ADDRESSING LIMITATIONS TO SEED RECRUITMENT IN LARGE SCALE RESTORATION

David Merritt, Todd Erickson, Miriam Muñoz-Rojas, Shane Turner, Andrew Guzzomi
Mine site restoration in the Pilbara

- 180,000 km² arid landscapes.
- Low woodlands (*Acacia*, *Eucalyptus*) over hummock grassland (*Triodia*).

- 795mt iron ore worth $63b in 2017.
- Mining disturbance exceeds 2300 km².
- Ministerial requirement to restore vegetation comparable to the pre-disturbed landscape (= high diversity).

- Large deficit of topsoil = seed input.
- Seeding with non-treated seeds and limited knowledge of seed quality, storage, and germination capabilities.
Operating mines and infrastructure

Legend

- Operating Mine & Infrastructure
- The Pilbara
- Conservation Estates

<table>
<thead>
<tr>
<th>ID</th>
<th>Total Area Within the Pilbara (km²)</th>
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<tr>
<td>The Pilbara</td>
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Mines Source: Department of Mines and Petroleum, Mindex database: “Site_Stage” = Operating
Tenure Source: Australian Government Department of the Environment, Pilbara IBRA Region; Department of Mines and Petroleum, Tenement database; and The Department of Environment and Conservation, DEC Managed Lands & Waters
# Projected cumulative mining

![Map of projected cumulative mining in the Pilbara region](image)

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With our present capacity:
Arid zone landscapes – limited topsoil

Pilbara region of Western Australia
120,000 ha (1200 km²) requiring rehabilitation
Equates to 600 tonnes wild collected seed at 5 kg/Ha.
Current collection capability: 6 tonnes pa.

Significant and increasing demand for wild seed is coupled with huge losses in restoration

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<th>Region</th>
<th>Biome</th>
<th>Establishment Rate (%)</th>
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<td>Australia</td>
<td>Mediterranean woodland</td>
<td>0 – 17%&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Australia</td>
<td>Arid shrubland</td>
<td>0 – 8%&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Australia</td>
<td>Tropical rainforest</td>
<td>1 – 33%&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>USA</td>
<td>Sagebrush Steppe</td>
<td>5 – 30%&lt;sup&gt;D&lt;/sup&gt;</td>
</tr>
<tr>
<td>USA</td>
<td>Arid grassland</td>
<td>7 – 17%&lt;sup&gt;E&lt;/sup&gt;</td>
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Source: <sup>A</sup>Turner et. al. (2006); <sup>B</sup>Commander et. al. (2013), Golos (2012); <sup>C</sup>Doust et. al. (2007); <sup>D</sup>Chambers (2000); <sup>E</sup>James et. al. (2011);
Research focus for seed use in restoration

- Majority of recruitment failure is between germination and emergence.
- Poor management of seed quality and dormancy further contributes to lack of recruitment.
- Holistic management of seeds is necessary for diverse seed mixes.
- Need to engineer the niche through seed enhancement and growth media management.

Seed Technology Research Programs

- **Seed Collection & Curation**
  - Collection timing
  - Quality and viability
  - Provenance
  - Seed farming...

- **Seed Banking**
  - Storage behaviour
  - Storage conditions
  - Seed longevity...

- **Seed Germination**
  - Dormancy release
  - Germination and emergence conditions
  - Storage effects...

- **Seed Enhancement**
  - Priming & coating
  - Precision delivery
  - Seeding rate
  - Sowing time....

Level of effective knowledge:

- High
- Low
Seed banking in industry for restoration

• Pros
  • Cool storage temperature.
  • Most accessions labelled with species name.

• Cons
  • Most labelling missing collection year, location, accession number.
  • Species ID not verified.
  • Species diversity low.
  • Volume of seed low relative to restoration area.
  • No information on seed quality available.
  • Seeds not dried prior to storage.
  • Seeds packaged in plastic or hessian bags.
  • Little knowledge of seed pre-treatments required.
  • Storage duration exceeds 10 years for seeds in hessian bags.
  • Seeds left outside in the sun.
Seed longevity is a complex trait


N=207
Protection of seed quality is paramount. Flexibility in storage conditions is ideal.

Storage conditions should consider:

- Seed type (longevity, storage behaviour, dormancy type).
- Storage duration.
- Designated end use of seeds.
On-demand seed pre-treatments at scale

- Simple, reliable and repeatable.
- Applicable to large quantities of seed.

Easy for some...... not so easy for others.
Seed dormancy types in the Pilbara

Physiological Dormancy (PD)
- Asteraceae
- Poaceae
- Eremophila
- Grevillea
- Goodenia
- Maireana

Physical Dormancy (PY)
- Fabaceae
- Sapindaceae

Non-dormant (ND)
- Eucalyptus
- Corymbia
- Hakea

PY+PD
- Malvaceae

MPD
- Hibbertia

N=103

Seed ecology has a clear role in developing germination methods

- Timing of seed maturation and seed dispersal.
- Soil temperature fluctuations (seasonal and diurnal).
- Rainfall data.
- Dormancy type.

- Design experiments that define the influence of temperature, moisture, light, other external cues as appropriate to the environment.

Mimic the environment.
Restoration Seedbank Initiative
Seed regeneration traits

Dormancy
Germination
Speed of germination
Emergence depth
Base water potential
Soil temperature/moisture influences
Seed persistence

Seed enhancement and delivery

**Primining**

**Coating and pelleting**

**Direct seeding**

**Improved vigour:**
- Increased speed germination.
- Greater uniformity germination.
- Increased stress tolerance.

**Mechanised delivery:**
- Precision sowing of mixed species.
- Defined seeding rate.
- Controlled sowing depth.

**Enhanced delivery:**
- Uniformity of size and weight.
- Incorporation of chemical/biological agents.
- Reduced predation.
Lab germ of viable retrieved seeds/florets

- High
- Low

Seedbank Persistence / Germination

- Months Burial: 0, 4, 8, 12, 2, 6, 10

- Prolonged period of dormancy maintenance

Germination is enhanced when cleaned from florets to seeds

Reduction in soil seed bank persistence
• Should we sow dormant seeds and let nature take its course?
  • Have smoke requiring seeds.
  • Have PY seeds 5 yrs in the soil and still all dormant.
  • Predation, erosion, viability decline.

• Should we alleviate dormancy in all seeds?
  • Reduced persistence in PD seeds of framework species.

• Should we de a 50/50 blend and build in bet-hedging?

• Can we “re-engineer” persistence through enhancement?
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