yields to address today's natural resource challenges and maintain 'healthy and productive farms and ranches' (USDA–NRCS 2019; Kiehl *et al.* 2014, p. 148).

Public land in the US is leased to local graziers to improve their economic viability. In part due to these considerations, restoration of public lands does tend to use cultivated native varieties, or nativars, because they outperform local native varieties on metrics such as Total Digestible Nutrients (TDN).[13]

The seeds of cultivars are also readily available in large amounts, which makes them an easy choice when large amounts of seeds are needed (Bucharova *et al.* 2019, p. 8). However, many traits selected for in typical seed orchards (such as seed shattering, low dormancy and synchronous phenology) are maladaptive in the wild (Espeland *et al.* 2016). Extreme cases of this type of selection are native plant cultivars or other improved varieties.

Not only are improved varieties often phenotypically invariant (Espeland & Hammond, 2013; Leger & Baughman, 2015) and therefore unlikely to respond to selection imposed by climate change and other adaptive hurdles (Espeland *et al.* 2016), but they have often been developed specifically for traits such as above-ground biomass accumulation, herbicide tolerance or suitability for mechanised harvesting (Chivers, *et al.* 2016 and references therein) that may be maladaptive in the long-term in some restoration environments (Leger & Baughman, 2015; Nevill *et al.* 2016, p. 7491).

Although seed availability is a key prerequisite of any restoration project, use of cultivars can be problematic, because the traits for which cultivars were bred differ from the traits that are favoured in the field, in restored populations (Leger and Baughman 2015). For example, grass cultivars have been bred for forage quality and yield, high seed production, seedling vigour or drought tolerance. Although these traits seem intuitively advantageous for successful restoration, natural selection in the field favours different traits including early flowering, small plant size and higher root allocation (Leger and Baughman 2015; Bucharova *et al.* 2019, p. 8). Domesticated species (cultivars) have been bred for high germination rates and uniform growth characteristics, whereas native species may have lower germination rates and more varied growth characteristics, allowing the species as a whole to better adapt to environmental stressors such as drought (Mock *et al.* 2016, p. 697).

The reduced genetic diversity of many cultivars, however, limits their ability to provide the genetic variation required to restore healthy communities and the potential for adaptation to future environmental changes (Johnson *et al.* 2010; Kiehl *et al.* 2014, p. 148).

[13] The American Seed Trade Association (ASTA) along with some other bodies have been lobbying Congress to direct the BLM to undertake only cultivar purchases.

Cultivars with a narrow genetic basis will constitute genetically uniform populations that support less diverse ecological networks and fewer ecosystem functions (Barbour *et al.* 2016; Harvey *et al.* 2017). Many cultivars have low phenotypic variability, e.g. with respect to flowering phenology or secondary chemistry, and thus support a limited number of dependent organisms, which results in homogenisation of communities across trophic levels (Zytynska and Preziosi 2011; Tahmasebi *et al.* 2014; Mody *et al.* 2017; Bucharova *et al.* 2019, p. 8).

12.2 Wild seed — Source Identified Native Seed (SINS)

Unlike cultivated agricultural seeds, native seeds are wild and have variability that may be critical to plants' and ecosystems' adaptive evolutionary potential. Ensuring maintenance of diversity in plant genetics is critical to ensuring restoration projects do not do more harm than good. In Europe, only wild native seeds are permitted in land restoration and rehabilitation work — it is illegal to use cultivars for land restoration.

Over the last decade in the US, there has been a distinctive trend away from non-native seeds, as practitioners of ecological restoration have sought provenance-specific seed better suited to establishment conditions and maintaining biodiversity at a restoration site. While the Bureau of Land Management (BLM) still uses native cultivars extensively, thanks in part to pressure from bodies such as the American Seed Trade Association (ASTA) and the Department of Agriculture (USDA), there is a trend away from nativars to mainly Source Identified Native Seeds (SINS).

SINS are wild-collected seeds generally collected by contractors, that are then turned over to growers who, in turn, grow them out, multiplying the volume of SINS available for restoration or further 'grow out'.[14] This is in line with what Australia has done with Seed Production Areas, except that in the US the process of contract farming is more widely established with many more farmers growing wildland collected seed for expansion.

The Seeds of Success (SOS) programme, managed by BLM, was established in 2001 to boost seed collection in support of the Native Plant Materials Development Program. The SOS National Collection now includes seed of over 6,000 native plant species, approximately 33 per cent of the US flora (Oldfield 2019, p. 381).

[14] The process for building SINS stock is to first wild-collect the seeds through the 'Seeds of Success' ('SOS') program, usually via independent contractors. Such individual collection efforts typically yield 1 to 5 pounds of the specified seed type. From there the seeds are turned over to an extractory, such as the US Forest Service's Seed Extractory in Oregon, for extracting, cleaning, testing, packaging, and other processing. From there the seeds are passed on to growers who, in turn, grow them out, thereby multiplying the number of SINS available for Emergency Stabilisation and Rehabilitation (ESR) plans or for use as further foundation seed.

This move towards source-identified, locally adapted native seed in the US can be traced to botanical research over the last three or more decades around seed zones and successful recovery efforts based on seed zones.

Seed Production Areas (SPAs) are seed farms which can more reliably produce seed than that available from wild populations, reducing the impact of collecting from wild and often stressed populations and generating seed of known genetic quality or to fulfill a specific landscape purpose (Broadhurst *et al.* 2016).

Presently most SPAs are for short-lived species such as grasses, herbs, and some forbs that can be readily cultivated and/or commercialised while, trees, shrubs and most forbs are collected in commercial quantities from naturally occurring populations. The bias in SPAs could be addressed to enable supply of seed for other key plant groups too (Broadhurst *et al.* 2016).

Because there is a significant number of species for which propagation protocols are not known, investment and coordination of research will be required before developing the agronomic expertise around seed farming.

Seed research will be centrally important for the future of biodiversity in Australia. The research budgets for understanding and managing native vegetation is a fraction of the spending on life sciences research in Australia yet the economic benefits of plants for food, medicines, construction, energy, and provision of the national green infrastructure is incalculable.

Protocols for seed production are developed by research bodies such as the state Botanic Gardens and this research and practical expertise with genetics is critically needed if the restoration sector's drive into seed production is to succeed. Providing a sound economic framework for appropriate seed production and a scientific approach to SPA establishment and maintenance will ensure appropriately produced seeds are available for restoration projects (Nevill *et al.* 2016, p. 7495).

13 PROVENANCE, THE MARKET AND SEED ZONES

A ‘seed zone’ (also called a ‘region of provenance’) is an area within which similar ecological and climatic characteristics are found, leading to stands of a given plant species throughout that zone exhibiting similar phenotypic or genetic characteristics. ‘Seed transfer zones’ are geographic areas within which seeds can be moved around with minimal risk of maladaptation (Kramer and Havens 2009; Havens *et al.* 2015, p. 122). The use of native seed from a given seed zone in restoration efforts within that same zone delivers superior establishment and survival rates when compared to utilising non-locally adapted native seed.

The most important objection against the transfer of ecotypes over a large spatial scale is the possible effect of an interacting biota (Bucharova 2017). Since plants are the main primary producers in terrestrial ecosystems, a myriad of other organisms depends on them. These organisms frequently differentiate between plant genotypes, so that their performance will be influenced by plant origin.

The current relationships between host plants and their interacting organisms are shaped by coevolutionary processes (Toju and Sota 2006; Garrido *et al.* 2012; Leimu *et al.* 2012), and introduction of foreign provenances will likely disrupt these relationships, with unpredictable consequences (Bucharova *et al.* 2019, p. 11).

FloraBank developed tools such as the Species Navigator to bring science to the field and improve outcomes. By inputting descriptive factors such as species name or GPS coordinates, tools today such as Sydney Botanic Gardens’ Restore and Renew simplify and reduce uncertainty in the decisions seed purchasers face by re-shaping the ‘choice architecture’.[15] [16]

Seed zones help counter the inappropriately strict geographic limits on sourcing provenance-specific seed without falling back on the ‘rule of thumb’ dogma of a 50km radius from the restoration site. Collectors in Australia report (Hancock *et al.* 2020) that seed purchasers routinely stipulated inappropriately restrictive provenance requirements in their orders which is not necessarily, nor even generally, the best descriptor of where to obtain the best adapted or most appropriate plant material (Leimu and Fischer 2008; Havens *et al.* 2015, p. 122).

While Australia does not yet have seed transfer zones (it has 89 IBRA regions), they are seen as a necessary precursor to supporting the sector in terms of seed procurement, trading and production.

[15] Choice architecture is the design of different ways in which choices can be presented to consumers, and the impact of that presentation on consumer decision-making.
[16] https://www.restore-and-renew.org.au or in the US the Seed lot selection tool — https://seedlotselectiontool.org/sst/ are helpful in reducing uncertainty in the purchasing process and helping guide purchasers make informed decisions.

With official seed zones, the opportunity to address the following exists:

- Level-setting the science in the sector to help purchasers as well as suppliers understand the boundaries for provenance.
- Demarcation of the Total Addressable Market (TAM) and show the feasibility of seed production areas.

Creating seed zones in the US and Germany has affected the economic opportunity associated with growing native seeds, as the site of production is limited, and the market for sale (the TAM) is similarly limited by regulatory barriers to entry. This provides thickness in the market at a local level, where outside producers cannot compete, and local purchasers must buy locally produced seed.

In Germany, there are 22 seed zones, but there are eight production zones so that while regional seed mixes can only be used within a given seed transfer zone and must be propagated separately for each, the propagation itself can take place anywhere within one of the eight production areas. This enables a single farmer to produce seeds from several seed transfer zones on the same farm and allows development of a profitable business (Bucharova *et al.* 2019, p. 14).

Importantly, ecotypic conditions should prevail, meaning that ecotypic factors are taken into account.

Aside from those producing native grasses and some forbs, native species seed production areas tend to grow smaller and more diverse stands with significantly different harvest schedules than more conventional commodity crops. This generally leads to relatively high per-unit production costs associated with, for example, sowing, weeding, monitoring, harvesting, cleaning and marketing.

Yields for native seed also tend to be more variable than conventional commodity crops (Jones and Young 2005). The physiological characteristics that allow them to survive in the harsh environmental conditions may reduce consistency and yield in agronomic production (Mock *et al.* 2016, p. 697).

In the US, some seed production areas are huge, but in many cases, these are production areas where native cultivars are being grown, rather that the Source-Identified Native Seeds (SINS). One operator in the sector explained that while the production economics of native seed are not as favourable as native cultivars, 'We don't need 10,000 acres for a crop. We need 10,000 one-acre plots.'

While restoration ecologists commonly advocate genetically diverse, provenance specific products (Bozzano *et al.* 2014), the seed industry maintains an approach which leads to a product of such high cost to produce, or such specialist need, that market forces do not justify its production (Nevill *et al.* 2016, p. 7494). This again pits nativars against SINS.

In contrast to non-native commodity crops, however, growing native seed can help the environment twice over. It has positive benefits on the ecosystem and biodiversity that are neither tallied nor rewarded as yet.

The need for small-scale and niche producers and collectors is likely to continue to maintain the supply of seed for key species, such as those that are more difficult and time-consuming to collect or process (Broadhurst *et al.* 2016).

14 SECTOR RESEARCH AND DEVELOPMENT

Historically in Australia, a mechanism which worked to help drive the agricultural industry's awareness of markets and support practical scientific knowledge diffusion has been state Departments of Primary Industries. As the outreach model has been demonstrably successful in several agricultural sectors, it may yet be as effective in coordinating the native seed sector.

Presently there is some information about native seed production within the agricultural section of the Department of Primary Industries.[17] Other organisations could become involved for plant types beyond grasses, to include forbs, shrubs and trees with critical input on propagation protocols provided through Botanic Gardens. Applied concepts developed by the Royal Botanic Gardens through the Saving our Species (SOS) partnerships for threatened species are applicable more broadly to restoration, and seed production areas. The opportunity to enhance the level of institutional cooperation between industry and research in this area is significant. For the Botanic Gardens, such partnering could represent a fee-for-service arrangement providing additional funding for practical research and coordination with a Research and Development Corporation (RDC) to consolidate expertise across the sector and create a distributed network of practitioners to develop required protocols.

For instance, CSIRO, through the Australian Tree Seed Centre, was instrumental in consolidating knowledge around breeding trees that were ideally suited to wood or paper production, eliminating R&D risks for multiple Australian businesses altogether.

Many of the mysteries around seed production may be better outsourced to the distributed ecosystem of growers who have a lot of tacit knowledge available to them. By employing an open innovation model (e.g. Chesborough), collaborating with science-based bodies such as the Botanic Gardens or CSIRO, the protocols required for many species could be discovered.

[17] https://www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/rangelands/publications-and-information/grassedup/seed-production

Given the constraints and number of ecoregions, the most efficient way forward for centralised bodies, such as the Botanic Gardens, would be to engage with industry to help crack dormancy protocols for those species not already considered threatened or endangered.

Such an initiative could work together with the National Environmental Science Program and the Environmental Restoration Fund. Other industry development initiatives could emerge to support native seed production through bodies analogous to the Clean Energy Finance Corporation (CEFC), providing loan or investment financing for projects to develop seed production areas. Such a body could be co-financed with the private sector as a public-private partnership (PPP) but more information on the market opportunities will need to be revealed before that.

Investing in practical restoration science will be necessary if we are to see a broad improvement in restoration outcomes Australia-wide.

As has already been stated, much of the industry expertise that is not in public institutions is held by restoration experts as tacit knowledge. Techniques and expertise in the steps required to successfully prepare a site and achieve plant establishment has value both to the owner and to the public. However, firms or individuals tend not to externalise the value they generate, instead looking to maximise profit.

Recent technological developments have seen this tendency reversed with people sharing valuable knowledge in groups. In theory, for instance, Wikipedia should not exist, yet in practice it does. Sometimes, people externalise value if they are part of a community. This is evidenced, in the US, by the Native Seed Network sharing its propagation protocols.[18]

15 MARKET DESIGN

Market design is a relatively new area of economic inquiry which recognises that transaction costs play a major role in shaping markets, and that efficient frictionless markets do not emerge automatically because certain impediments to transactions exist. Yet, as mentioned earlier, a well-functioning and efficient market for seed is crucial to the success of a number of ecosystem services markets, as well as civil infrastructure projects, mining rehabilitation and other public land restoration projects.

While some markets evolve naturally, many do not, or if they do, chronic market failures render them inefficient. Matching markets such as the one for native seed generally only achieve efficiency through centralised exchange mechanisms. Any transactions that *do* take place in the absence of a designed, centralised market for seed will occur through bilateral transactions in which economic value is eroded by high transaction costs.

[18] https://npn.rngr.net/propagation

Transaction costs refer to the costs required in making any economic trade. Another now deceased Nobel Laureate of Economics, Douglas North, demonstrated that those institutions that facilitate low transaction costs increase economic performance and are actively selected by participants looking to transact. That is, where individuals are at liberty to choose from competing transaction mechanisms, they will naturally prefer the mechanism that creates the most value and distributes value between buyers and sellers in a way that is considered 'fair'. Mechanisms that systematically distribute value unevenly (i.e. asymmetrically) will be avoided by the disadvantaged participant.

While the seed market currently relies on bilateral exchange, this is because a centralised market does not yet exist. Centralisation would cater for greater efficiency in transactions by 'thickening'[19] the market and increasing the incidence of beneficial matches.

A centralised market would also provide a single central point of truth for transacted prices for various species and sub-species of seed. It is critical to understand the market would provide the mechanism to oversee and govern the appropriate sourcing and sowing of seed based on appropriate methods and the latest scientific understandings around provenance and genetics.

However, the institutions[20] that would enable the centralised market to work effectively would still need to be designed. A mechanism design methodology, combining modern micro-economic theory and experimental economics techniques, will be needed. Institutions are incentive mechanisms through which humans structure interaction. Generically, institutions work to govern the way we interact through:

- formal rules
- informal norms and
- enforcement.

The market for seed lacks institutions, especially in terms of enforcement, which makes it heavily reliant on informal norms to drive efficiency. In instances where transactions are occurring between people who know one another, informal norms can play an outsized role in driving efficiency such that formal rules and enforcement mechanisms are not as critical.

[19] A thick market has a high number of buyers and sellers, which means that there is a high volume of trade and a low level of price volatility.

[20] Institutions are the humanly devised constraints that structure political, economic, and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights). Throughout history, institutions have been devised by human beings to create order and reduce uncertainty in exchange. Together with the standard constraints of economics they define the choice set and therefore determine transaction and production costs and hence the profitability and feasibility of engaging in economic activity.

Where transacting is occurring between people who do not know one another, the transaction costs increase, and informal norms are less effective in lowering transaction costs. In such an impersonal market, the requirement to have institutional design, particularly in terms of formal rules and enforcement, is greater. Institutions are always imperfect in themselves, but they structure incentives in ways that can reduce transaction costs and improve efficiency in a market.

In past decades, when the market was smaller, the importance of formal rules and enforcement mechanisms was less necessary for efficient transactions.

Certain transaction complexities associated with native seed trading once addressed could help facilitate greater productivity in the market for seeds, with risk being appropriately or fairly allocated.

Based on modern microeconomic theory, a design process (**mechanism design**) has emerged that allows such mechanisms to be created. The field of mechanism design allows the specific rules, processes and incentives to be designed to achieve public policy outcomes (the **goal function**), given the **economic environment** in which the mechanism will operate.

One of the fundamental principles of mechanism design is that only those mechanisms that cause truthful revelation of relevant information can be efficient. In these mechanisms, the dominant strategy of market participants must be to truthfully reveal valuations. The design process will need to demonstrate this design principle. Every market that works well does so because participants compete only at those margins where it is advantageous and will generate economic efficiency.

The rules that are designed to govern transactions are the design space. With seed, to create efficiency, we need to identify the information that must be revealed before engaging in, say, an auction, such as provenance, seed purity, collection date or delivery date etc. We also need to ensure we have correct incentives in the contracts, such that there is a disincentive to cheat.

The task of the market designer is to define the specific rules, processes and incentives that together define the mechanism so that it:

- achieves the given public policy goals
- maximises economic efficiency and ecosystem outcomes and
- distributes value fairly given transaction complexities.

Fortunately, we do not need to design our market *de novo*, as we could look to how the US Bureau of Land Management's tri-annual Seed Buys are conducted.

Quality assurance in the market for native seed is widely recognised as an issue. Truth in labelling exists in many other market segments as do quality standards, but in native seed as a prominent Australian botanist remarked, 'It is buyer beware!'. Every purchaser seems to have stories from engaging in the market where they have either received high weed, non-viable seed, or even seed that is not the species they purportedly bought.

In comparison to the agricultural sector, for example, seed has certain minimum standards, but the marketing of native seed does not have the same regulatory oversight. This is why the native seed sector needs to develop its institutions further.

Generally, native seed does not really fit within the traditional pedigreed seed certification system because native seed varieties do not fit the legal definition of a variety, where variety is legally defined as distinguishable, uniform and stable.

Several US states, however, have native plant certification programs that certify to the Pre-Variety Germplasm standards of the Association of Official Seed Certifying Agencies (AOSCA), and, in Canada, the Seed Growers Association has developed a similar native plant certification program.

The Bureau of Land Management (BLM) has set a minimum purity, germination (or TZ), and pure live seed (PLS) for most of the species or types of seed utilised in seed projects on western US public lands. The minimum PLS is usually based on the standards for the seed types as set by AOSCA.

As mentioned earlier, mining companies are the biggest buyers of native seed in Australia (by volume), and scope exists to leverage their procurement rules in the seed market. Working with the state run Minerals Councils' sustainability committees, alongside the Minerals Council of Australia (MCA), would provide the opportunity to establish industry-led sustainable and profitable protocols for the seed supply chain. It is also envisaged the minerals sector could auspice a market design pilot.

Government agencies at all levels must follow procurement regulations, and many have procurement officers to ensure that the contract terms for native seed acquisition comply with those regulations. Little information exists on the purchasing of seed conducted by or through NRMs, however.

Seed zones here, again, would support steps toward certification of species or sub-species by source. There is, in some sense ,a taxonomic 'rabbit-hole' around native seed with botanists discovering more and more sub-species/varieties, as they look closer at native species, and sometimes, dividing species thereby creating further discrete species, not just sub-species.

Few countries have regulations on tree seed markets, or successfully enforce them (Gregorio *et al.* 2017; Nyoka *et al.* 2015). Accreditation of seed sources and nurseries can be an important step towards ensuring the use of more diverse seed of documented provenance. Accreditation should also be a process for strengthening capacities and monitoring progress, rather than simply certifying those who meet pre-set requirements. Local entrepreneurs, non-governmental and community-based organisations can benefit from job and income opportunities associated with seed production, but need support to achieve accreditation and access seed markets (Gregorio *et al.* 2017; Lillesø *et al.* 2017; Jalonen *et al.* 2018, p. 8).

The US Forest Service runs a Seed Extractor which cleans, tests, processes, packages and documents etc native seed for storage, seed increase and future use and does this for wild collectors and/or growers. Alongside this federal facility, the US has state-based authorities providing certification on seed source. While this service is not free, it provides critical confidence for the buyers and also helps reward high quality growers or pickers. These state authorities provide yellow certification labels, which represent either seed sourced from the wild or seed grown from wild seed.

Several seed analysis laboratories also exist, both privately and publicly run, which provide critical and importantly, affordable, information for the seed growers to enable them to trade their products and provide certainty in the market.

Certification and assurance improve the quality of the seed being traded and reduce the likelihood of marginal seed collectors undercutting the more professional collectors and can also improve natural resource management outcomes and reward sustainable practices.

A European quality assurance system has also been developed, but this does not cover the whole chain from seed production to restoration project, as it ends with the sale of the seeds. The consequence is that unmonitored seed lots, often unsuitable and foreign to the region, are being used (Elzenga *et al.* 2019, p. 378) although it is against the law to use cultivars in restoration work in Europe.

Because Australia's seed sector is coordinated through informal networks and supply is fragmented rather than centralised, there is no generally available assessment of the commercial opportunities across the whole sector.

16 CONTRACT DESIGN AND FUTURE MARKETS

According to merchants, purchasers do not necessarily understand the challenges and requirements of purchasing wild seed, often expecting it would be available 'off the shelf' like agricultural crop seeds. Further, seed is often purchased on comparative price alone, with no specification other than species. This simplistic approach ignores numerous factors such as seed source, collection ethics, cleanliness, viability, health, genetic appropriateness and ecological/morphological variation likely to improve restoration success. The cheapest seed is often selected even though it may not meet the stated objectives of site restoration or give rise to vegetation that is resilient and sustained onsite in the long-term (Broadhurst *et al.* 2015, p. 31). As mentioned already, it is important to recognise seed markets as matching markets and acknowledge that decisions based solely on price will not necessarily yield efficient outcomes.

The role and importance of the seed supply chain remains poorly understood and even completely unacknowledged in policy or funding frameworks (Broadhurst *et al.* 2015, p. 29). Seed supply assurance in terms of both quantity and quality could improve restoration outcomes for the many smaller projects undertaken annually across Australia by community groups and landholders (Broadhurst *et al.* 2015, p. 29). Many community revegetation projects do not get sufficient lead time from funding sources to place such orders and are sometimes required to demonstrate planting results in the field before the seed required can even be collected (Mortlock 1999).

A restoration professional in Western Australia estimated that as many as three out of four revegetation projects undertaken with NRMs were not able to get enough seed due to insufficient lead time on seed orders.

The reality is that the markets for most native seeds are characterised by low-level demand, insufficient to cover the costs of the minimum level required for permanent seed supply services.

In economics, the theory of the 'second best' relates to the situation when one or more optimality conditions cannot be satisfied and so the best equilibrium that can hope to be achieved is the second best. In the context of seed, the insufficiency of demand relegates the market equilibrium to one of second best and in order to achieve the second-best equilibrium, some institutions should be developed to help it function more efficiently.

The institution that could enable an improvement in the efficiency of the market is the development of some services to improve coordination of demand and help contract supply.

The lead times of the development of plant materials and seed can range from a few months to five or more years, making the acquisition of sufficient provenance-specific seed challenging even in proactive projects with longer lead times. The contractual means of procuring seed plays a significant role in shaping the sector's economic structure.

Posting of bid lists by public agencies provides growers with an indication of current needs and identification of materials that might be collected or grown successfully for the speculative market (Kiehl *et al.* 2014, p. 151).

In the US, the government seed requirements are published as standard solicitations on federal websites such as FedConnect.net, where vendors can also see what buys have been awarded and to whom they were awarded. BLM contracting officers and staff administer the resulting vendor contracts in accordance with the Federal Acquisition Regulations ('FAR'). The BLM also publicises its seed requirements through presentations.

A similar initiative could exist in Australia with requirements for proposed restoration work gazetted giving adequate time to grow the seed if required and enable more growers or collectors to compete to supply contracts.

For merchants or pickers, the risk with committing to a forward contract is that weather affects the seed crops and there may not be enough in the wild to fulfil the order. Wild seed production is also by its very nature 'boom and bust' and requires seed to be collected when available which is often out of step with financial year funding and sometimes with appropriate seasonal conditions for its establishment.

The risk to yields for collectors is different to that for growers. As a consequence, a collector may be less inclined to forward contract for seed volume because they would then have to assume the risk that weather may negatively impact yields. In contrast, growers, because they use agricultural methods with irrigation and fertiliser, have more certainty in their yields.

Some native seed is bought and sold on a spot market and under spot delivery (advance production) where sellers incur costs of production before taking their product to market. Under forward delivery (production-to-demand), inventory loss risk is zero since only goods that will be sold are produced.

Contracts to purchase seed generally place all the production risk on the supplier. In contrast, contracts to support a seed production process, typically on an ongoing basis, often contain provisions for risk sharing between the buyer and supplier. By introducing more efficiency in risk sharing, more production could potentially come on-line.

Policies and contracts designed to lower production risk for native seed producers are likely to motivate increased native seed production. Forward contracting would increase native seed production and improve returns to native seed producers — adopting both policies would raise the native seed industry's productivity.

Contract farming is generally recognised for its potential to sustain and develop the production sector by contributing to capital formation, technology transfer, increased agricultural production and yields, economic and social development and environmental sustainability. Mindful of the role contract farming can play in agricultural development, some governments have instituted enabling policies to attract private sector investors and to coordinate ventures with local producers, sometimes under public-private partnerships (PPPs).

Contract farming promotes supply chain financing by facilitating the provision of credit to producers and to contractors, with derived benefits for all participants in the chain. A typical feature is the provision of working capital by the contractor either directly or by guaranteeing third-party provision, or in the form of inputs which mean a producer can begin production without facing upfront payments.

To date, Australia has limited contract farming or forward contracting of seed with most seed simply sourced from the wild. Contract farming orders or forward contracting could help underwrite the emergence of more seed production areas, especially if production risks were shared.

Growers in the US are reportedly reluctant to diversify their native seed production to a wider range when there is no certainty of sale and fluctuating demand (Shaw and Jensen 2014). Efforts to diversify and scale-up native seed production depend to a large extent on adequate and reliable funding for development and ultimately on market demand, which is often driven by stochastic events (Oldfield *et al.* 2019, p. 83).

In terms of seed collectors, a retainer would likely be a better contractual mechanism to secure greater species diversity, where for example serotinous species are involved.

Sourcing appropriate planting stock is an inherently long-term process and so for such information to be adopted operationally, much more stable and efficient administrative systems for financing are required.

In the US, the largest native seed purchaser, the Bureau of Land Management (BLM), has had some success increasing the diversity and improving the supply of native seed through what is known as an Indefinite Delivery/Indefinite Quantity (IDIQ) contract. These contracts contain provisions for producers to receive fixed crop establishment fees that provide a guaranteed income based on farmed area for a given species, regardless of ultimate yields, reducing the amount of production risk a supplier typically faces. These contracts have proven particularly useful for the source-identified native seeds which have uncertain germination rates and can be more challenging to grow out.

17 THE MARKET AND REDUNDANCY

The complexity of maintaining capacity to revegetate land with native seed is not unlike the complexity of ensuring enough hospital beds to accommodate an overflow of patients during a pandemic. The redundancy requirements are impossible to calculate exactly, and the balancing act of redundancy and efficiency is ultimately one that has to be decided by people and their government; it will not be solved by addressing market imperfections alone.

Redundancy is ambiguous because it seems like a waste if nothing unusual happens, but resiliency is mission critical, where efficiency is not. For insurance, as for any other product or service, the dictum that 'there's no such thing as a free lunch' holds true.

While investing in redundancy can seem logical in retrospect, it costs more and is not always required, making the return on investment or other financial efficiency ratios appear weaker. With long time horizons, mistaken assumptions on discount rates can introduce a myopic bias and stymie proactive decision making.

Relying on the market system to provide redundancy is unrealistic and may introduce an unintended secondary risk of a cascading failure, in which subsequent fires further reduce available seed supplies in the market. Relying on remnants for seed in a time of increased risk of bushfire, as we now face in an era of climate change, is neither logical nor sustainable. While conservation seed banks at the Botanic Gardens and similar institutions add some storage capacity to the commercial system, often as a mix of long-term conservation collections and active collections for restoration and research, these stocks are not for reactive restoration problems.

An actuarial approach taking into account the dynamic character of nature and the movement inherent in its processes is required. Embedding redundancy in a system is complex. Using history as a guide to the future implicitly assumes the system is closed. For example, Japan's Fukushima's nuclear plant was built to withstand the biggest earthquake when it was built. A bigger earthquake was, however, yet to come. Mathematical statistician Nassim Nicholas Taleb explains that this is a result of the Lucretius Problem. The Lucretius Problem is a phenomenon where we assume the worst-case event that has happened is the worst-case event that can happen. In so doing, we fail to understand that the worst event that has happened in the past surpassed the worst event that came before it.

Rather than assuming the native seed sector participants will operate with excess capacity and underwrite the reactive restoration requirements of the environment, the Commonwealth Government could contract collectors or establish key production areas with industry. A similar contract to the IDIQ in the US could work well if it were accompanied with the critical proviso, the growers or pickers could not assume inventory risk.

The resiliency of the systems we need to maintain our ecosystems, prevent ecological loss and undertake ecological restoration requires access to native seeds in much larger volumes than the conservation seed banks presently store. Our present conservation seed banks are not designed to provide seed for landscape scale restoration or emergency rehabilitation.

18 RESTORATION SEED BANKS AND WAREHOUSING FOR PROACTIVE AND REACTIVE RESTORATION

Restoration seed banks are a relatively new phenomenon that have emerged, most notably in the US, to address the environmental management needs of landscapes impaired by human disturbance or stochastic events such as fires. In some cases, they may be better described as restoration seed warehouses, because they are more akin to an inventory for future use in the field as distinct from conservation seed banks which act as vaults for preserving genetic diversity and research.

In order to respond to the kind of large-scale stochastic events Australia is now experiencing more frequently, we too will need to build antifragility into our supply of native seed and develop restoration seed stores.

Presently, we have a de facto reliance on excess seed inventories belonging to non-profit organisations or native seed merchants as the nation's fallback. Again, while conservation seed banks have been established to prevent species loss, they cannot be used to help stabilise landscapes after fire or protect large-scale ecosystems.

As the risks of fires and other stochastic events rise, the scale of demand for native seed will inevitably increase, yet without practical measures to increase supply and inventories, we will not be in a position to provide adequate stewardship to the ecosystem services upon which we rely.

The US has made strategic investments to expand the capacity of the country to respond to wildfires *and* support restoration of degraded landscapes and disturbed land reclamation. The Burned Area Emergency Response (BAER) Program assists with the emergency stabilisation measures required following fires.

The Bureau of Land Management in the US has built storage capacity for 2.6 million pounds (1.2 kilotonnes) of seed, with refrigerated storage at three warehouses having a total capacity of 135,000 pounds (61 tonnes) to ensure capacity to respond to wildfires and also to help ensure availability of seed for restoration work.

If the US experience is anything to go by, with the seed requirements for reactive restoration projects being in magnitudes greater than for proactive restoration projects, the need for Australia to develop seed inventories for restoration is crucial.

While much of the US's demand for native seed arises suddenly in response to large wildfires or other large-scale events, a lot of the BLM seed is also used for collaborative projects with private and public bodies such as state land projects, mining companies and Departments of Transportation. Seed therefore does not go to waste and arguably helps simplify and reduce marketing spend for seed suppliers.

By building a seed warehouse, the Australian Government would have a double advantage of being able to strategically secure native seed access at the same time as driving green collar job growth across the regions by expanding the seed and restoration sector's capacity to deliver higher quality restoration outcomes.

Restoration seed stores could be strategically located around the country in key seed zones where impact (across a range of measures) is greatest. The deciding factors for what restoration warehouses ought to hold would require a different framework but one similarly attentive to at-risk species and degraded landscapes requiring rehabilitation or restoration.

19 STRATEGIES — RECOMMENDATIONS

To address capacity constraints in the seed sector and position it for sustainable growth, the following recommendations include some which are more readily executable and/or urgent than others and as such are arranged within the short-term timeframe of 2021–2025 or that of the second-half of the present decade, 2025–2030.

Where a strategy relates to a National Vegetation Framework (NVF) goal, it is noted in brackets:

1. Increase the national extent and connectivity of native vegetation
2. Maintain and improve the condition and function of native vegetation
3. **Maximise the native vegetation benefits of ecosystem service markets**
4. **Build capacity to understand, value and manage native vegetation**
5. **Advance the engagement and inclusion of Indigenous peoples in management of native vegetation**

Broadly, some strategies are focused on overcoming market failures in the trading of seed, while others focus on the development of greater scientific understanding on how to grow seed or structure the industry for greater collaboration.

Critically, the recommendations are looking to increase information flow in the sector, both to reveal opportunities for investment, and coordinate existing resources, be they human capital or natural capital. These recommendations are initial and iterative in nature.

The ecosystem service approach will be critical to expanding the availability of seed available by incentivising contributing landholders. The existence of a market for native seed is not widely understood by many people and as such the degree of participation in the sector, by landholders or pickers, is limited. In economic terms, there's basically a missing market for seed from the landholder's perspective because there's no known offset to the costs of investing in native vegetation.

Through establishing more transparent pricing signals in the ecosystem service of seed production (both active and passive), and seed collection, the market for seed can be better serviced than it is currently.

19.1 2021–2025

1. Pilot market mechanism for native seed transactions (NVF Goal 3; NVF Goal 4)

(Work with the Department of Planning Industry and Environment which already has a market-based trading mechanism in development (the Biodiversity Offset Exchange (BOX)) with the University of Melbourne's Centre for Market Design)

- Present the mechanism to the state level Resource Regulators and Minerals Councils to identify mining companies willing to participate in a market pilot.
- By centralising the market pilot at a regional level, increased thickness will drive efficiency and be more suited to matching buyers with sellers and reduce the transaction costs and risks associated with buying and selling seed. Other organisations, such as NRMs, or the Biodiversity Conservation Trust may then also be interested in participating.

- The market would provide a means to improve oversight and governance and ensure appropriate sourcing and use of seed in line with current science on provenance and genetics.
- Provide transparency and critical price data at a sub-species level to inform those looking to engage in the seed sector.
- It will improve supply chain quality by incentivising collectors to develop the necessary credentials and disclose important information such as:
  - Proof of licence
  - Collection area coordinates
- The market pilot could:
  - enable ecosystem service markets for native vegetation and seed
  - support seed purchasers communicate and observe aggregate seed demand
  - support experimentation with novel contract design between buyers and sellers
  - reveal where shortfalls in seed may exist and allow price signals to highlight opportunities
  - require detail of seed purity, provenance, weed content etc
  - introduce forward contracts for trading seed
  - provide incentives for repeat business

2. Promote the treatment of seed as an ecosystem service to engage passive landholders and activate latent seed and land resources (NVF Goal 3; NVF Goal 5)

- Educate and enable landholders and farmers to engage with the seed market via their collector or audit their natural botanic capital so they can more appropriately manage and maintain remnant vegetation to sustain ongoing or grow yields.
- Support initiatives to increase the number of properties (and seed collection sites) networked into the regional level to understand both the carrying capacity of the ecoregion and enable environmental markets to function more efficiently than at present.
- Engage Indigenous Australians in understanding seed as an ecosystem service and its value, especially given their ownership or management over 23 per cent of Australia's land area.
  - Greening Australia has existing relationships with some communities. This may be expandable based on identifying areas where native title has priority and allows traditional owners to extract seed and other traditional resources for commercial or cultural purposes. Organisations such as the Indigenous Land and Sea Corporation as well as the Indigenous Business Australia may provide coordinative capacity in this endeavour.

- There is a network of landholders who are into conservation because they have covenants on their land to the NSW BCT. There are now covenants on over 24,000 hectares of high priority under-represented vegetation types on private land. They have a full comprehensive customer relationship. There's been expert surveys on every property (thousands of hectares) that has an agreement with strategic monitoring.
  - Greening Australia could coordinate with the Biodiversity Conservation Trust (BCT) about the possibility of inviting the conservation landholders to participate in making seed available for collection and sold or donated into the aforementioned market.

3. Develop a supply and use model to establish the ecosystem services accounts for the sector (NVF Goal 4)

- The Australian Bureau of Statistics Ecosystem Services Team has indicated willingness to provide guidance on how to use the System of Environmental-Economic Accounting: Experimental Ecosystem Accounting (SEEA-EEA) international framework to integrate and track changes for complex biophysical data, economic data and other human activity to enhance the management and capacity to oversee both seed availability (as an ecosystem service) and ongoing biodiversity. The SEEA framework assures consistency with the System of National Accounts (SNA). Over time, the SEEA framework will assist stakeholders to assess how social, economic and environmental goals can be appropriately balanced. To this end SEEA could be used to produce accounts that describe indicators of resource use and environmental intensity, indicators of production, employment and expenditure relating to environmental activities and indicators of environmental assets, net wealth, income and depletion of resources.

4. Explore the idea of developing a seed leasing system, similar to the European Wildlife Bank model where a repurchase agreement essentially occurs, recycling natural capital in an almost like-for-like exchange (NVF Goal 3)

5. Develop a strategic seed reserve policy and program for stochastic events (NVF Goal 4)

- Work with CSIRO and the Department of Agriculture, Water and the Environment (AWE), to extend the analytical tools developed to inform bushfire recovery projects, by combining it with novel tools such as the Habitat Condition Assessment System (HCAS) to reveal at-risk areas and species with a view to inform strategic collecting of seed from at-risk species.

6. **Provide fee-for-service contracts to Botanic Gardens to provide propagation protocols for commercial seed growers (NVF Goal 4)**

   - Engage key skillsets available at the Botanic Gardens to make available, to interested landholders or entrepreneurs, the necessary knowledge or access to knowledge for native seed production. Research Centre for Ecosystem Resilience (ReCER) at the Royal Botanic Gardens Sydney could assist.
   - Promote skills and training packages available via Registered Training Organisations (RTOs) and encourage industry linkages e.g. Botanic Gardens and increase training opportunities for people looking to start seed production.

7. **Improve the network of existing resources, such as FloraBank and Florabase with a view to understanding gaps (NVF Goal 4)**

   - Re-establishing Regional Vegetation Guides combined with Botanical/Flora Surveys could provide key information to help improve native revegetation outcomes and enhance the supply of appropriate seed where required.
   - The Native Seed Network ('NSN') in the US is a resource to provide information on native seed for use in landscape scale restoration. It provides a directory of native seed vendors and the products that they offer. It collects/provides info on where the seeds come from and how they've been handled, so that seed consumers can make informed decisions. Seed collectors in Western Australia cited the importance of the state government run FloraBase website.

19.2 2025–2030

1. **Develop seed warehouses to match with the strategic seed reserve system ensure adequacy of seed for rehabilitation of degraded lands by stochastic events and/or ongoing government-funded restoration work by NRMs (NVF Goal 4)**

2. **Develop seed zones (NVF Goal 4)**

   - Once the ecoregions have been identified, establishment of a body to provide oversight of the seed sector to ensure seed is available could be developed. This body could commission seed production and help ensure as the plant material centres in the US do, that as many growers as possible could be engaged.

3. **Identify an organisational type to provide strategic oversight and research for the advancement of the native seed sector (NVF Goal 4). Cf the Grains Research sector Development Corporation (GRDC) and enable the sector to coordinate its resources for scientific research, sector financing or shared commercial investment opportunities e.g. Agricultural Innovation Australia (AIA), Clean Energy Finance Corporation (CEFC)**

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