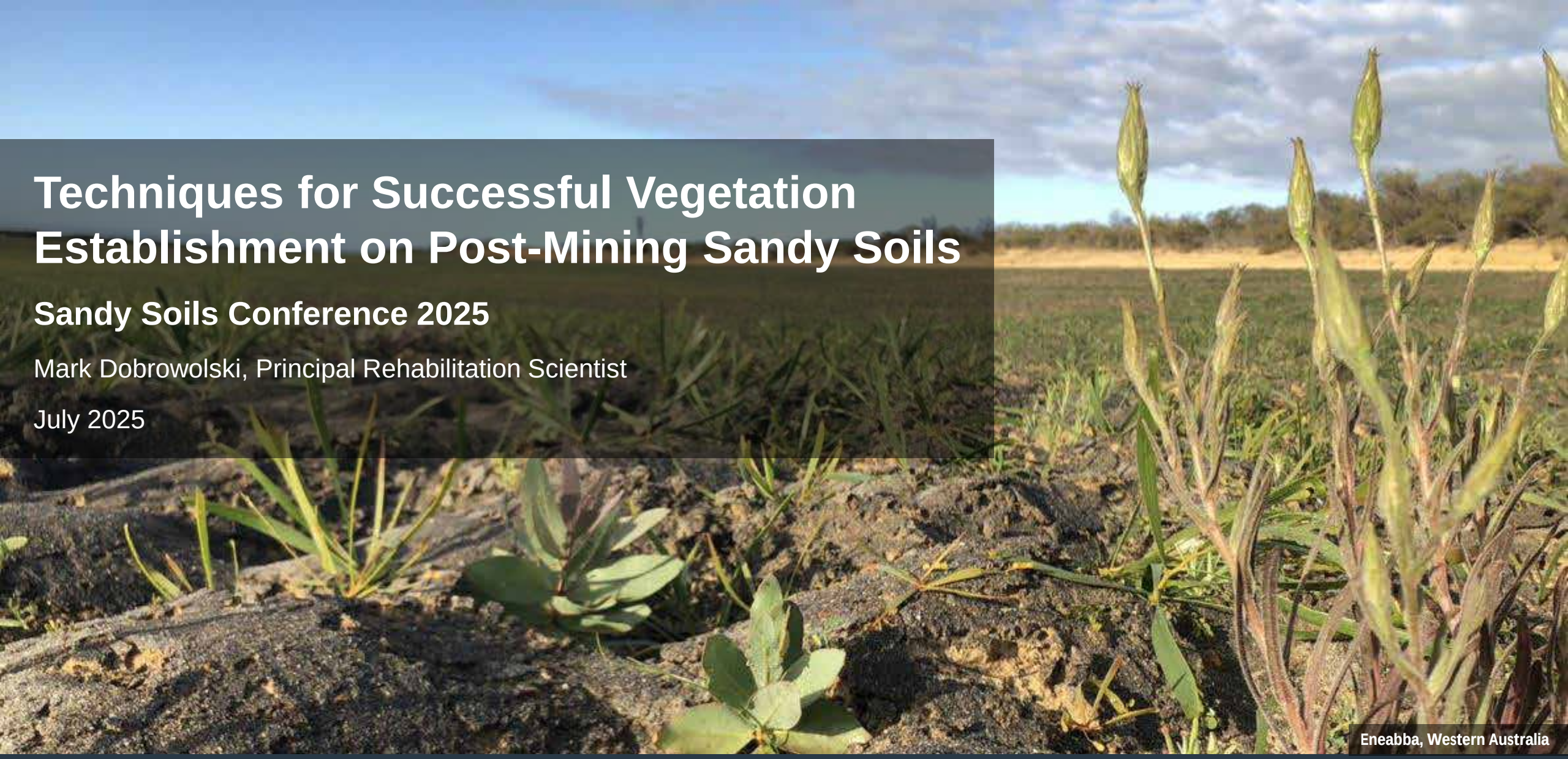
Techniques for Successful Vegetation Establishment on Post-Mining Sandy Soils

Sandy Soils Conference 2025

Mark Dobrowolski, Principal Rehabilitation Scientist

July 2025



Eneabba, Western Australia

OUR PURPOSE

DELIVER SUSTAINABLE VALUE

ILUKA

Necessity is the mother of invention

Restoration is possible

Mineral sands (Ti and Zr minerals) have been mined at Eneabba since 1974

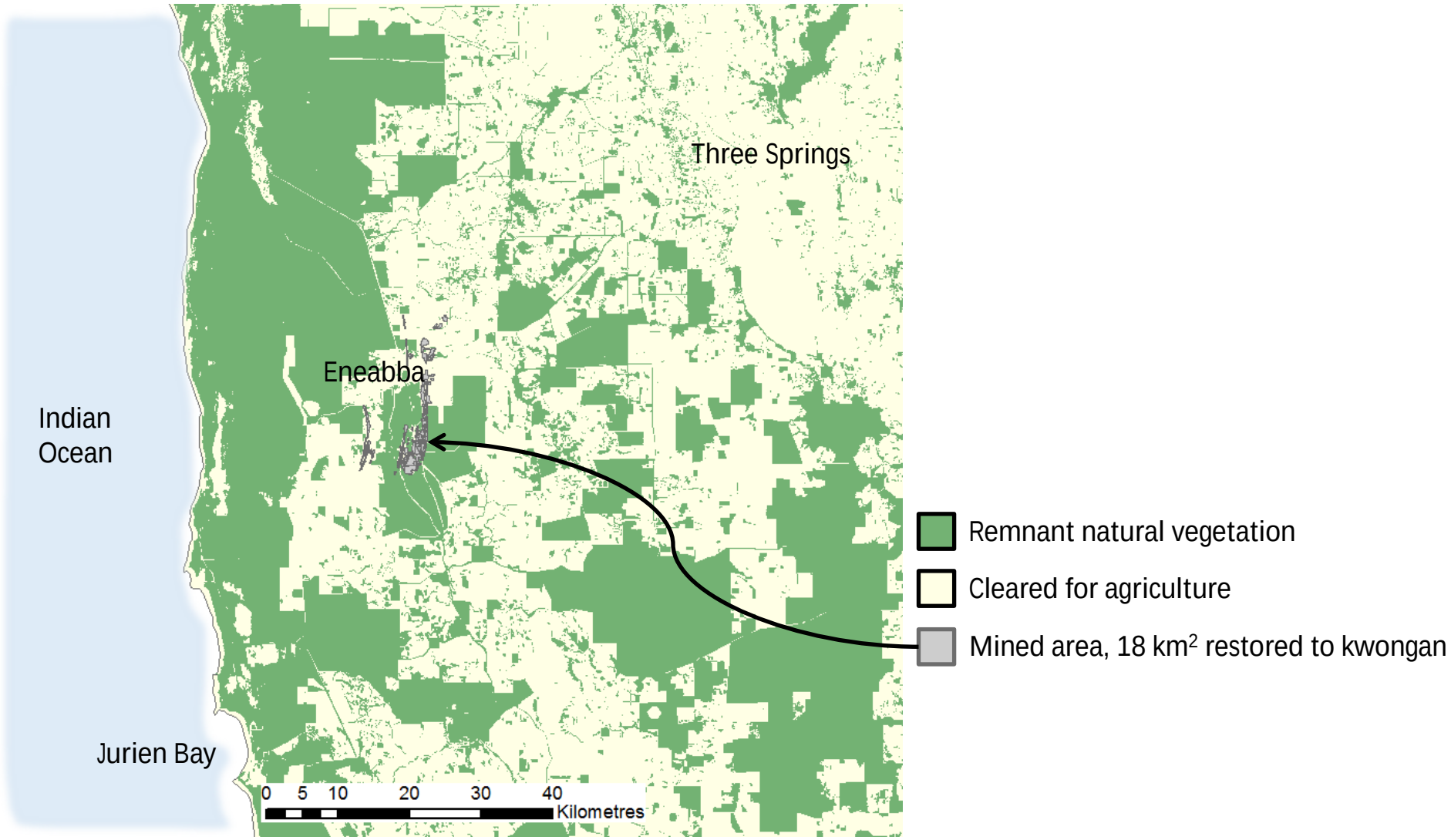
Mining:

- Topsoil and subsoil stripping and separate stockpiling
- Overburden removal
- Ore-body removal and separation by density
- Tailings return to void

Rehabilitation:

- Landform reconstruction of the tailings or overburden
- Soil profile reconstruction with subsoil and topsoil
- Stabilisation, seeding, and planting

At Eneabba in WA's Mid West, Iluka has restored 18 square kilometres of kwongan vegetation over the last 40+ years



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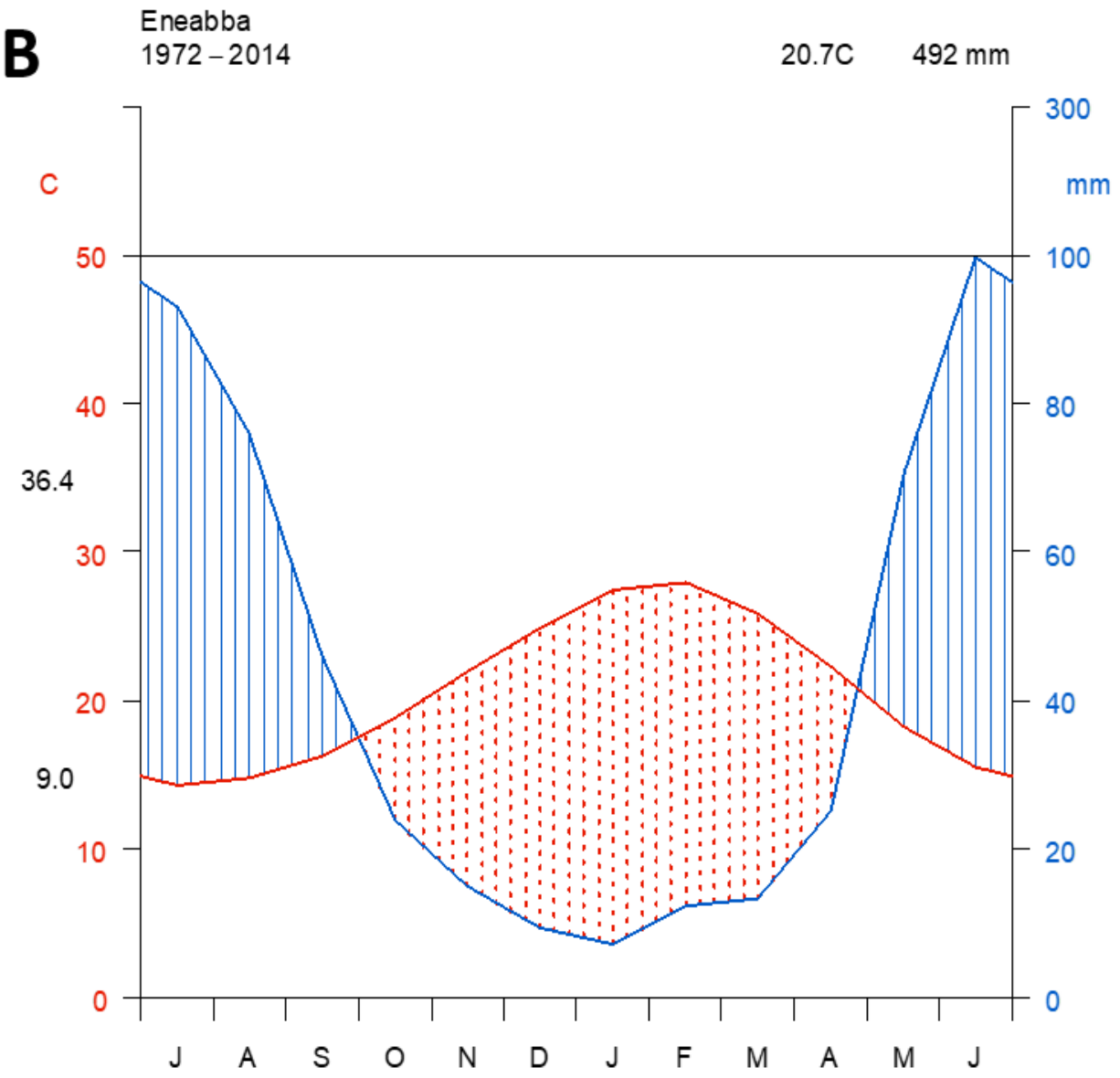
Eneabba has a Mediterranean-type climate with pronounced summer drought

A

B



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Soil stability is a key factor affecting rehabilitation success at Eneabba

Wind erosion at Eneabba during summer, 2013

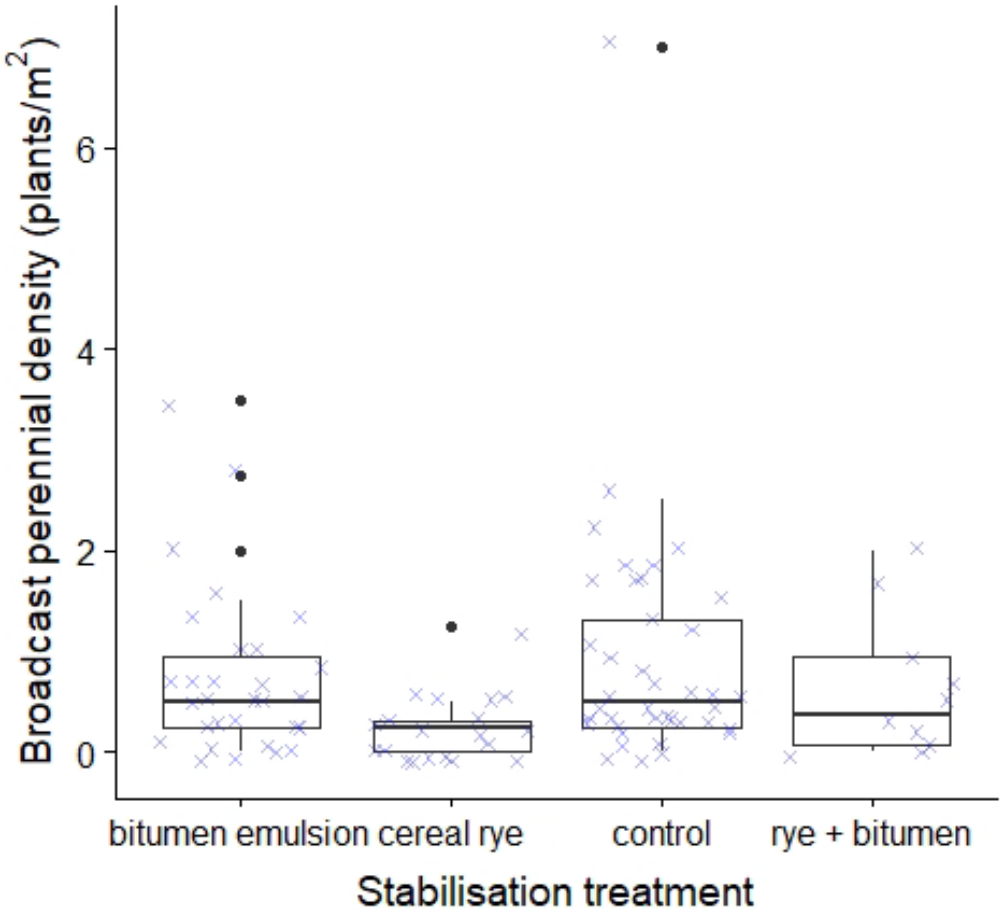
Mulch harvest and spread on topsoil of rehabilitated areas previously provided stability, seed, organic matter, and niches for native seedlings to establish

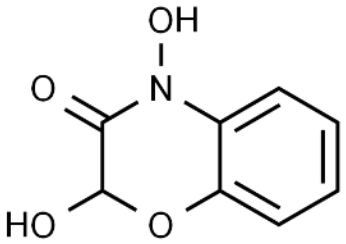
Undisturbed kwongan holds most seed in its canopy (234–494 seeds/m^2) rather than in topsoil (140–174 seeds/m^2)*

Stockpiled topsoil provided only 9% of germinable seed in rehabilitation* and decreased with stockpile age

*Bellairs SM, Bell DT (1993) Seed stores for restoration of species-rich shrubland vegetation following mining in Western Australia. *Restoration Ecology* 1: 231–240.

Cover crops like cereal rye, although helping with soil stability, exude chemicals toxic to germinating native seed





DIBOA *or* 2,4-dihydroxy-1,4-(2*H*)-benzoxazine-3-one

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SPL


2015


2015

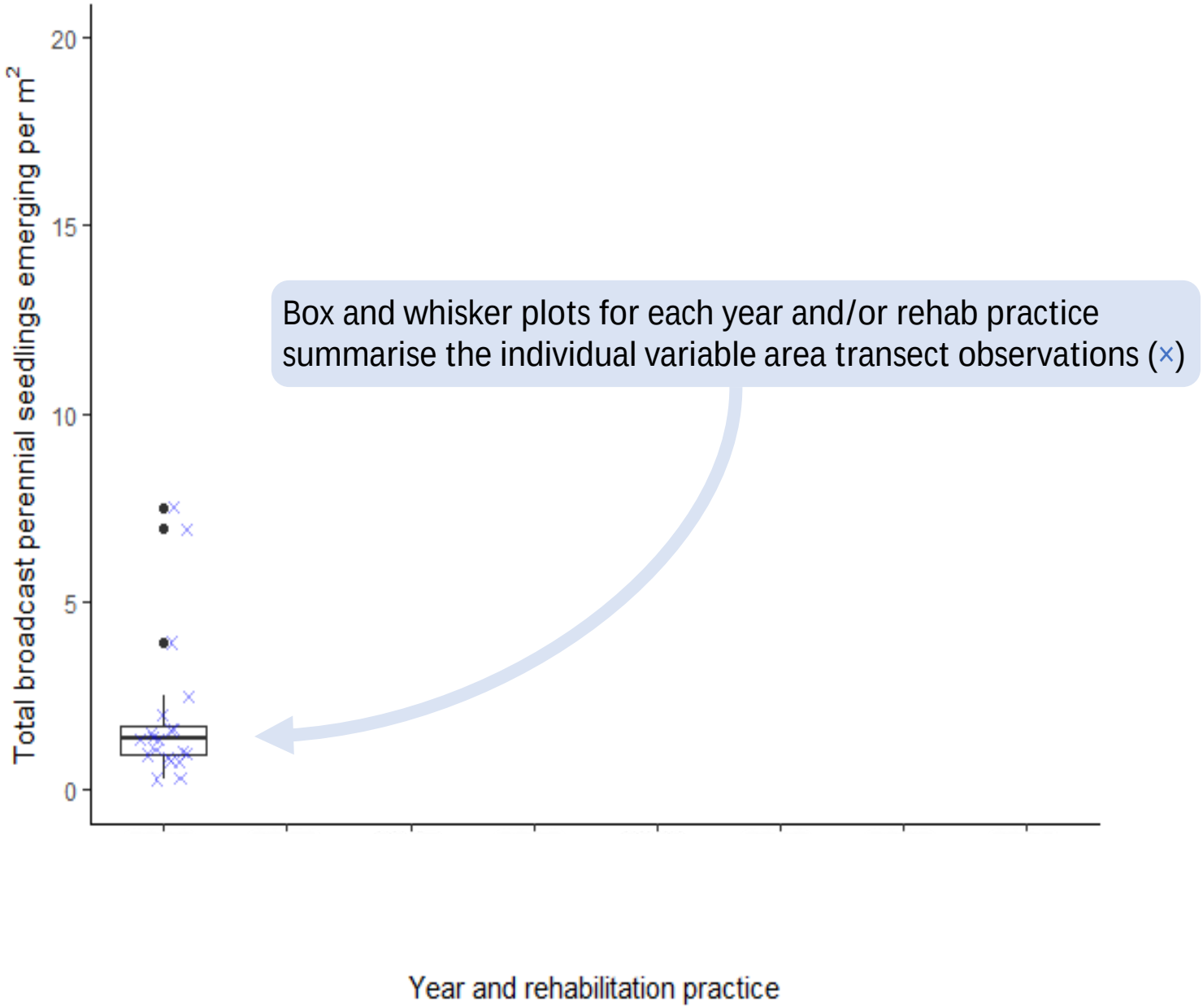

2015

2016


CATERPILLAR
2016


2016

We measured success using variable area transects (VATs) and the number of broadcast perennial native seedlings that emerge in spring



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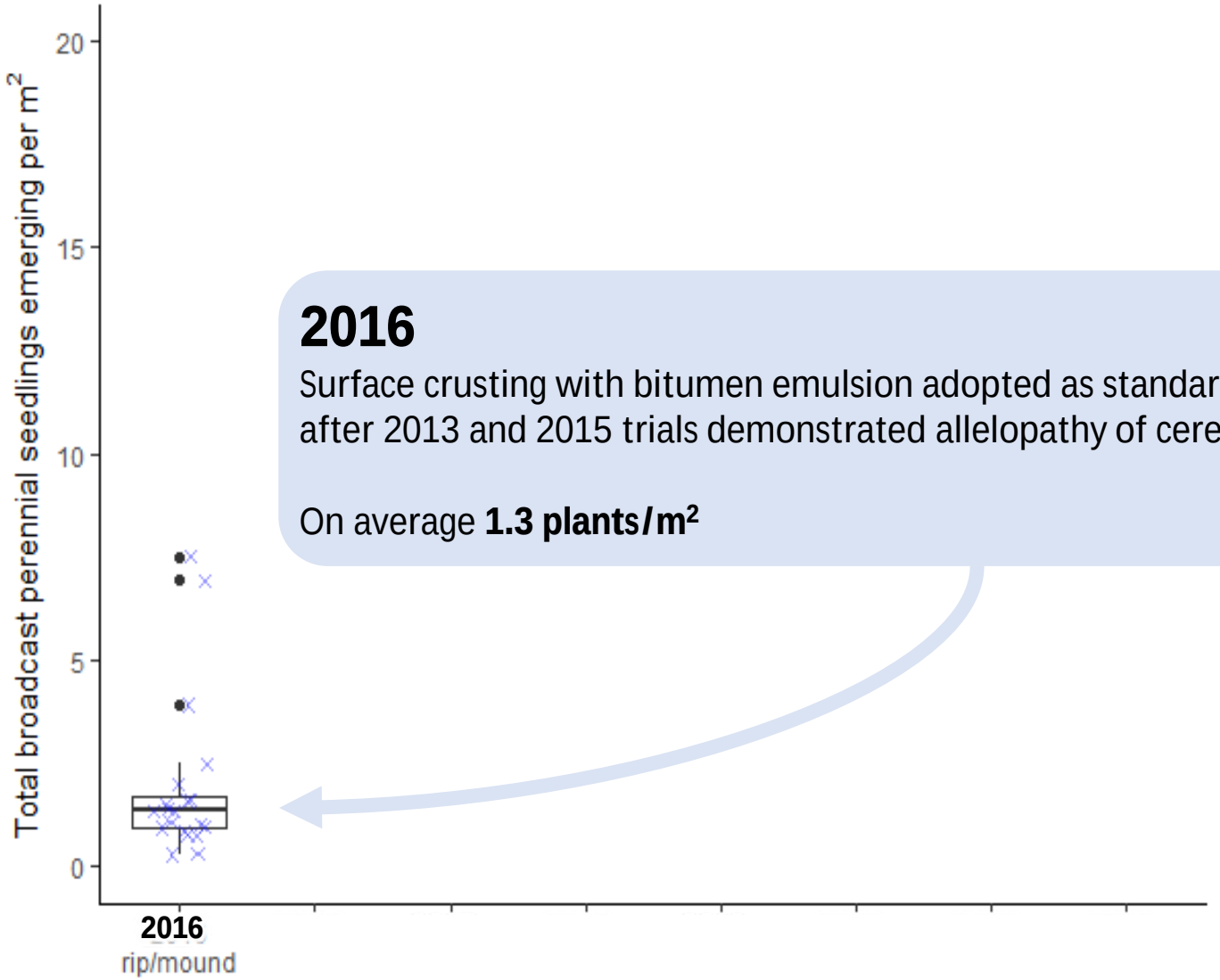
449 mm annual Eneabba rainfall



2016

Surface crusting with bitumen emulsion adopted as standard practice for stabilisation after 2013 and 2015 trials demonstrated allelopathy of cereal rye

On average **1.3 plants/m²**


2016

Published November, 1971

DIVISION S-6—SOIL AND WATER MANAGEMENT AND CONSERVATION

Water Infiltration Control: a Channel System Concept[1]

R. M. Dixon and A. E. Peterson[2]

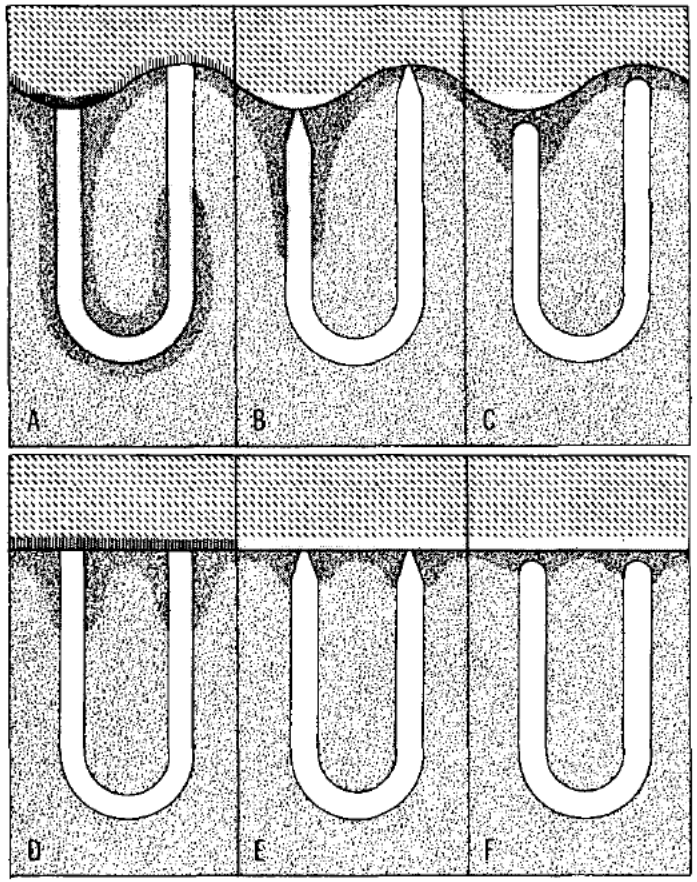
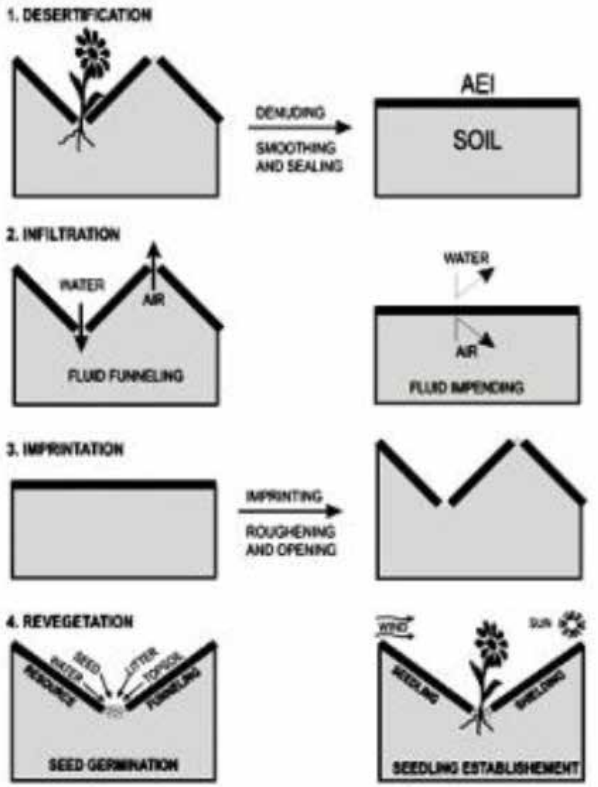


Fig. 2—Idealized channel system states representing six combinations of soil surface roughness and openness. States A, B, and C represent rough surfaces with open, constricted and closed water intake and air exhaust orifices; states D, E, and F represent smooth surfaces with open, constricted and closed orifices.

AEI MODEL FOR RESTORING VEGETATION

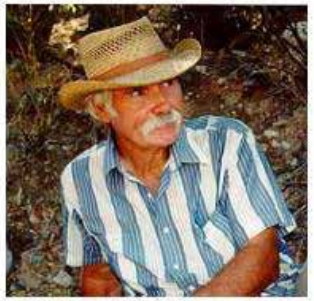


A process that denudes, smooths, and seals the air-earth interface (AEI) to inhibit infiltration and revegetation processes.

A process that exchanges rainwater and soil air across the AEI. Infiltration is rapid across a rough-open AEI and slow across a smooth-closed AEI.

A process that roughens and opens a smooth-closed AEI to accelerate infiltration, revegetation and desertification reversal.

A process, beginning with seed germination and seedling establishment, that needs, creates and maintains a rough-open AEI to reverse desertification and rebuild topsoil.



Dr. Bob Dixon

imprinting.org

We combined land imprinting with dilute bitumen emulsion to increase infiltration and reduce erosion in sandy soils

2017


2017

2017


2017


2017


2017

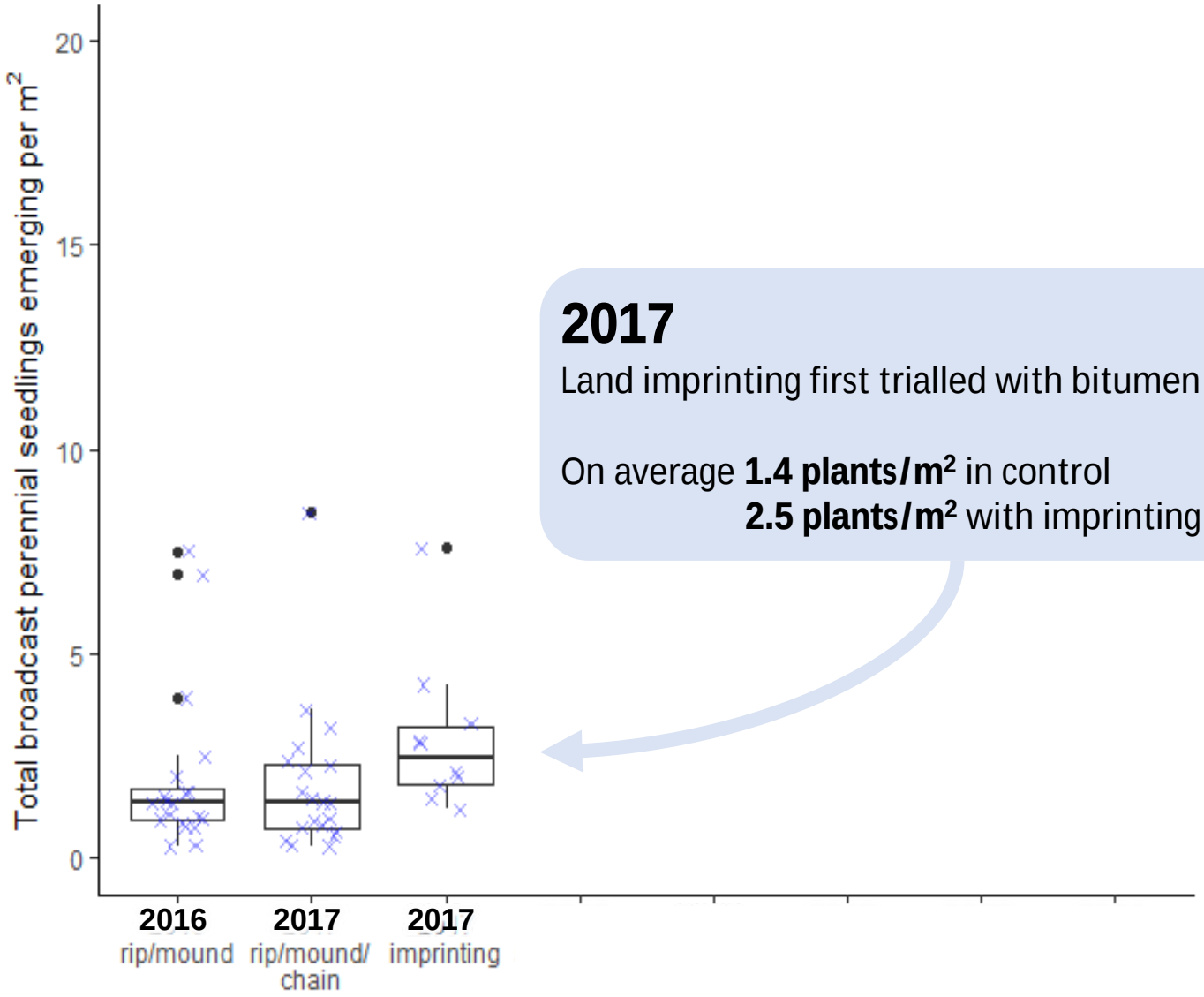

2017


2017

Seedlings emerge through bitumen stabilised imprints that increase infiltration

2017

449 **417** **417** mm annual Eneabba rainfall



2017

Land imprinting first trialled with bitumen emulsion

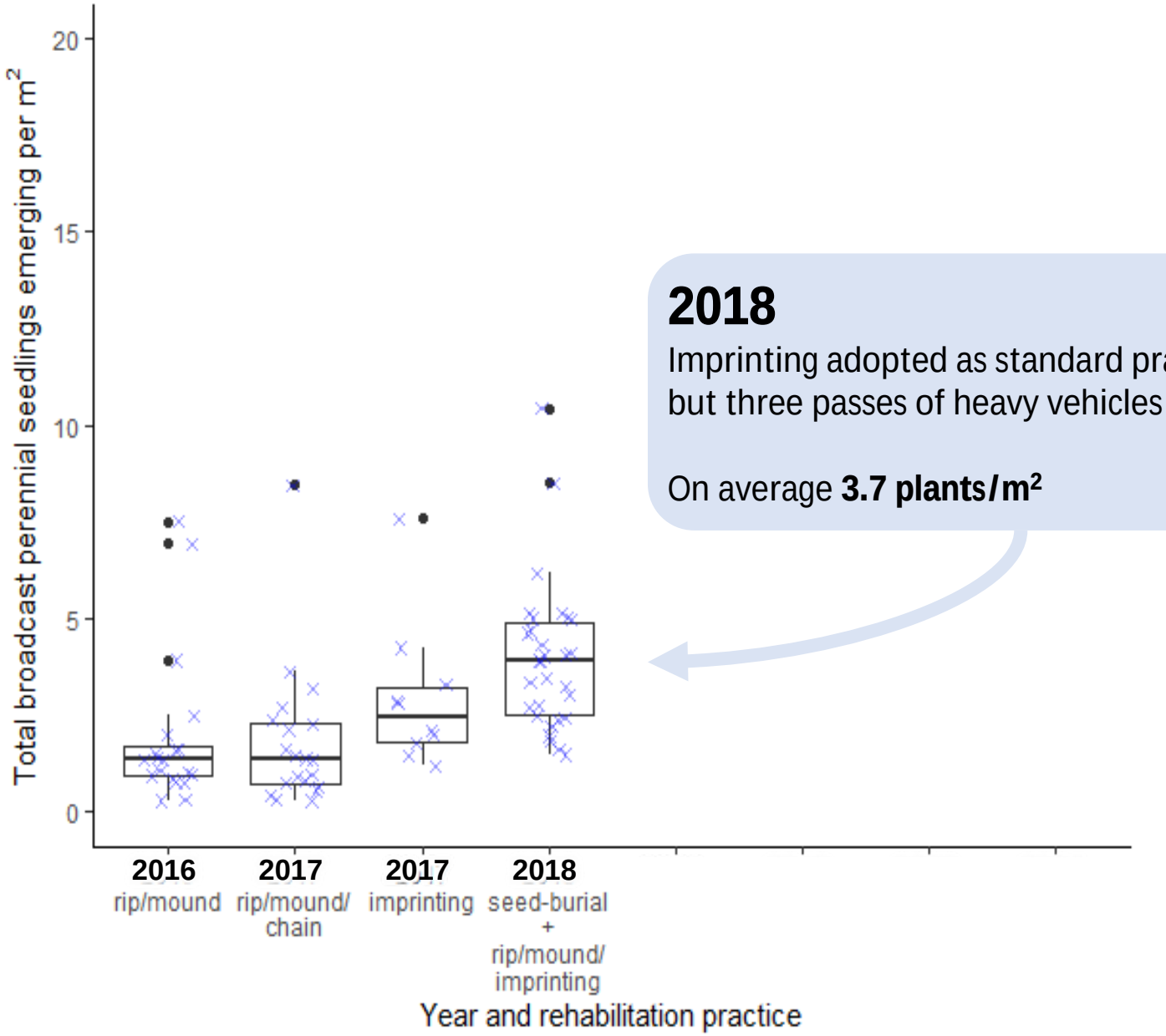
On average **1.4 plants/m²** in control
2.5 plants/m² with imprinting


Spring 2017


Summer 2017


Autumn 2018

449 **417** **417** **476** mm annual Eneabba rainfall



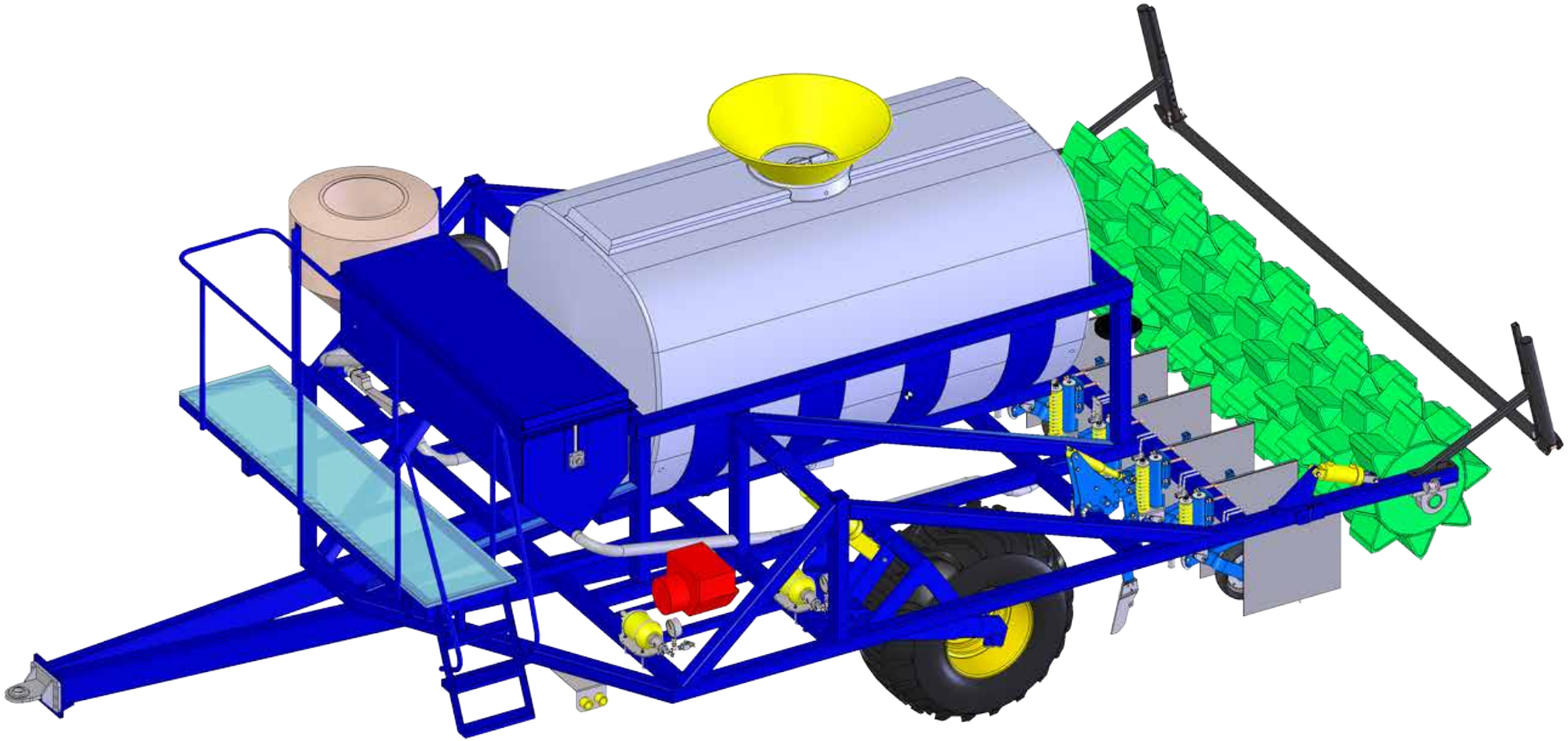
2018

Imprinting adopted as standard practice in 2018 but three passes of heavy vehicles required

On average **3.7 plants/m²**

2019

Flora Restorer is designed to fertilise, scarify the soil surface, air-seed diverse seed, land imprint, and spray an artificial soil crust in one pass



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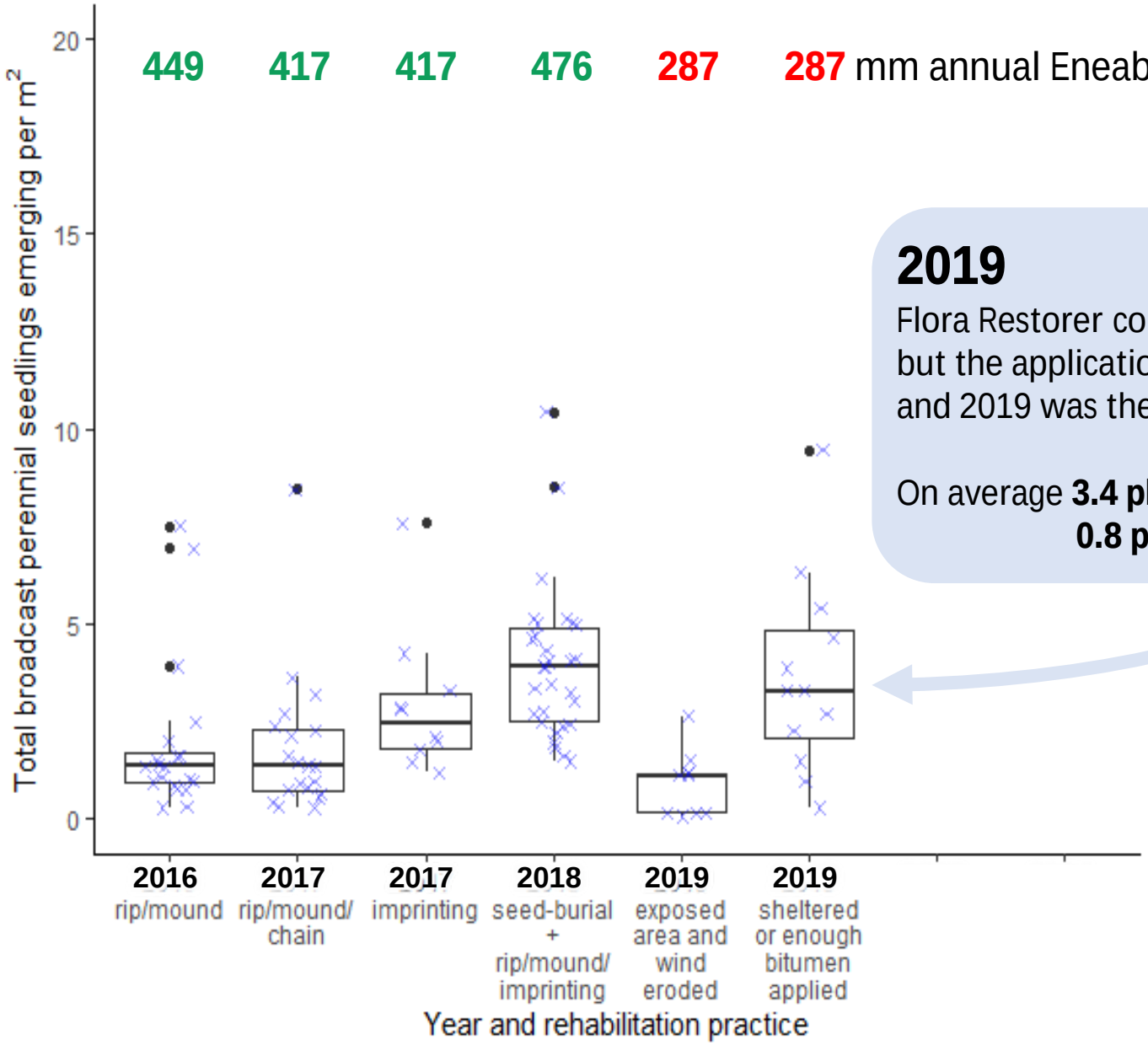
2019

2019

2019, the year of Flora Restorer commissioning, was the driest year on record yet winter rains began with heavy downpours



2019

Flora Restorer commissioned
but the application of bitumen emulsion was too low and 2019 was the driest year on record

On average **3.4 plants/m²** in sheltered areas
0.8 plants/m² in eroded areas

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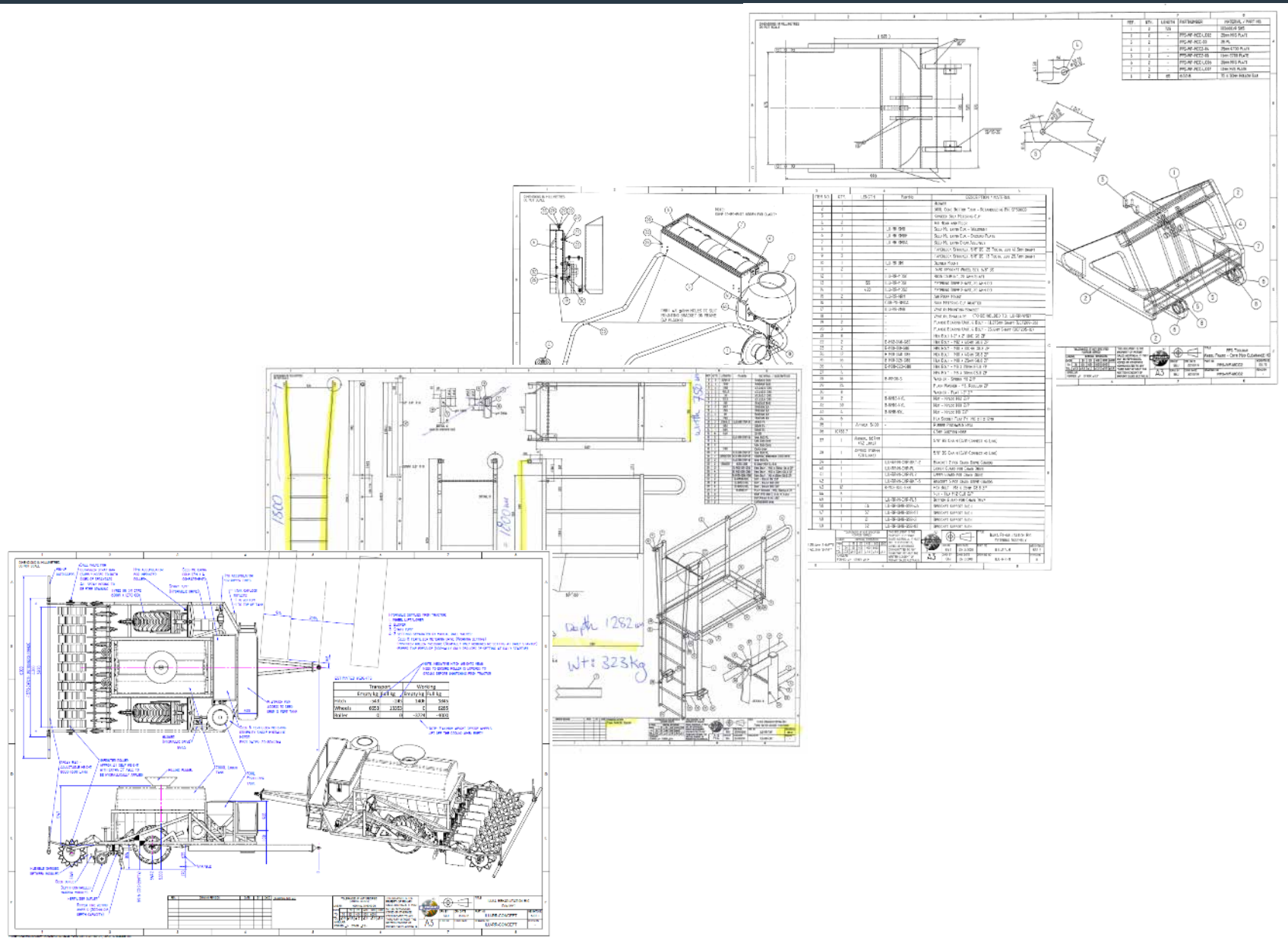
Redesign and modifications for Flora Restorer delivered the required spray rate among other safety and structural improvements



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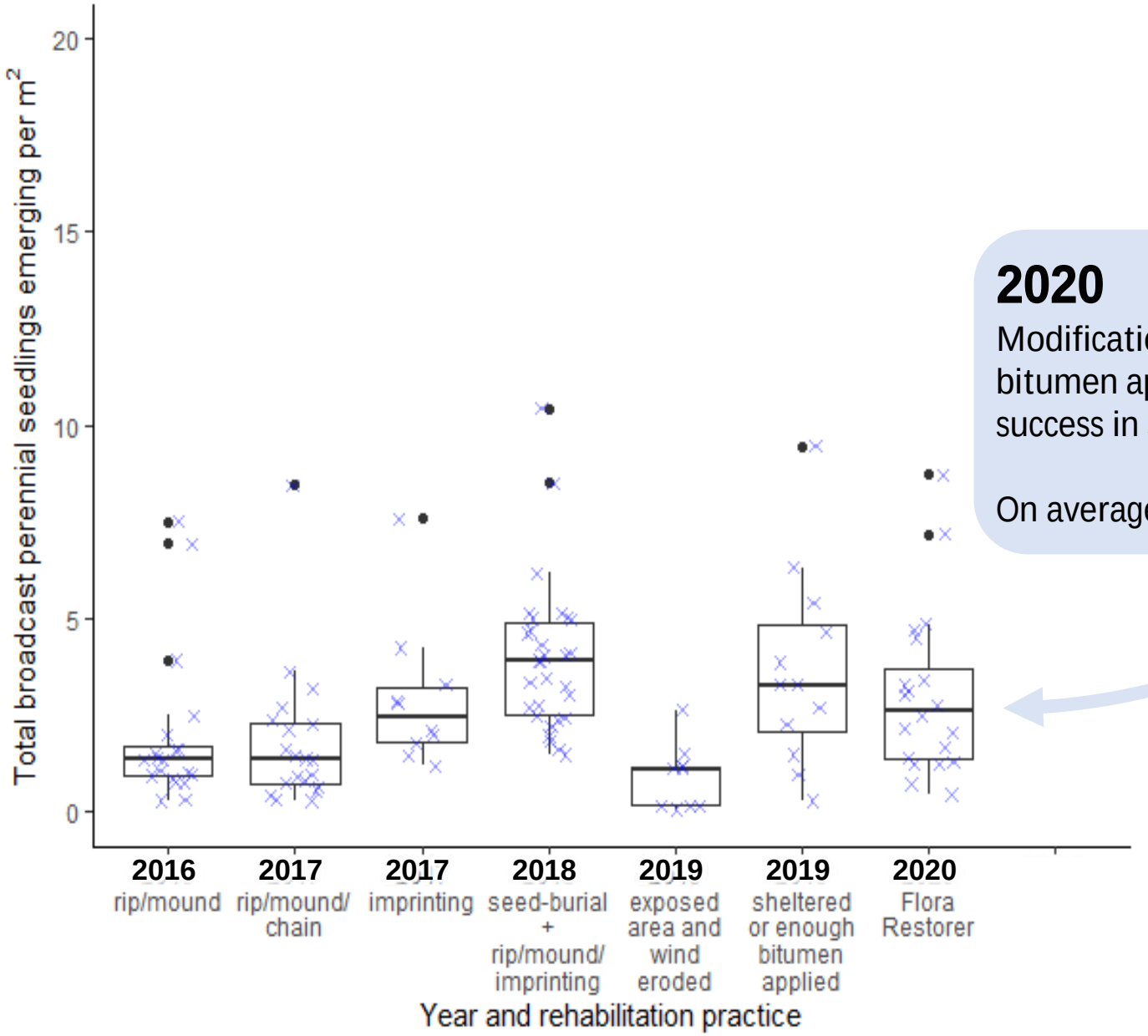
2020


2020

449 417 417 476 287 287 365 mm annual Eneabba rainfall

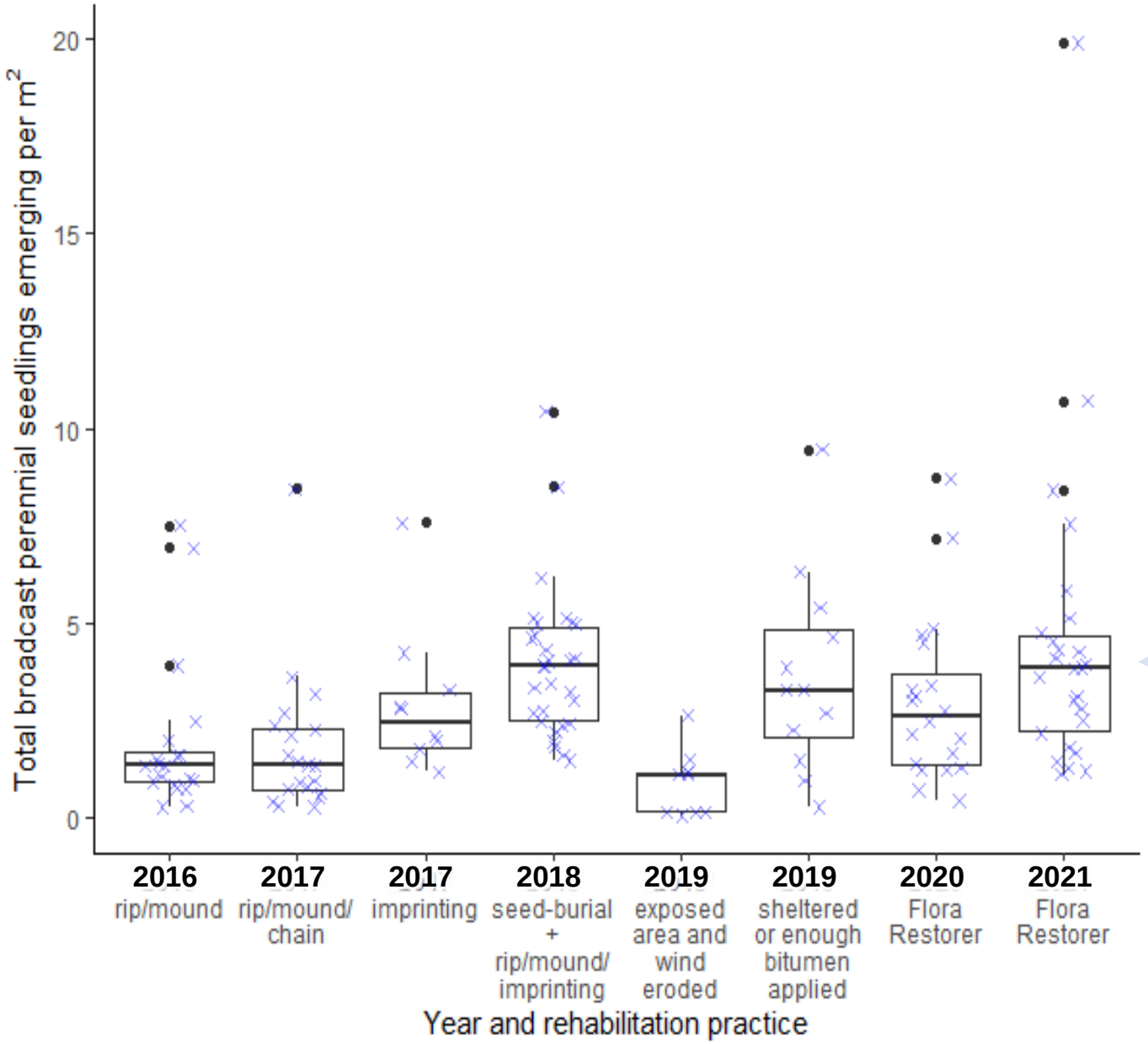


2020

Modifications made to Flora Restorer improving bitumen application rate and operational safety; success in spite of low rainfall

On average **2.6 plants/m²**

449 **417** **417** **476** **287** **287** **365** **684** mm annual Eneabba rainfall



2021

Flora Restorer operating well;
an excellent rainfall year;
Seed pelleting trialled in rehab

On average **3.6 plants/m²**

Independent botanical monitoring of permanent transects confirms Flora Restorer's superior rehabilitation outcomes...

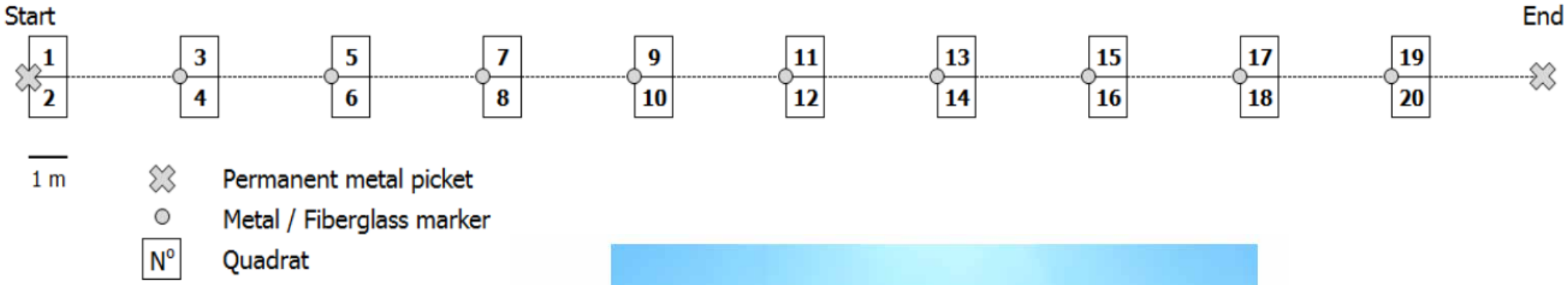


Plate 17: Block 18AS - Transect 2 Start

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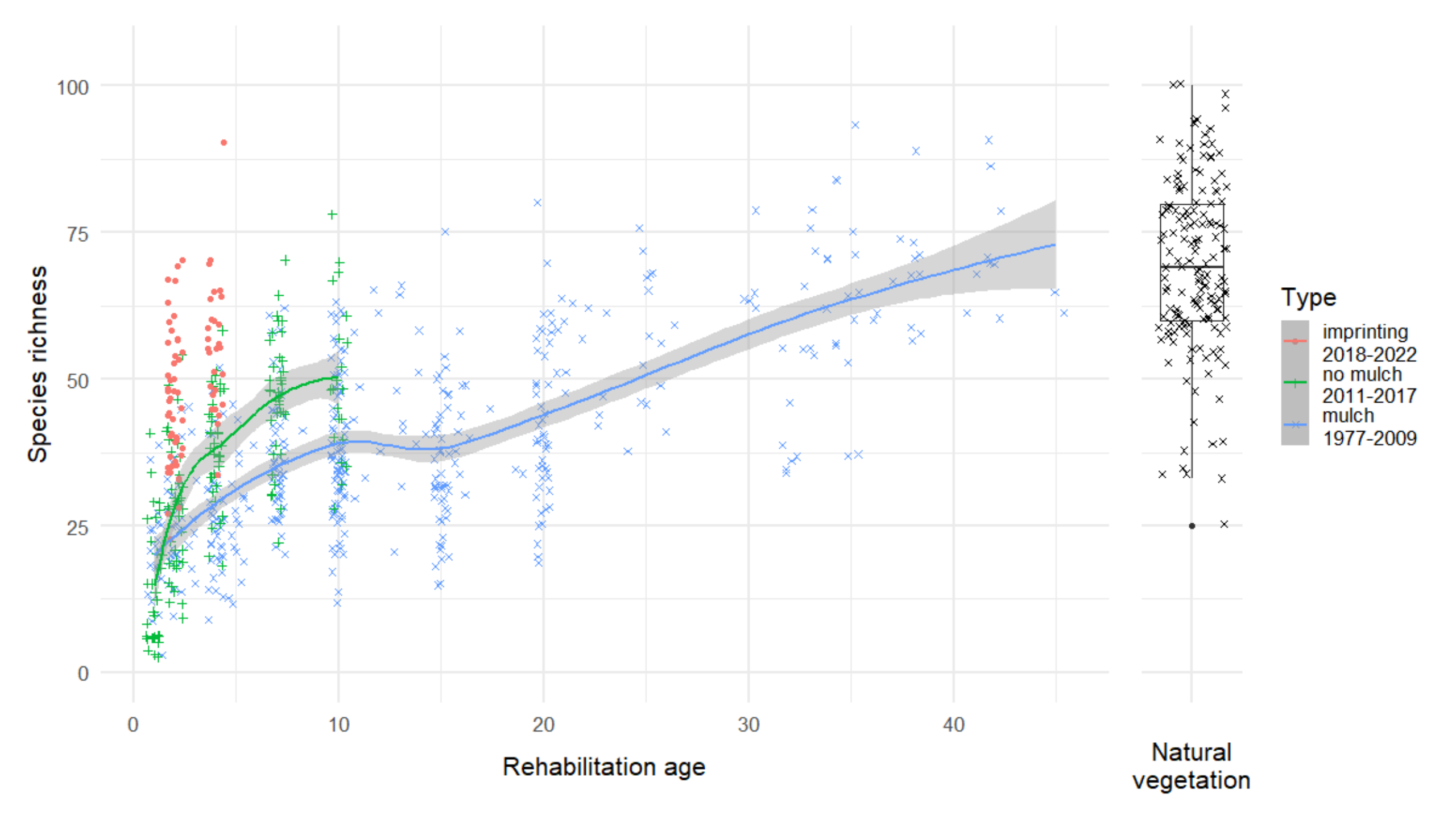
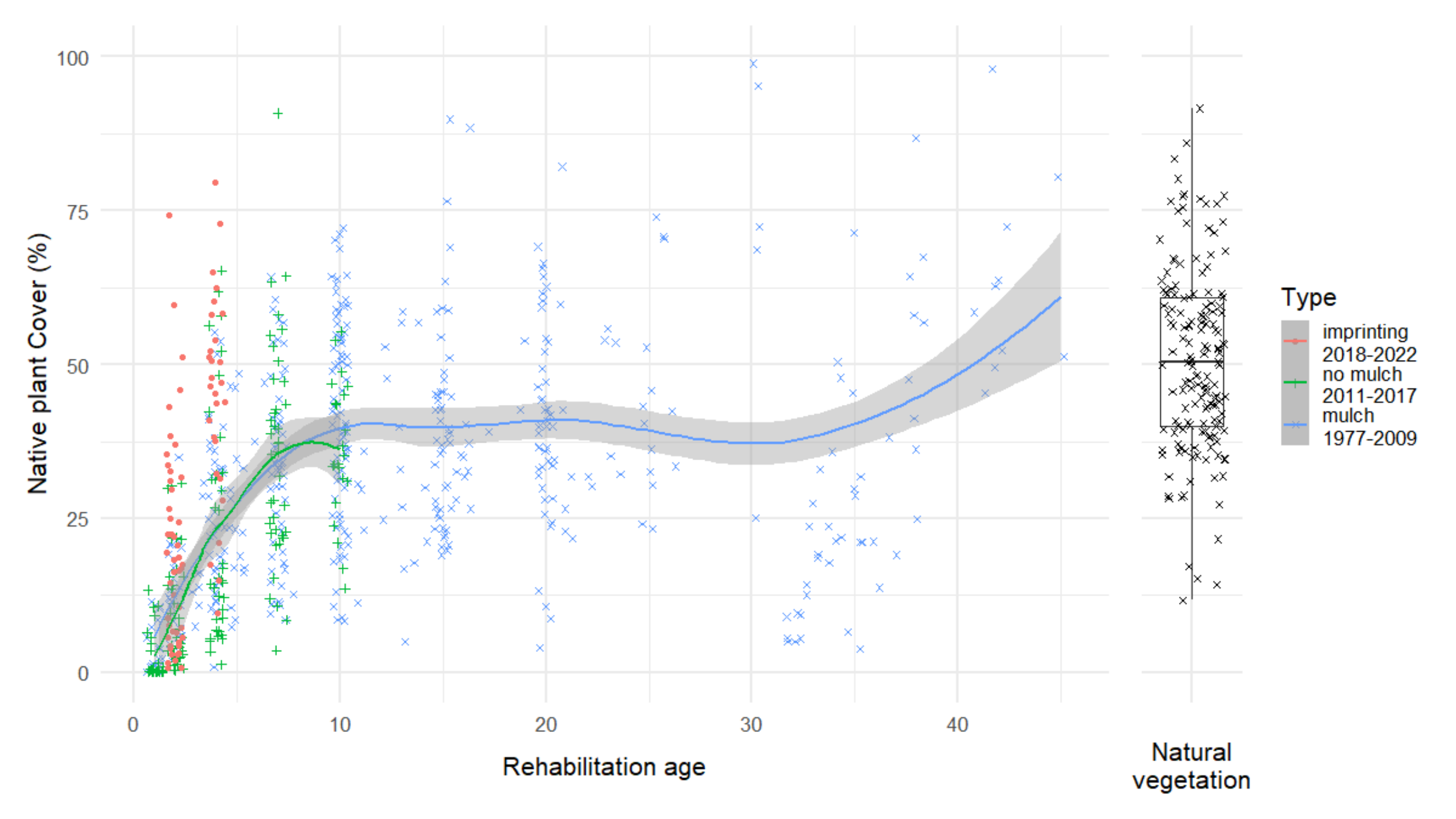

Species richness
100
75
50
25
0
0
10
20
30
40
Rehabilitation age
Natural vegetation
Type
imprinting 2018-2022
no mulch 2011-2017
mulch 1977-2009


100
75
50
25
0
Native plant Cover (%)
0
10
20
30
40
Rehabilitation age
Natural vegetation
Type
imprinting 2018-2022
no mulch 2011-2017
mulch 1977-2009

Necessity is the mother of invention

Flora Restorer – fertilise, scarify, seed, imprint, and spray artificial soil crust

Flora Restorer

Sowing a Diverse Ecosystem

Golden Gecko Awards for Environmental Excellence recognise leading practice and innovation in environmental management

Awarded annually by WA Government
Department of Mines, Industry Regulation and Safety

GOLDEN GECKO
Awards for Environmental Excellence

2022 Winner

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Why is emergence more consistent with imprinting and soil crusting?

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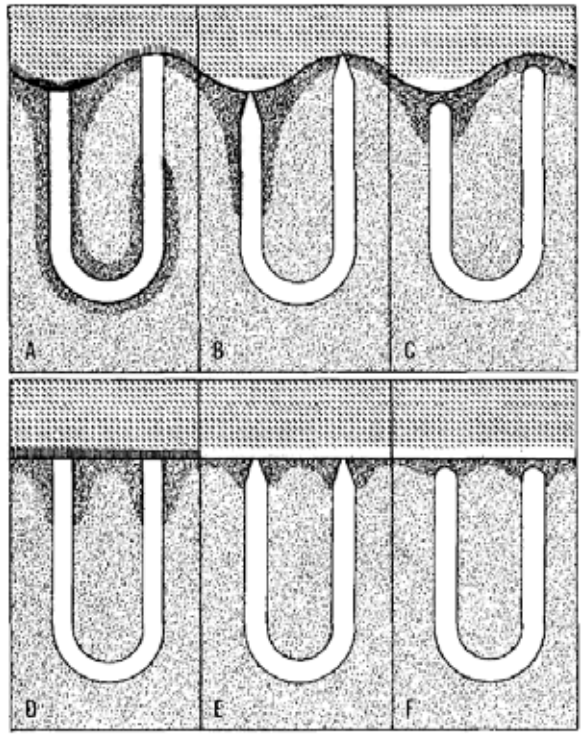

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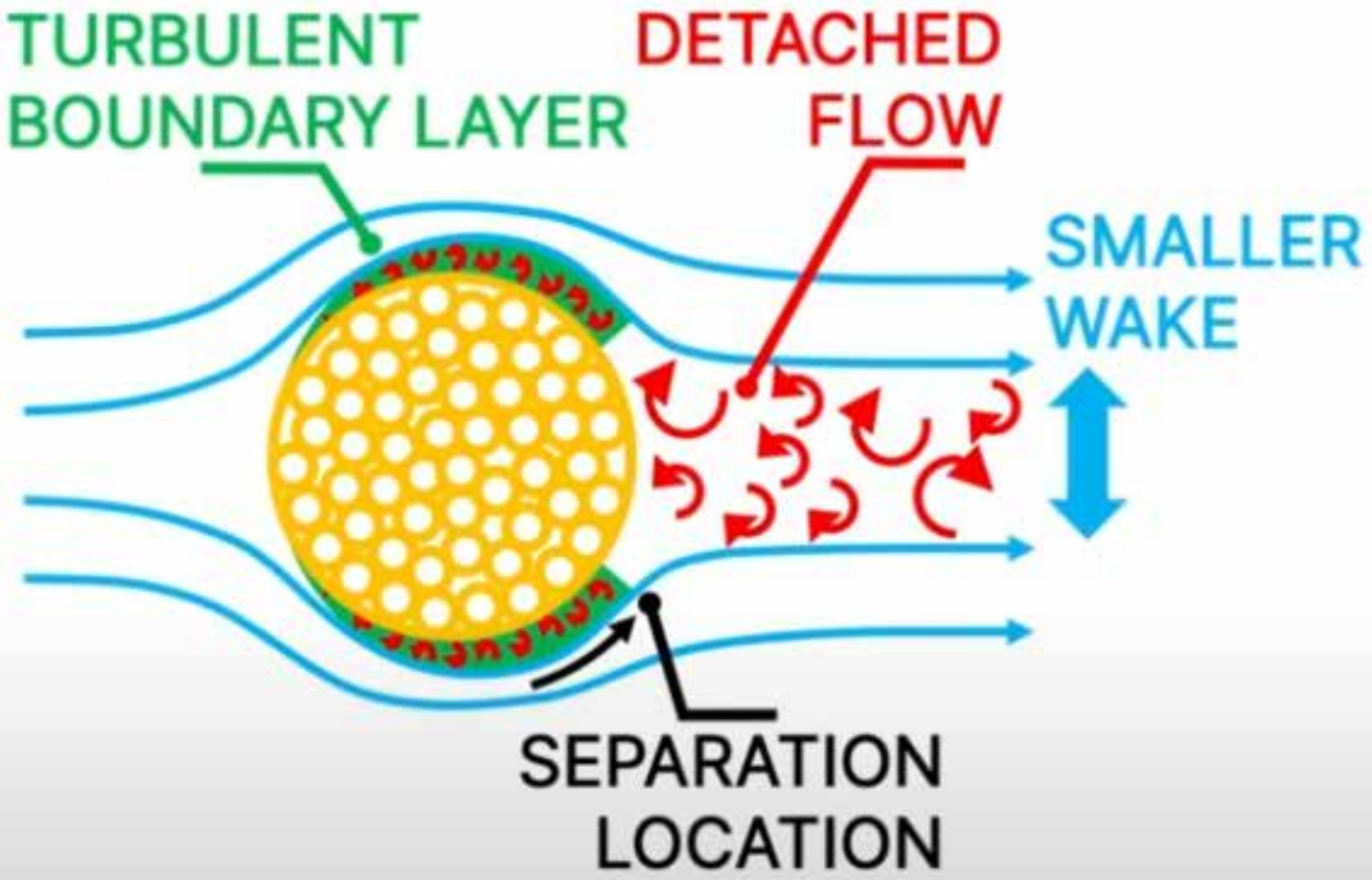
Increased infiltration?

3 L storage per imprint implies **35 mm** rainfall storage on surface

5 L storage per imprint implies **59 mm** rainfall storage on surface

Why is emergence more consistent with imprinting and soil crusting?

Imprinting creates a thicker, **turbulent boundary layer**
reducing wind speed, and therefore **lowering transpiration**, at the surface?



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Why is emergence more consistent with imprinting and soil crusting?

Analogous to **biological soil crusts** of arid landscapes

It mimics the source/sink or inter-patch/patch sequences of natural landscapes (c.f. Tongway et al.)

For more information contact

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