A synthesis of seed-based restoration research in the desert:

the *Pilbara Seed Atlas Project* and beyond

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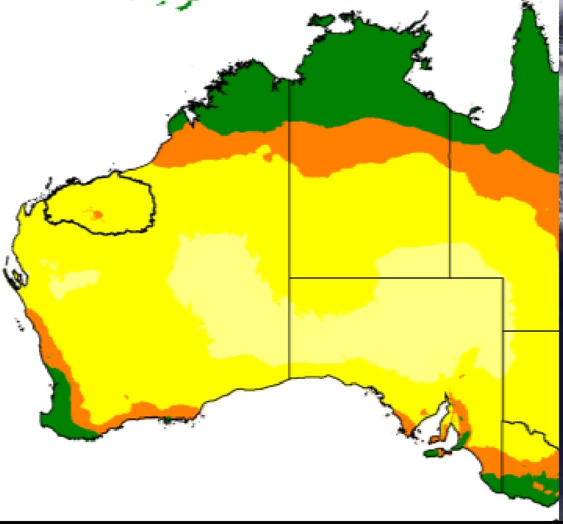
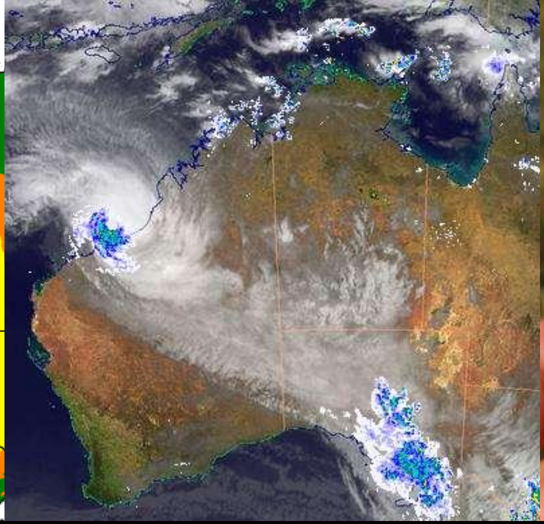
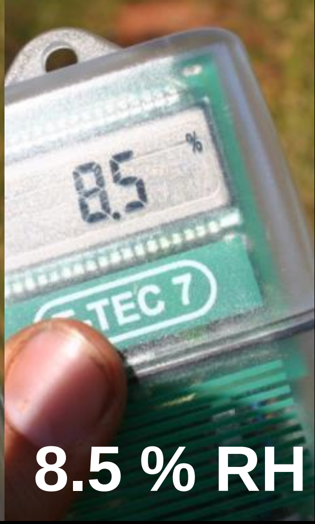
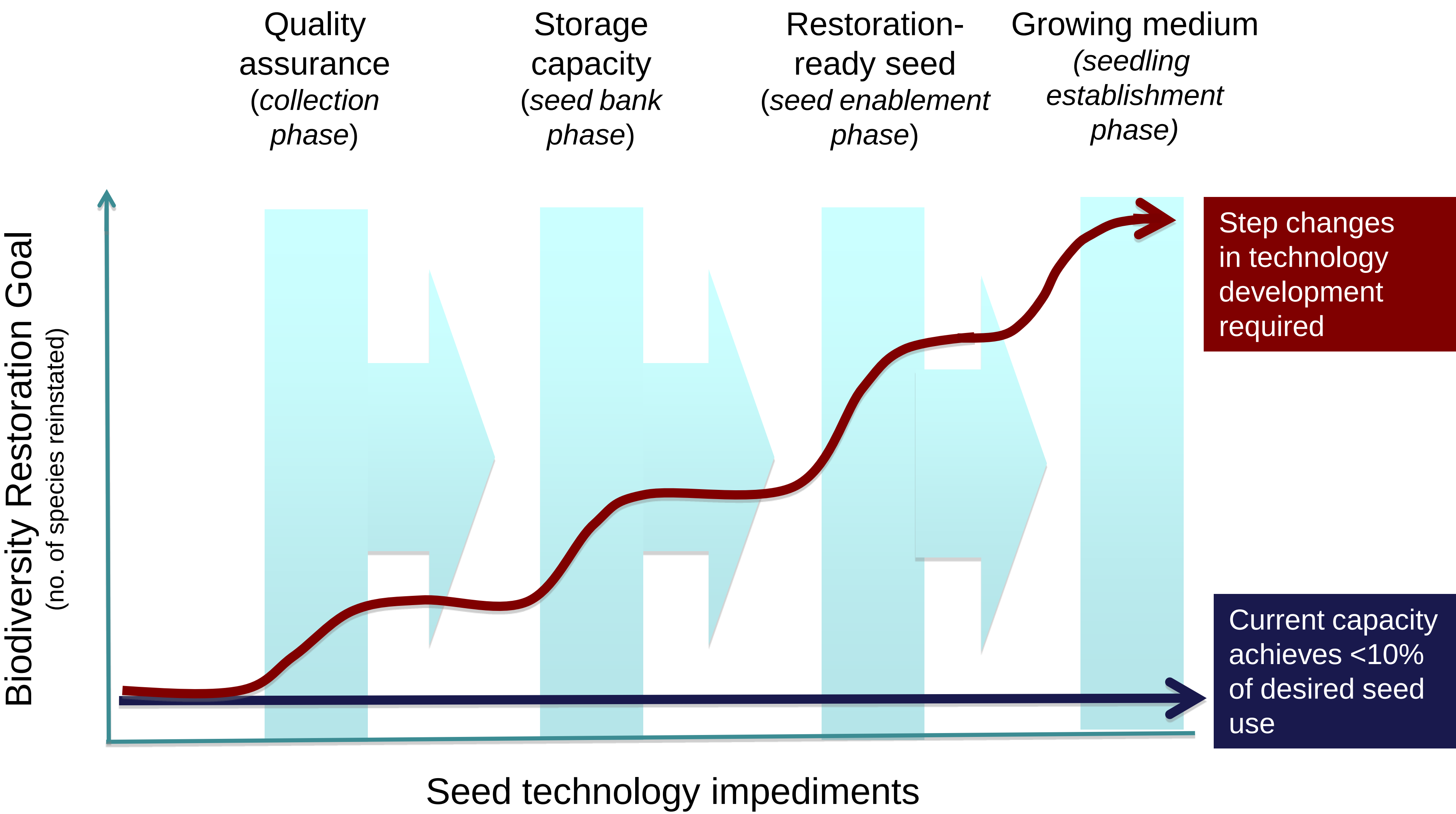


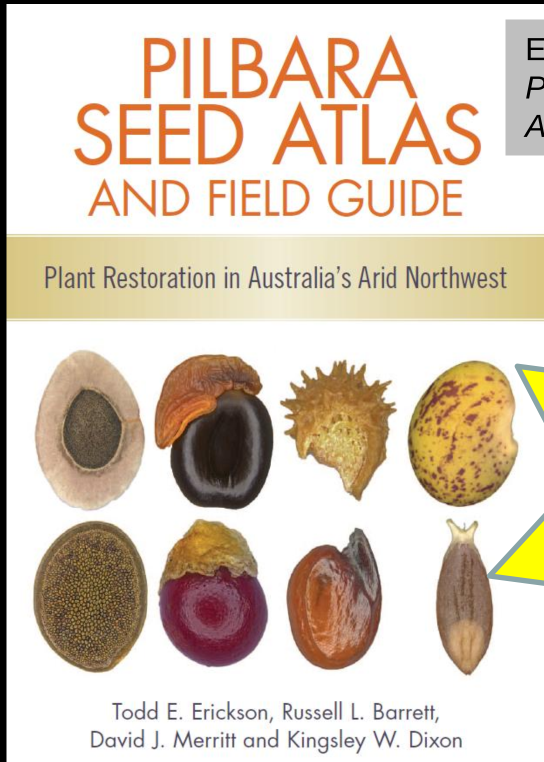




...the Pilbara bioregion......

...improving restoration at scale through seed-based research......





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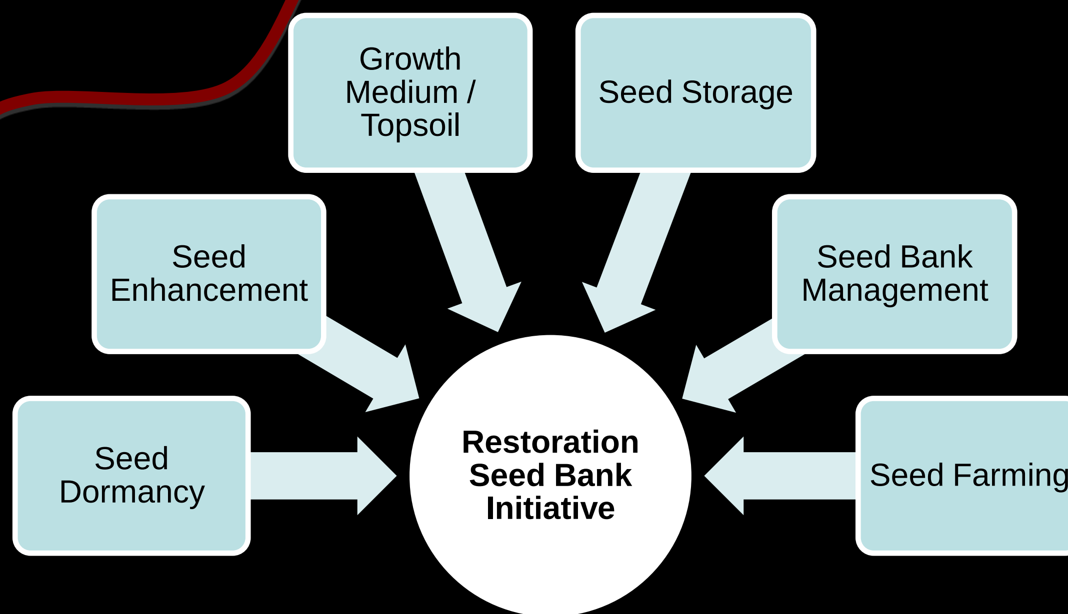
Step changes in technology development required



The "Pilbara Seed Atlas"

Seed-use manual and plant identification guide

Specimen location map (Pilbara region)

Typical position within the landscape (un-shaded)

Phenology calendar (e.g. mature seed ready for collection – brown circle)

Seed collection details

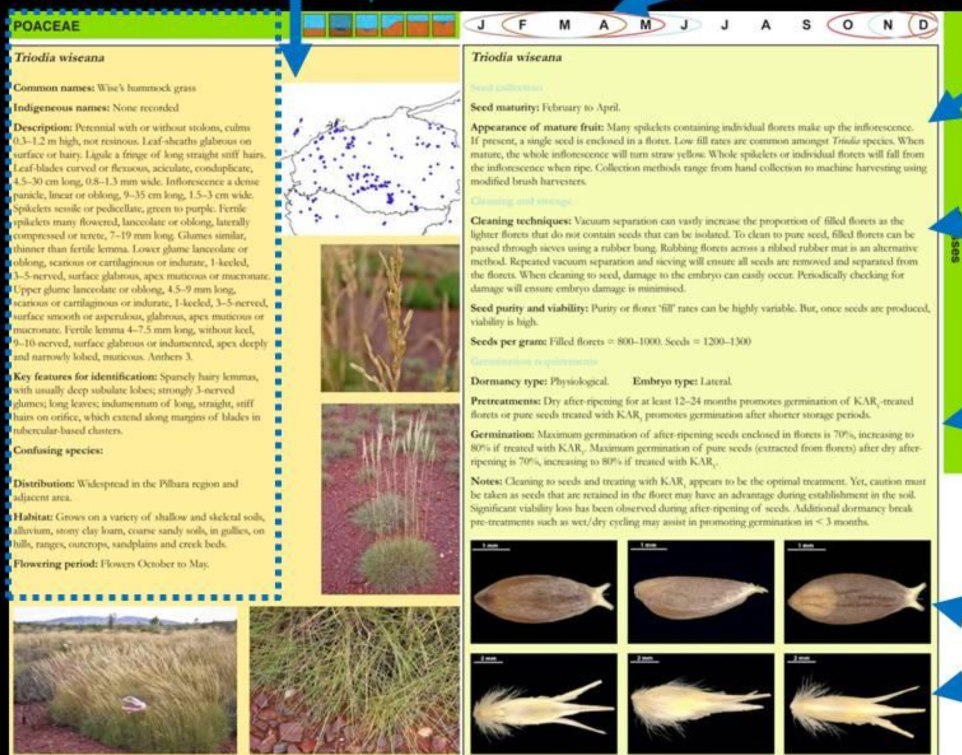
Seed cleaning & quantification details

Plant family & taxonomic description

Seed dormancy & germination requirements

Fruit & seeds images

Field image diagnostics



POACEAE

Triodia wiseana

Common names: Wise's hummock grass

Indigeneous names: None recorded

Description: Perennial with or without stolons, culms 0.3–1.2 m high, not resinous. Leaf-sheaths glabrous on surface or hairy. Ligule a fringe of long straight stiff hairs. Leaf-blades curved or flexuous, aciculate, conduplicate, 4.5–30 cm long, 0.8–1.3 mm wide. Inflorescence a dense panicle, linear or oblong, 9–35 cm long, 1.5–3 cm wide. Spikelets sessile or pedicellate, green to purple. Fertile spikelets many flowered, lanceolate or oblong, laterally compressed or terete, 7–19 mm long. Glumes similar, thinner than fertile lemma. Lower glume lanceolate or oblong, scarious or cartilaginous or indurate, 1-keeled, 3–5-nerved, surface glabrous, apex muticous or mucronate. Upper glume lanceolate or oblong, 4.5–9 mm long, scarious or cartilaginous or indurate, 1-keeled, 3–5-nerved, surface smooth or asperulous, glabrous, apex muticous or mucronate. Fertile lemma 4–7.5 mm long, without keel, 9–10-nerved, surface glabrous or indumented, apex deeply and narrowly lobed, muticous. Anthers 3.

Key features for identification: Sparsely hairy lemmas, with usually deep subulate lobes; strongly 3-nerved glumes; long leaves; indumentum of long, straight, stiff hairs on orifice, which extend along margins of blades in tubercular-based clusters.

Confusing species:

Distribution: Widespread in the Pilbara region and adjacent area.

Habitat: Grows on a variety of shallow and skeletal soils, alluvium, stony clay loam, coarse sandy soils, in gullies, on hills, ranges, outcrops, sandplains and creek beds.

Flowering period: Flowers October to May.

J F M A M J J A S O N D

Triodia wiseana

Seed maturity: February to April.

Appearance of mature fruit: Many spikelets containing individual florets make up the inflorescence. If present, a single seed is enclosed in a floret. Low fill rates are common amongst *Triodia* species. When mature, the whole inflorescence will turn straw yellow. Whole spikelets or individual florets will fall from the inflorescence when ripe. Collection methods range from hand collection to machine harvesting using modified brush harvesters.

Cleaning techniques: Vacuum separation can vastly increase the proportion of filled florets as the lighter florets that do not contain seeds that can be isolated. To clean to pure seed, filled florets can be passed through sieves using a rubber bung. Rubbing florets across a ribbed rubber mat is an alternative method. Repeated vacuum separation and sieving will ensure all seeds are removed and separated from the florets. When cleaning to seed, damage to the embryo can easily occur. Periodically checking for damage will ensure embryo damage is minimised.

Seed purity and viability: Purity or floret 'fill' rates can be highly variable. But, once seeds are produced, viability is high.

Seeds per gram: Filled florets = 800–1000. Seeds = 1200–1300

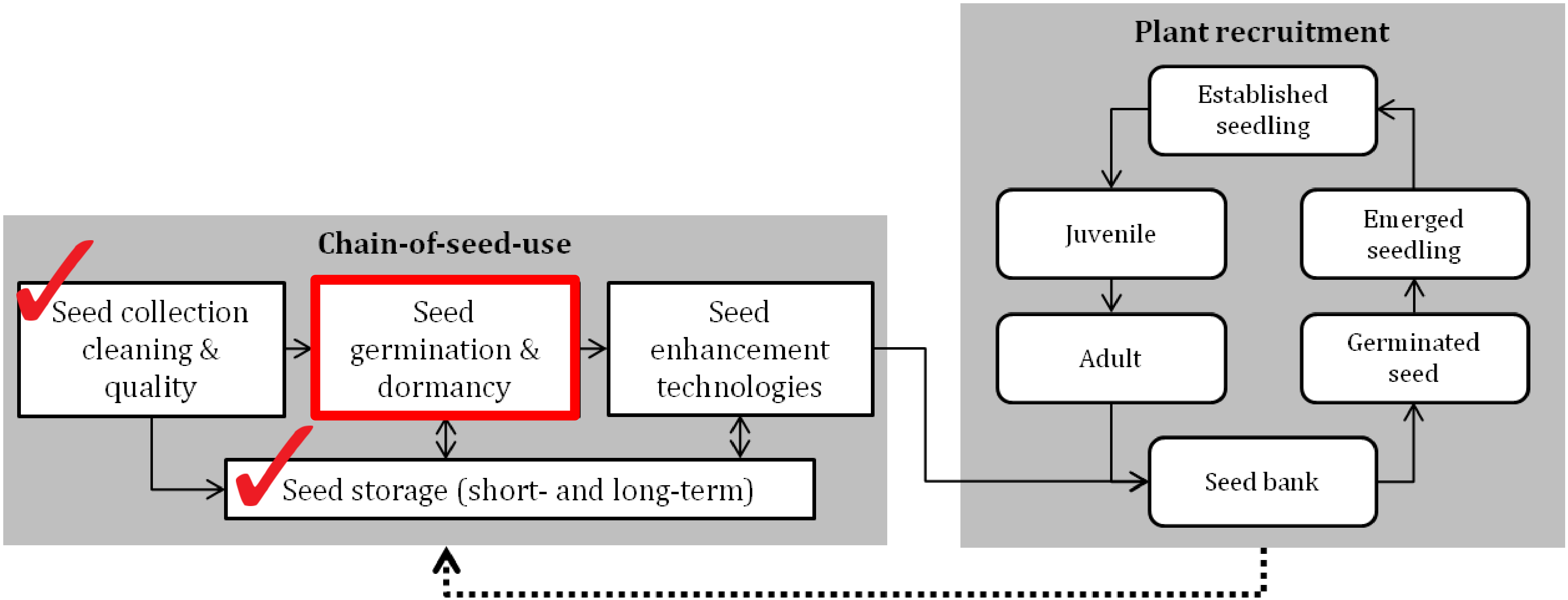
Dormancy type: Physiological. **Embryo type:** Lateral.

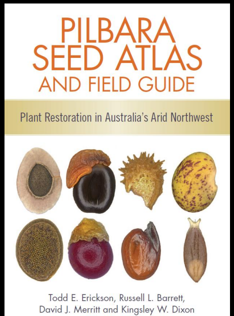
Pretreatments: Dry after-ripening for at least 12–24 months promotes germination of KAR_1-treated florets or pure seeds treated with KAR_1 promotes germination after shorter storage periods.

Germination: Maximum germination of after-ripening seeds enclosed in florets is 70%, increasing to 80% if treated with KAR_1. Maximum germination of pure seeds (extracted from florets) after dry after-ripening is 70%, increasing to 80% if treated with KAR_1.

Notes: Cleaning to seeds and treating with KAR_1 appears to be the optimal treatment. Yet, caution must be taken as seeds that are retained in the floret may have an advantage during establishment in the soil. Significant viability loss has been observed during after-ripening of seeds. Additional dormancy break pre-treatments such as wet/dry cycling may assist in promoting germination in < 3 months.

...improving restoration by using the chain-of-seed-use....





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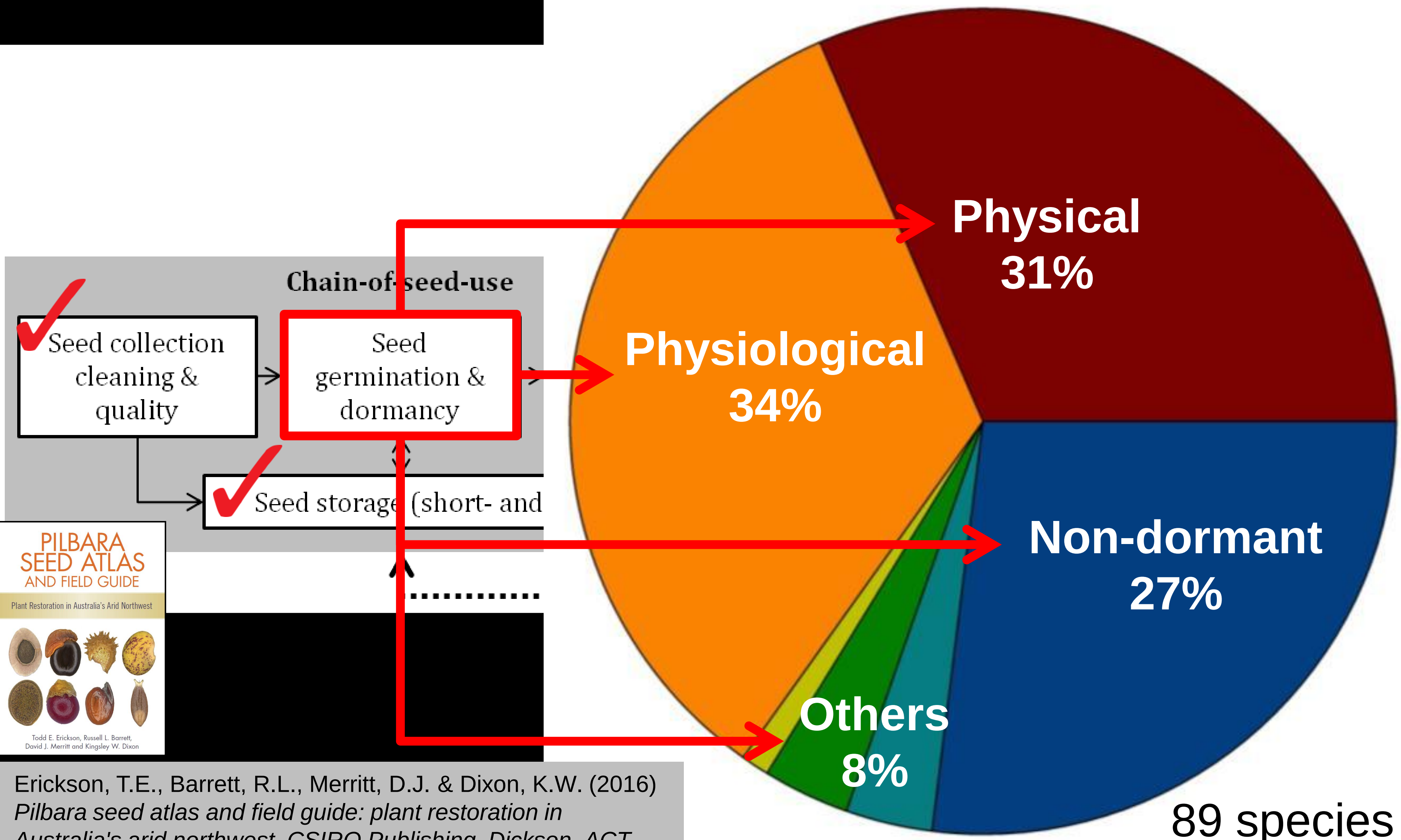
Seed dormancy classification….



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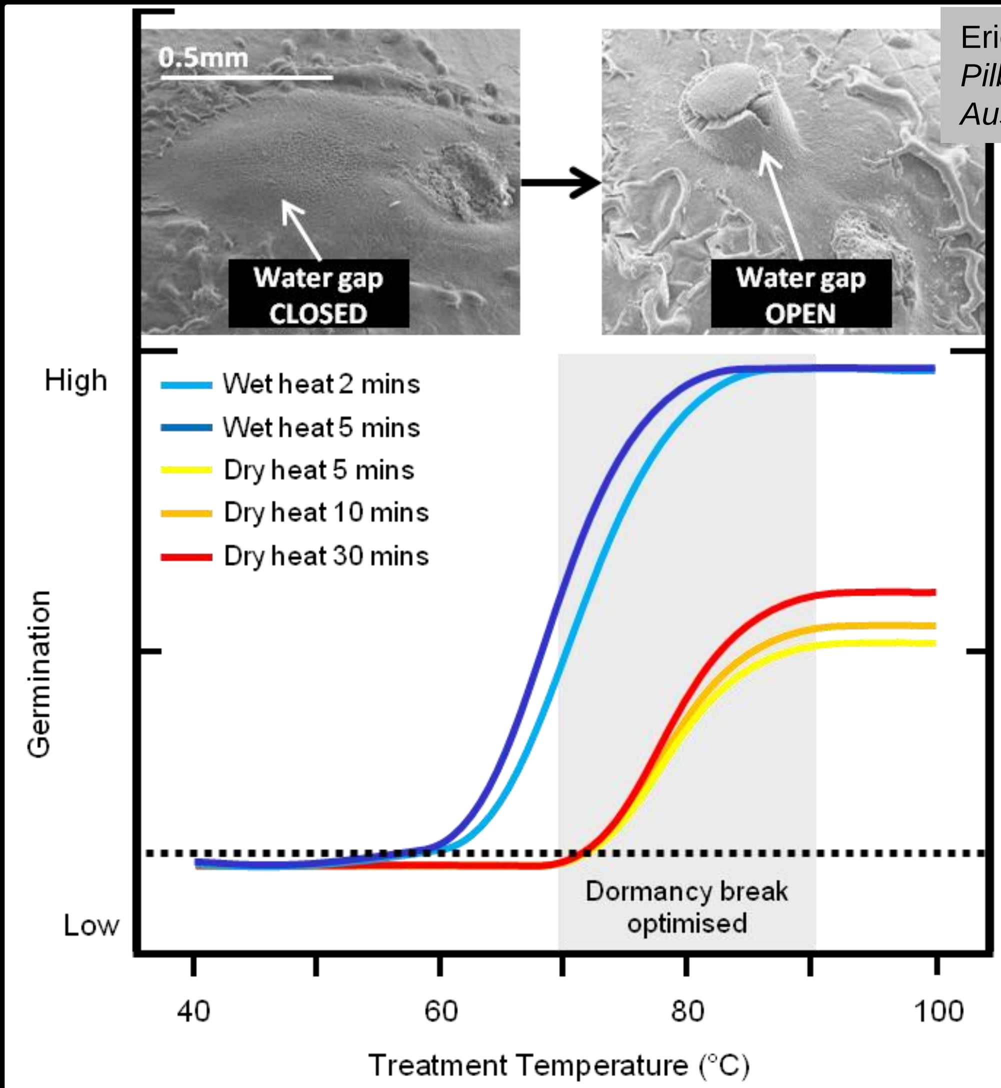
Overcoming physical dormancy….



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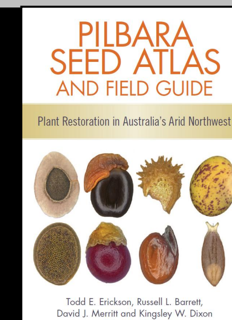
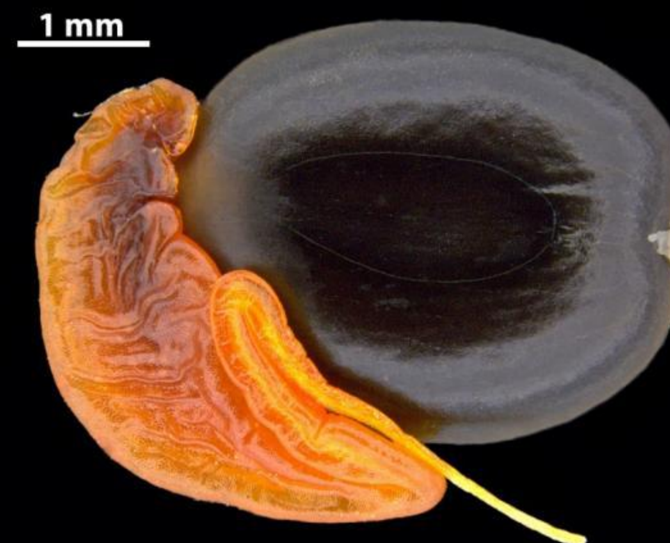
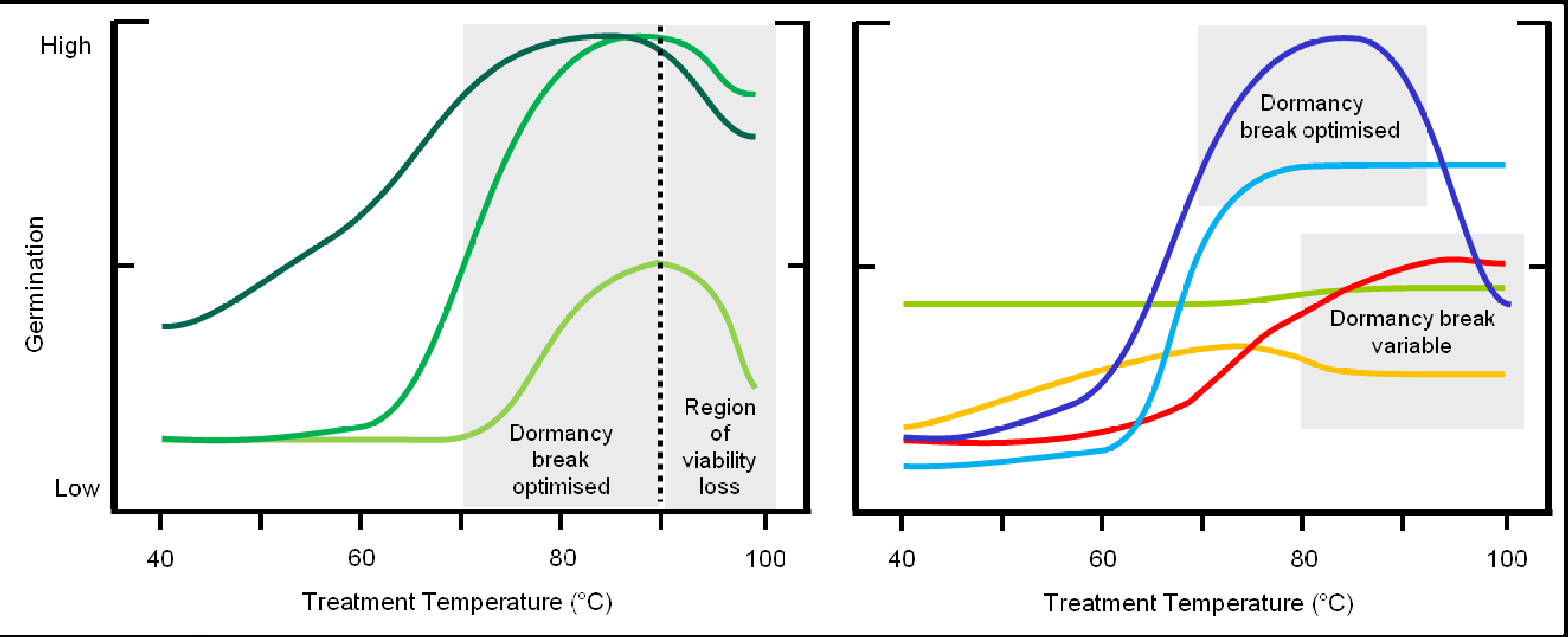
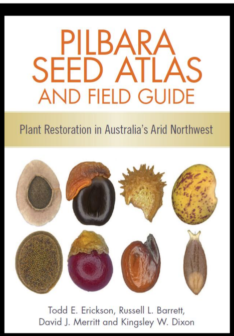




Overcoming *physical* dormancy….





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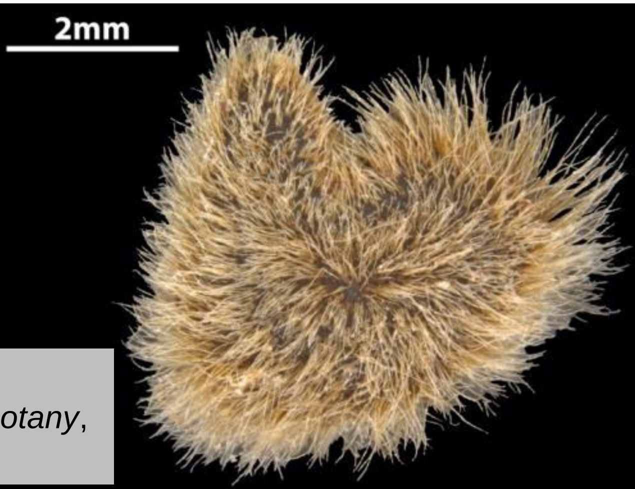
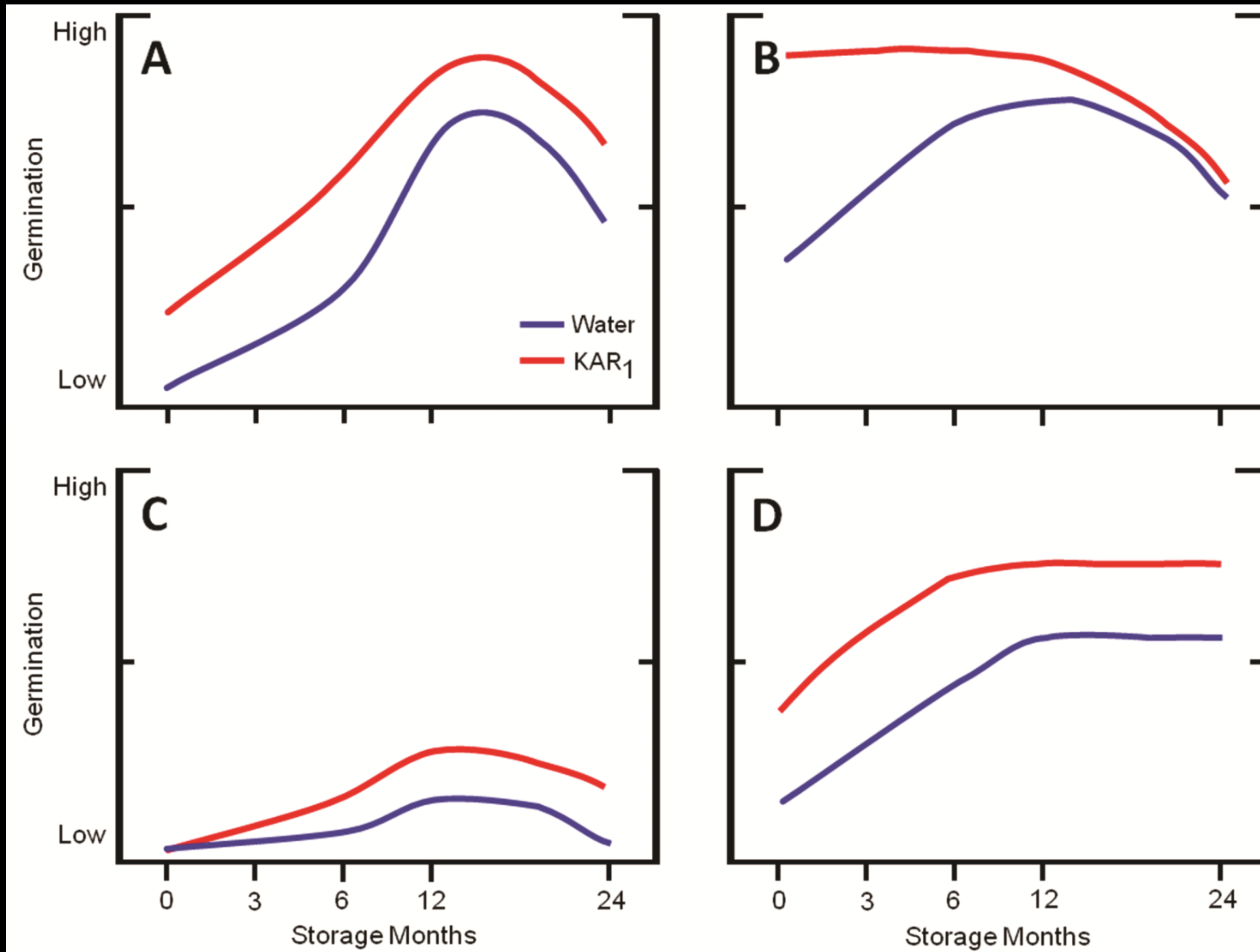


Overcoming physiological dormancy….



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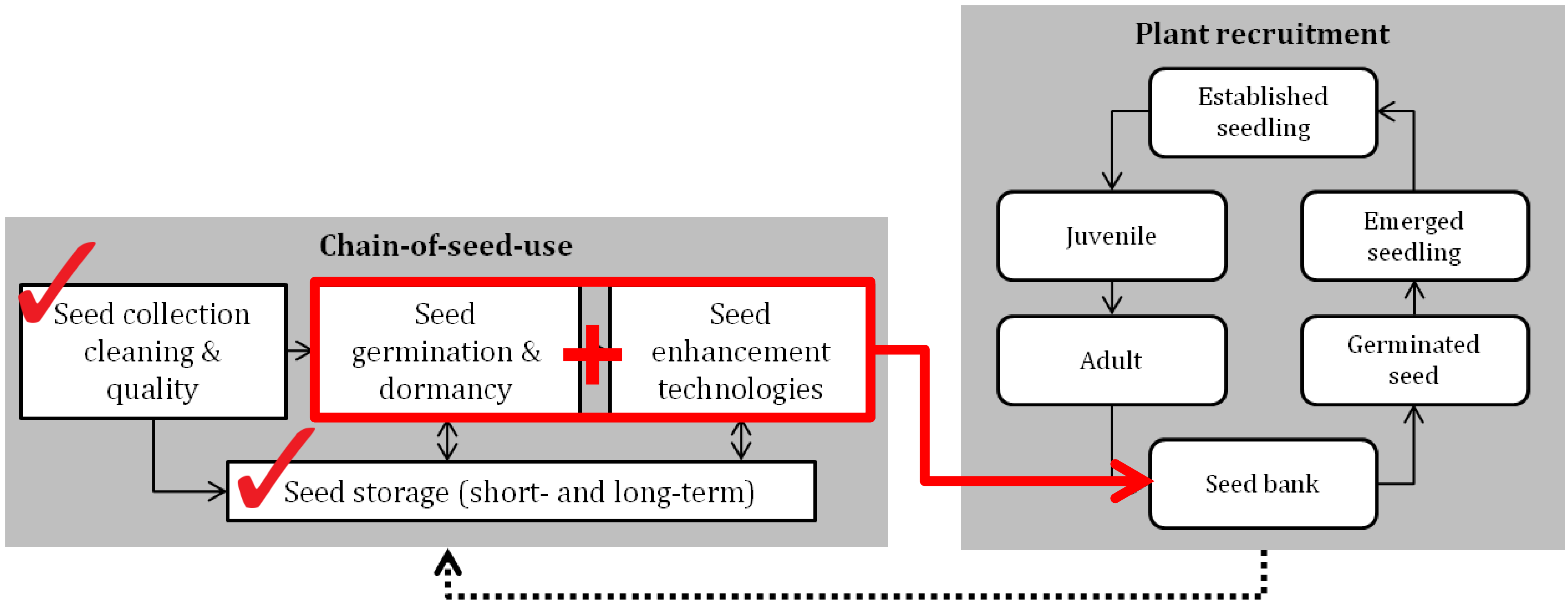
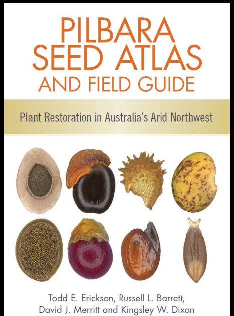
...improving restoration by using the chain-of-seed-use....





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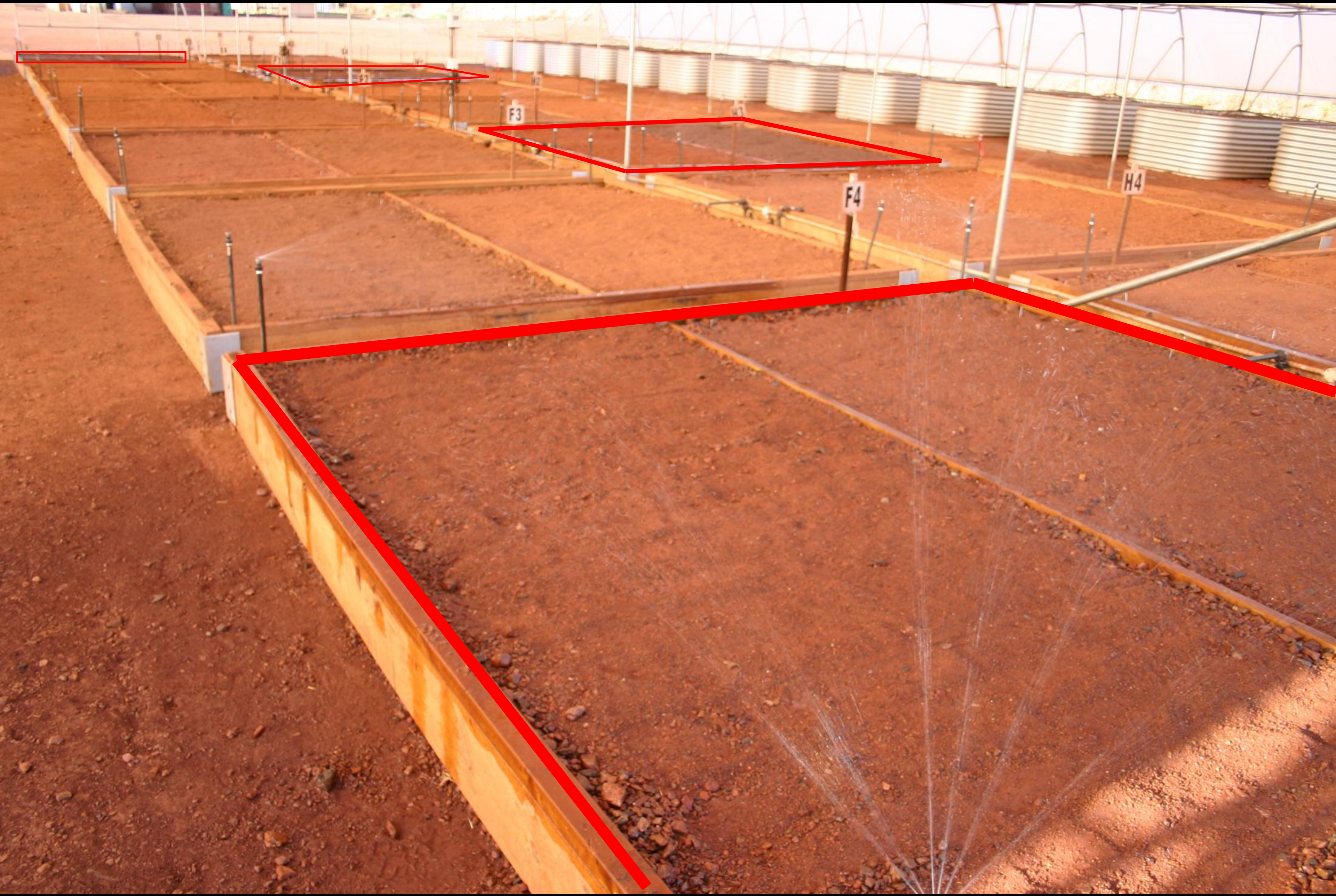
F3
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Some un-published field trial data removed

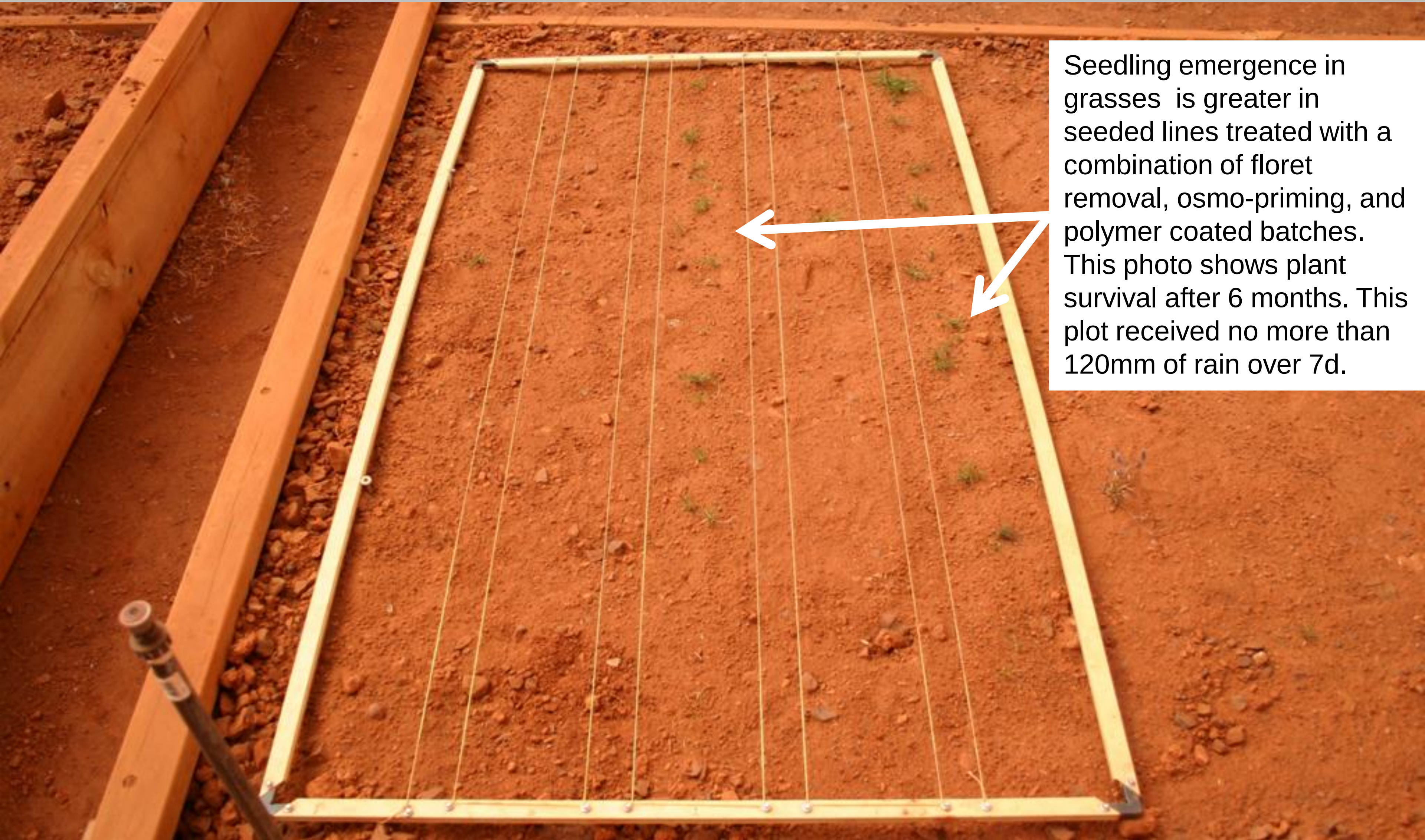
Seed enhancement technologies currently being investigated.......

Extruded pellets

Osmo-priming

Precision flash-flaming

Seeding experiment evaluating the influence various seed pre-treatments including the removal of floret structures in grasses and the application of additional seed enhancement technologies (e.g. polymer seed coats and osmo-priming) across various soil types and simulated rainfall regimes



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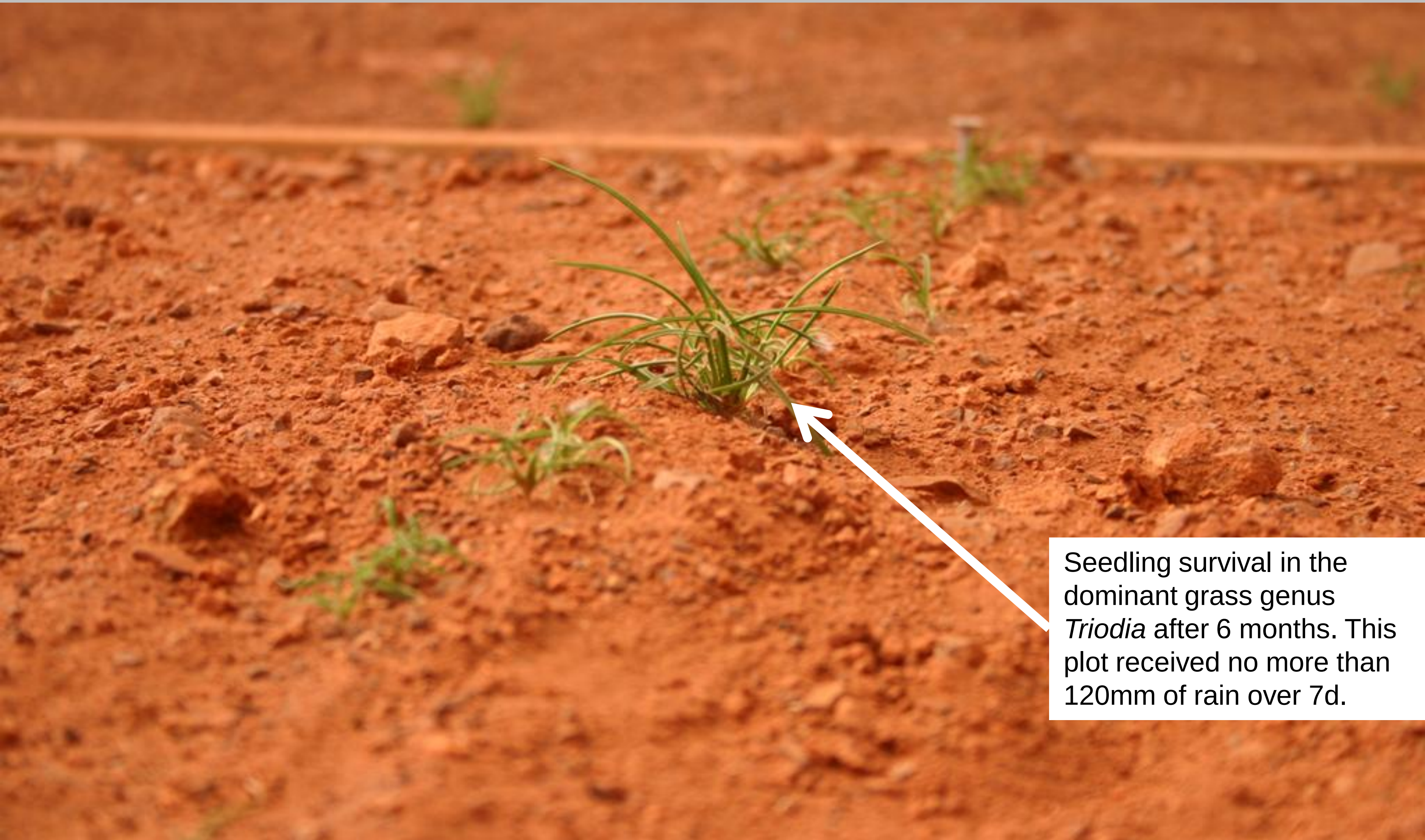

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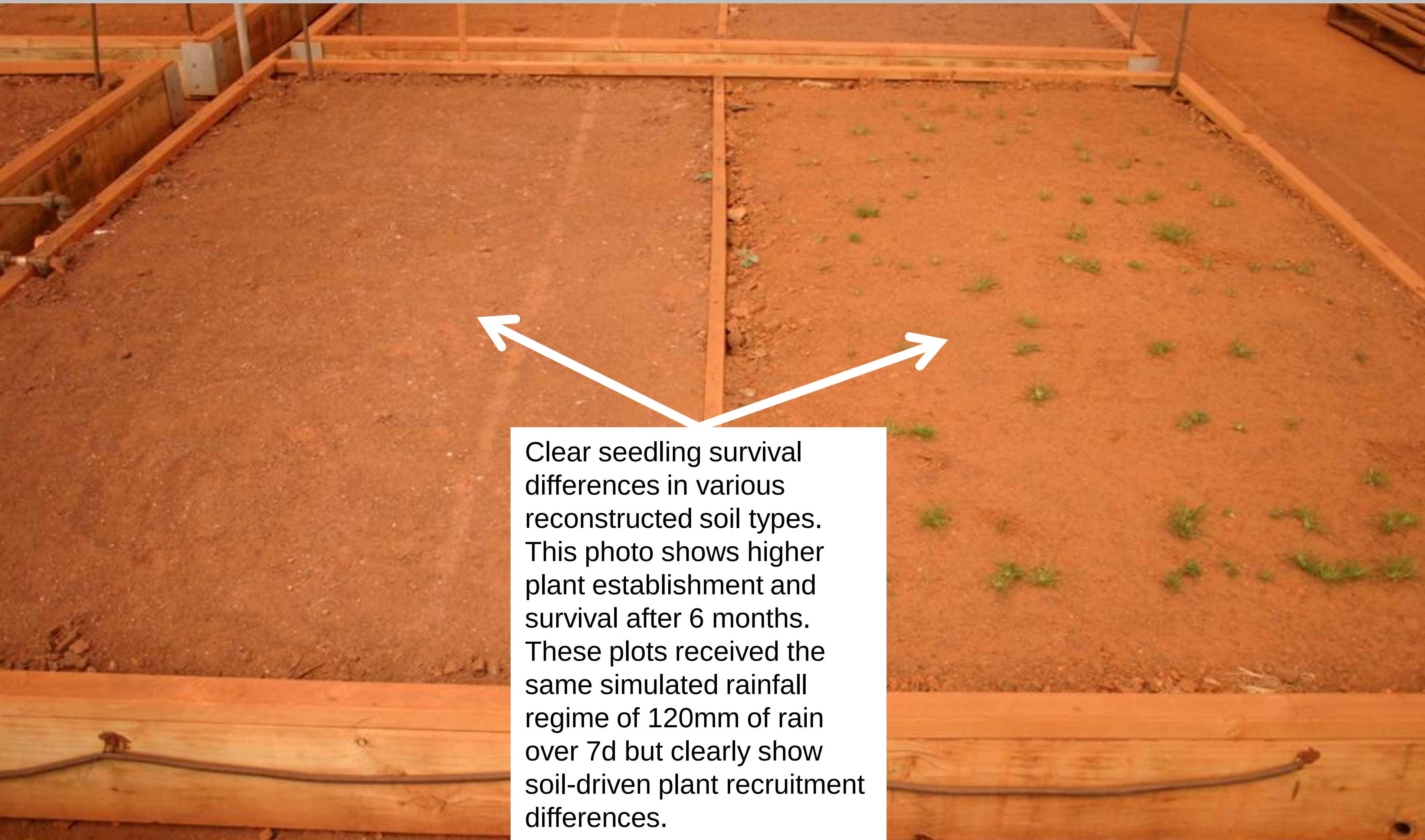

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Some un-published field trial data removed

What does this all mean to Pilbara practitioners?

- Species available for use in restoration range from deeply dormant to "ready-to-go"
- Dormancy classes need to be indentified and treatments developed
- Implementing the chain-of-seed-use makes this possible for 100s of species
- Species that have "hard seeded" seeds have a relatively easy to overcome dormancy mechanism
- To increase the diversity available, research needs to focus on overcoming *physiological dormancy*
- Cleaning and dormancy break protocols have been developed to streamline batch processing (e.g. heat treatments, DAR/WD cycling, flash flaming)
- Seed enhancement technologies, combined with dormancy break treatments, have improved the likelihood of seedling establishment (i.e. 20-40% emergence)
- Must implement field trials to determine if our adopted research approach leads to successful restoration

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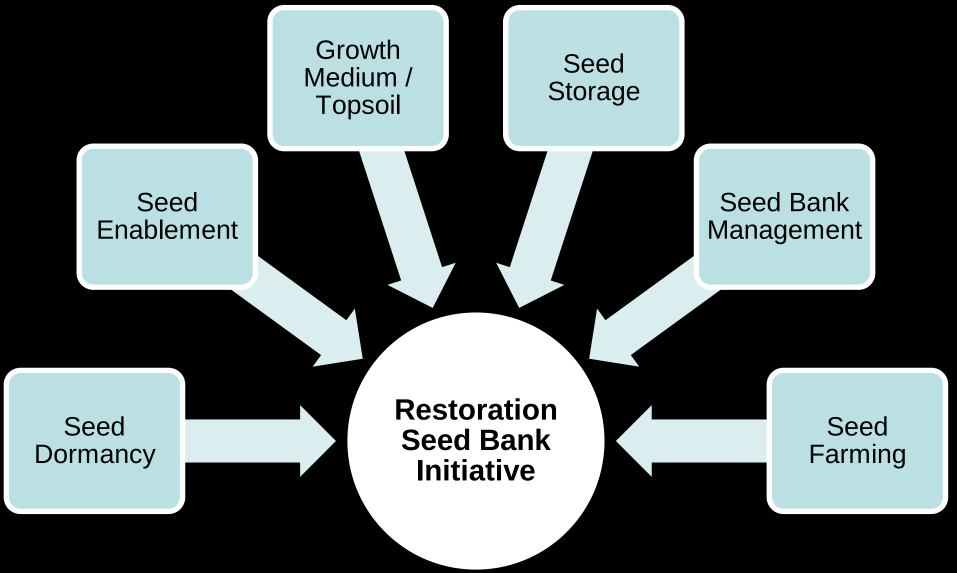

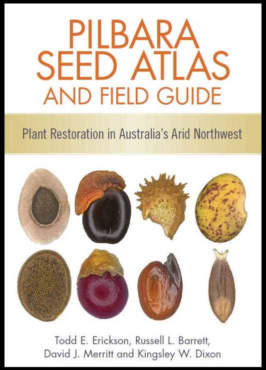

Post-Docs + Research Team

- Dr Todd Erickson
- Dr Miriam Munoz-Rojas
- Dr Alison Ritchie
- Dr Shane Turner
- Dr David Merritt
- Prof. Kingsley Dixon
- Mr. David Symons
- Ms. Christine Best
- Mr. Dylan Martini
- BHPBIO staff and research collaborators

Post-graduate students

- Wolfgang Lewandrowski (PhD)
- Olga Kildisheva (PhD)
- Mallory Barnes (Hons)
- King Yong Ling (Hons)
- Amy Watkins (Hons)
- Ewan Morrison (Hons)
- Amber Bateman (Hons)
- Tayla Kneller (Hons)
- Elvan Ling (Hons)
- Bennett Lovelady (Hons)

Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

INTRODUCTION ARTICLE

Setting the scene for dryland recovery: an overview and key findings from a workshop targeting seed-based restoration

Olga A. Kildisheva[1,2], Todd E. Erickson[1,3], David J. Merritt[1,3], Kingsley W. Dixon[1,3,4]

TECHNICAL ARTICLE

Flash flaming effectively removes appendages and improves the seed coating potential of grass florets

Andrew L. Guzzomi[1,2], Todd E. Erickson[3,4], King Y. Ling[1], Kingsley W. Dixon[5], David J. Merritt[3,4]

RESEARCH ARTICLE

Overcoming physiological dormancy in seeds of *Triodia* (Poaceae) to improve restoration in the arid zone

Todd E. Erickson[1,2,3], Nancy Shackelford[4], Kingsley W. Dixon[1,2], Shane R. Turner[1,2], David J. Merritt[1,2]

RESEARCH ARTICLE

Plant recruitment from the soil seed bank depends on topsoil stockpile age, height, and storage history in an arid environment

Peter J. Golos[1,2,3], Kingsley W. Dixon[1,2,4], Todd E. Erickson[1,2]

RESEARCH ARTICLE

Soil quality indicators to assess functionality of restored soils in degraded semiarid ecosystems

Miriam Muñoz-Rojas[1,2,3,4], Todd E. Erickson[1,2], Kingsley W. Dixon[1,2,3], David J. Merritt[1,2]