Ecological restoration in Saudi Arabia

The Thumama Park Restoration Trial

Proven (knowledge driven), Cost Effective, Scalable restoration solutions

Patrick Courtney, **Kingsley Dixon**, Jason Stevens, Ellery Mayence

Kings Park and Botanic Garden, West Perth, WA, 6005

School of Plant Biology

The University of Western Australia, Crawley, WA, 6009

KINGS PARK & BOTANIC GARDEN

BOTANIC GARDENS & PARKS AUTHORITY

THE UNIVERSITY OF WESTERN AUSTRALIA

Why our approach

"To achieve the restoration of biodiversity and ecosystem services, restoration actions need to be tightly coupled with 'state-of-the-art' scientific progress"

Montoya et al 2012. Trends in Ecology and Evolution 27:12

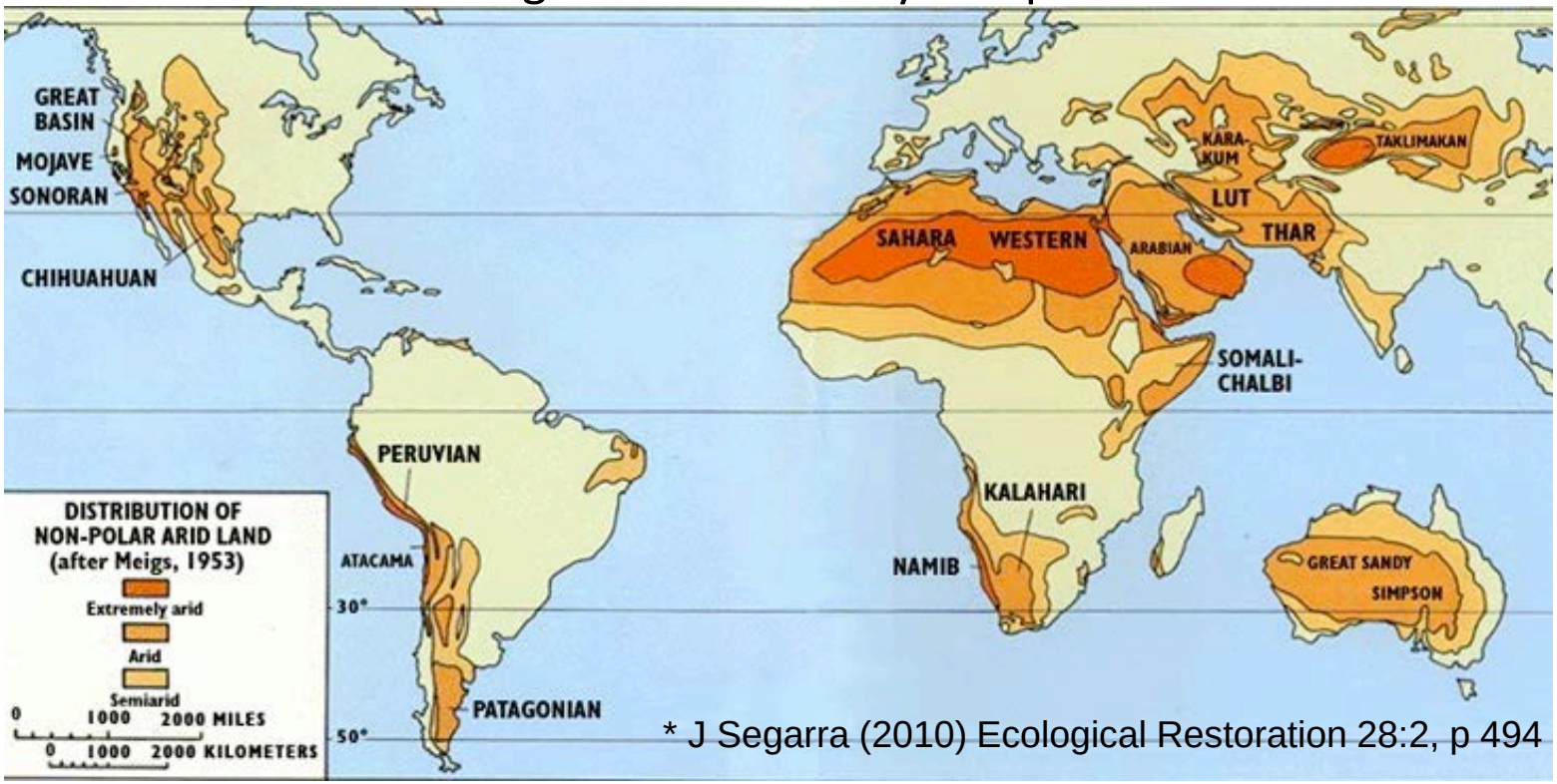
Target Plant Concept

- Quantifiable seedling attributes that are linked to outplanting success

Courtesy Anthony Davis

Drylands of the world

41% of the earth's surface; sustain 38% of the global population*; Drylands store 45% of the global terrestrial carbon; support 50% of world's livestock; one third of global biodiversity hotspots.



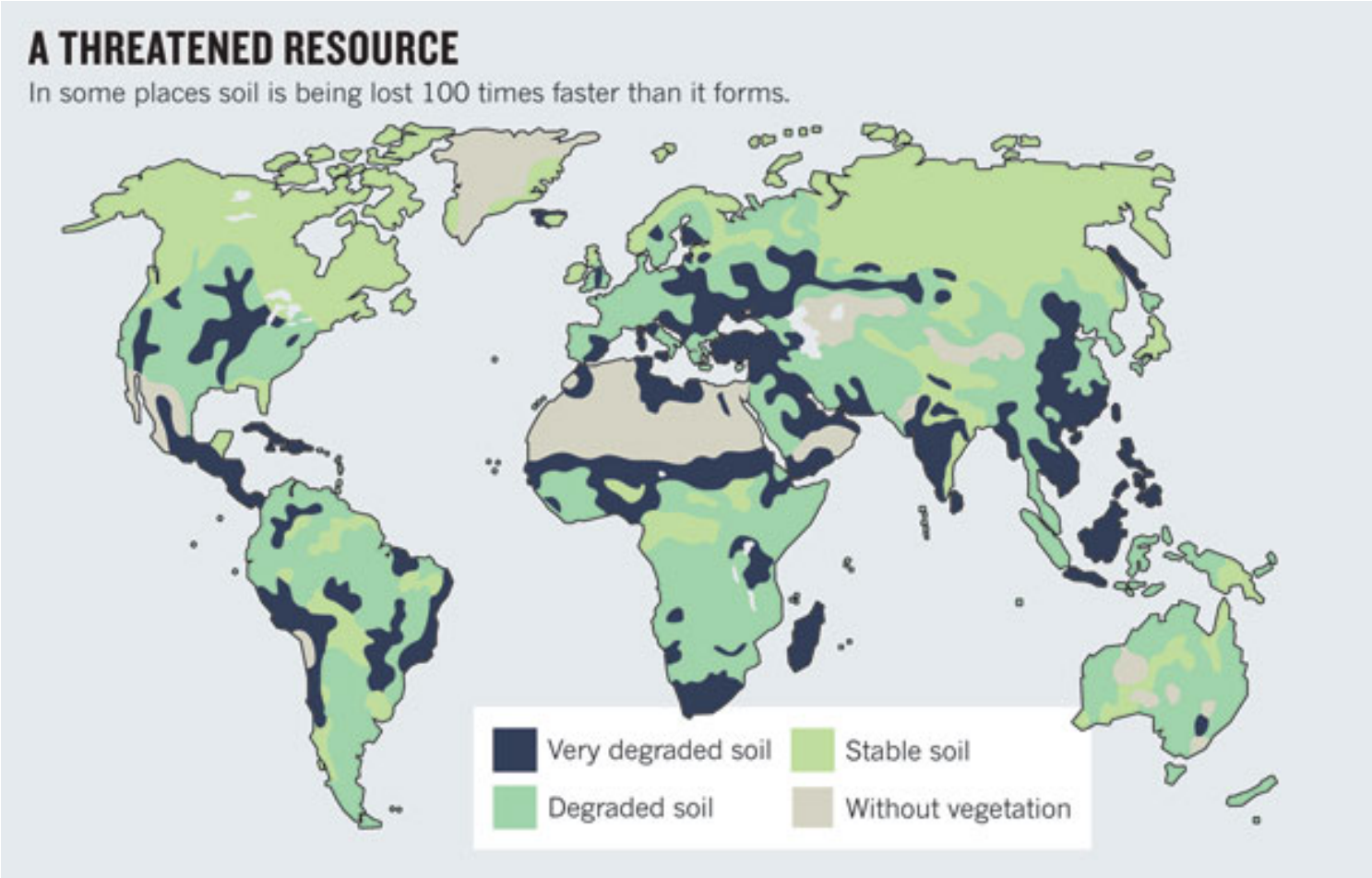
* J Segarra (2010) Ecological Restoration 28:2, p 494

Sahara

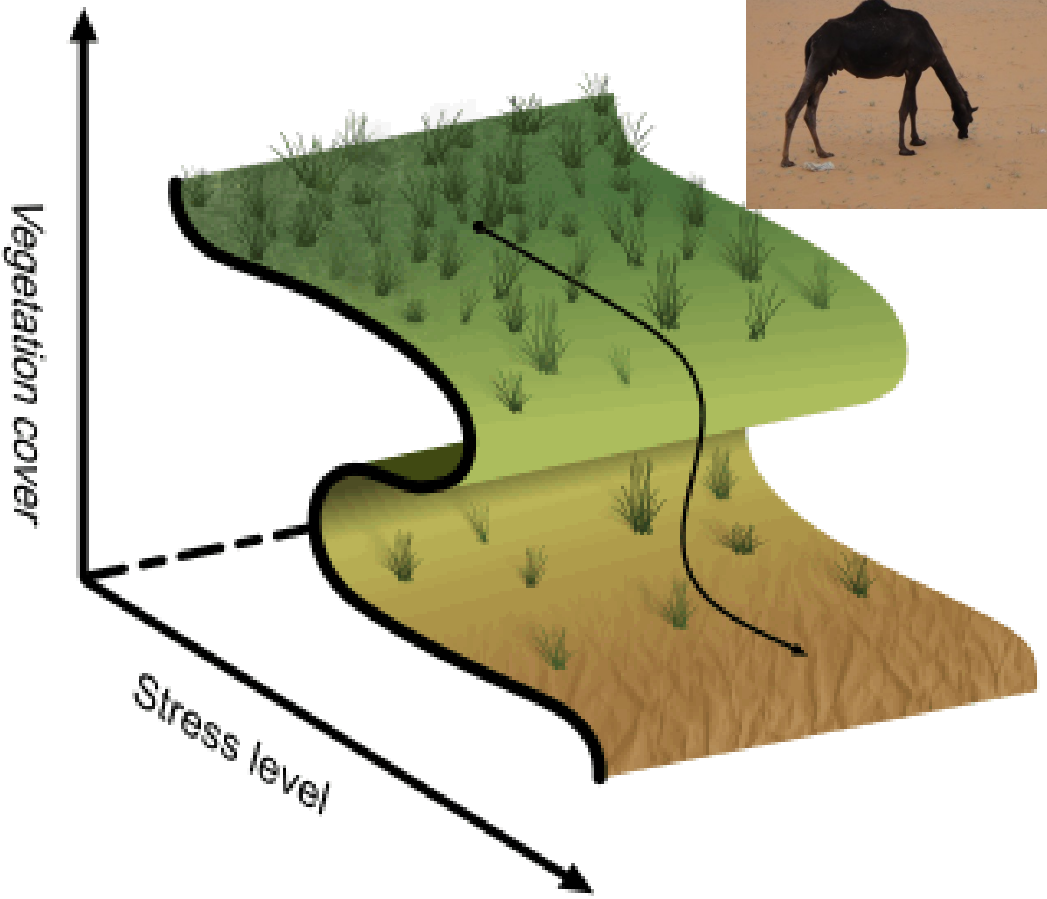
Arabian Desert

Australian Arid Zone

Losing soil at up to 10cm pa
Estimate of desertification: up to 20%



Drylands reach degradation tipping points



What makes arid land restoration challenging
But exciting!

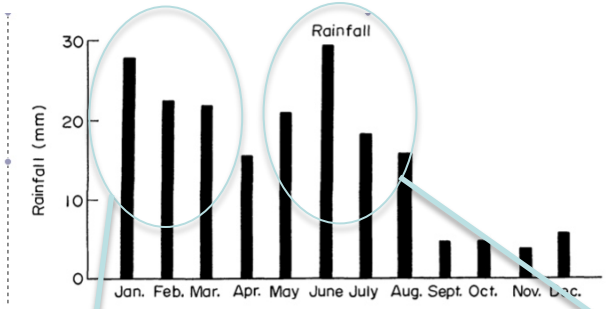
- Rapid degradation.
- Limited understanding.
- Pulse-driven (rain)– timing of restoration.

We achieve barely 5% restoration success rates*.

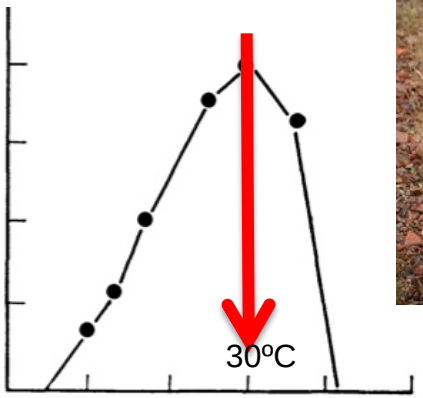
Verstraete, M.M., *et al.* (2009) *Front. Ecol. Environ.* 7

These are pulse driven systems – 20 minute rainfall event

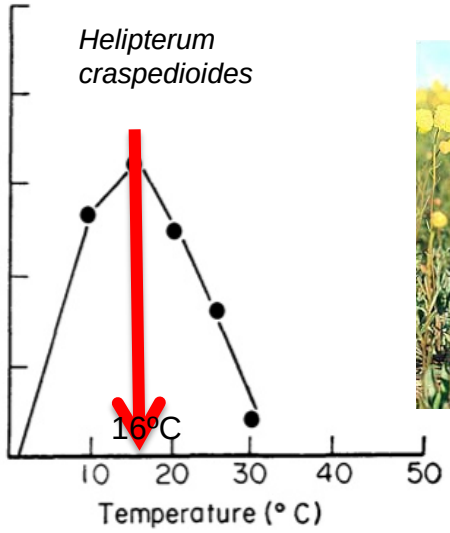
The summer winter rainfall divide driving contrasting plant phenologies in Australian deserts



Aristida contorta



Helipterum craspedioides



Mott 1972 J Ecol.

Knowledge based decisions

Water in the environment at three scales

Landscape

Local

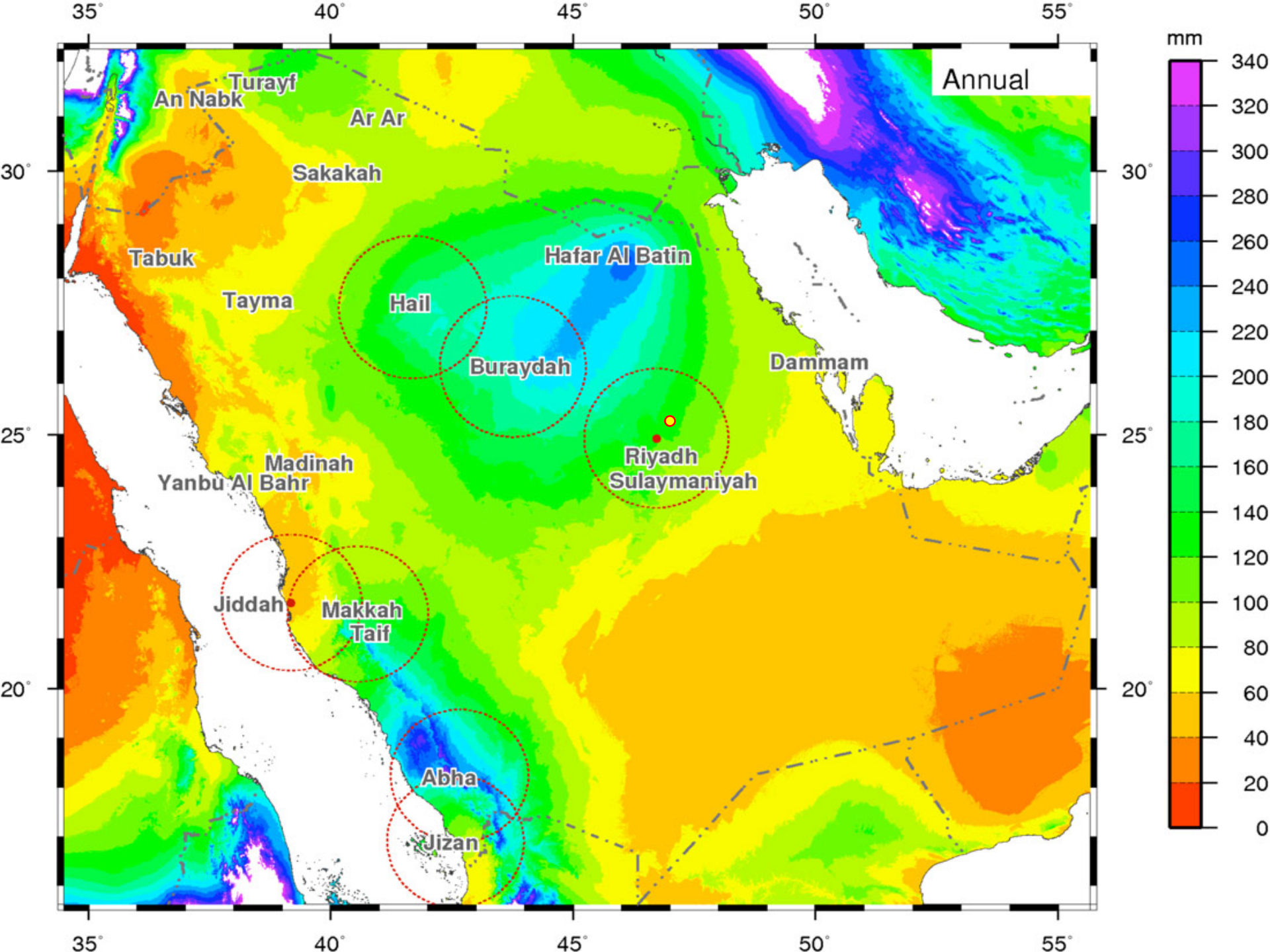
Plant-scale.

Thumama Park Restoration Trial

The Target Plant Concept
Quantifiable seedling/direct seeding attributes that are linked to outplanting success

Understanding water in the plant and the environment – seedling age, water delivery, timing, stress


© Nations Online Project
SAUDI ARABIA
National capital
Emirate capital
City, town
Major airport
Int'l boundary
Main road
Secondary road
Railroad
Jerusalem
AMMAN
Turayf
An Nabk
'Ar'ar
IRAQ
Basra
ISLAMIC REPUBLIC OF IRAN
ISRAEL
JORDAN
Suez
Sakakah
Al Uwayqilah
Al Jawf
Rafha
KUWAIT
KUWAIT CITY
Shiraz
Tabuk
Hafar al Batin
Persian Gulf
Tayma
Ha'il
EGYPT
Al Jubayl
Buraydah
Dammam
Dahran
BAHRAIN
MANAMA
Unayzah
Al Majma'ah
Ar Rass
Al Aziziyah
Al Hufuf
QATAR
DOHA
Ras Al Khaymah
Dubai
Riyadh
Salwa
ABU DHABI
Aswan
Medina
Yanbo
As Sulaymaniyah
Red Sea
UAE
Zalim
Jiddah
Mecca
At Taif
Al Bahah
Port Sudan
Abha
Najran
YEMEN
Jizan
SUDAN
ERITREA
KHARTOUM
N
0 100 200 300 km
0 100 200 mi
إحترم
مشاعر السكان
والزوار الآخرين
لسياحة ممتعة وبيئة جميلة


Annual
mm
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
35°
40°
45°
50°
55°
30°
25°
20°
Turayf
An Nabk
Ar Ar
Sakakah
Tabuk
Tayma
Hail
Hafar Al Batin
Buraydah
Dammam
Riyadh
Sulaymaniyah
Madinah
Yanbu Al Bahr
Jiddah
Makkah
Taif
Abha
Jizan

Thumama Park Restoration Trial : restoring framework communities

Three *Acacia* framework trees ; framework shrubs
103,000 plants, 128 treatment combinations + precision seeding

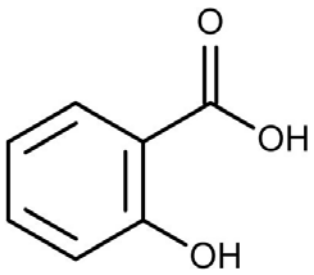
Focusing water in the establishment niche

1	**Nil**	**No Water (controls)**
2	**SA drip**	**Seasonal Average for Riyadh per month**
3	**Low drip**	**1L/plant – Monthly**
4	**High drip**	**3L/plant - 2 times per week**
5	**SA deep pipe**	**Seasonal average for Riyadh**
6	**Low deep pipe**	**1L/plant – Monthly**
7	**High deep pipe**	**3L/plant - 2 times per week**

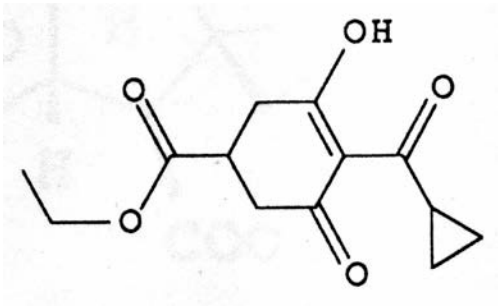
Deep pipe (20cm) infiltration

Very deep (2m) pipe infiltration

Plant protection and optimising transplanting success



Salicylic acid (Aspirin)



Trinexapac-ethyl (Moddus)

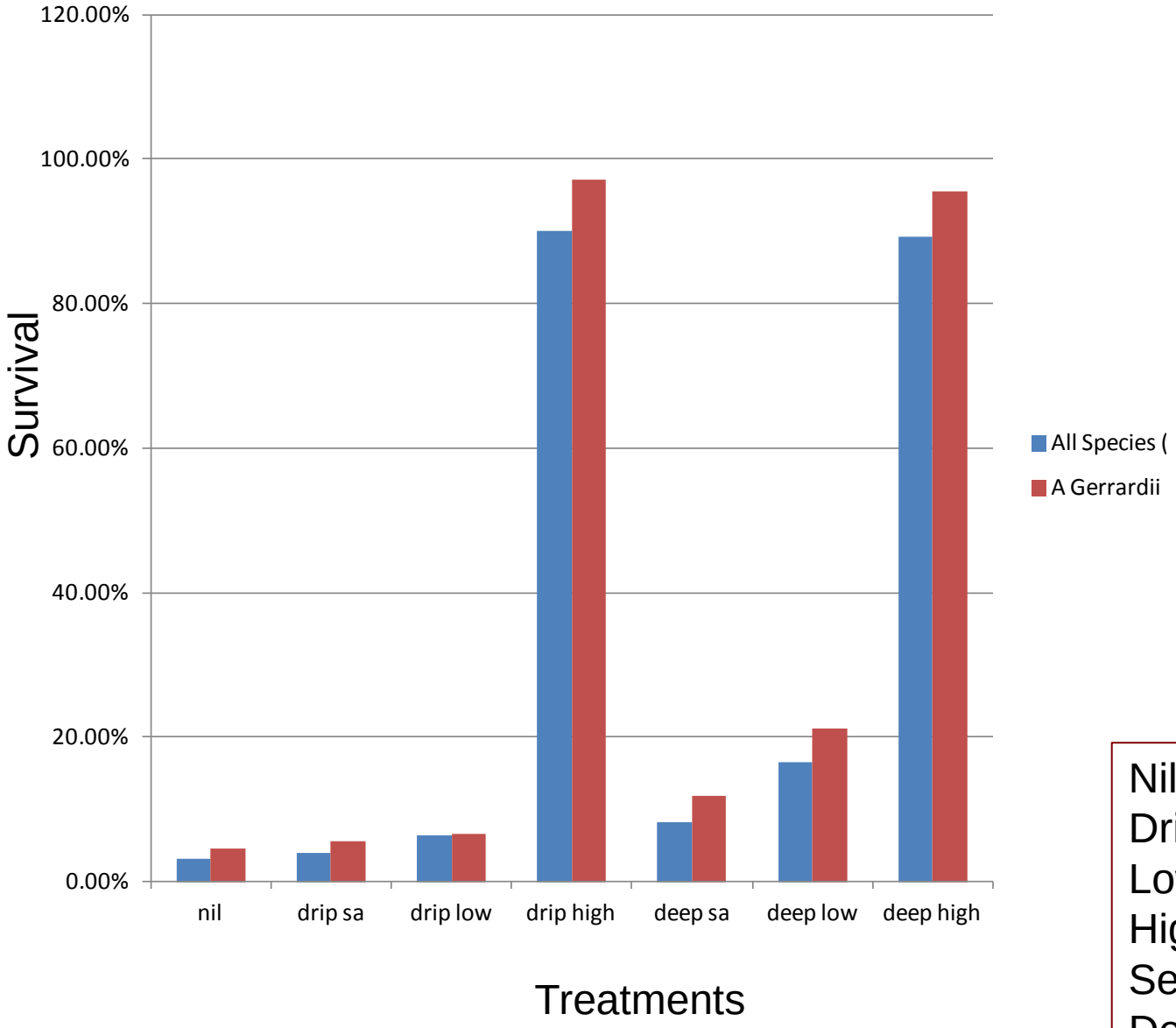
Smarter seed use: a key to unlocking restoration potential

Improving seed use efficiency – currently <10%

First use of:

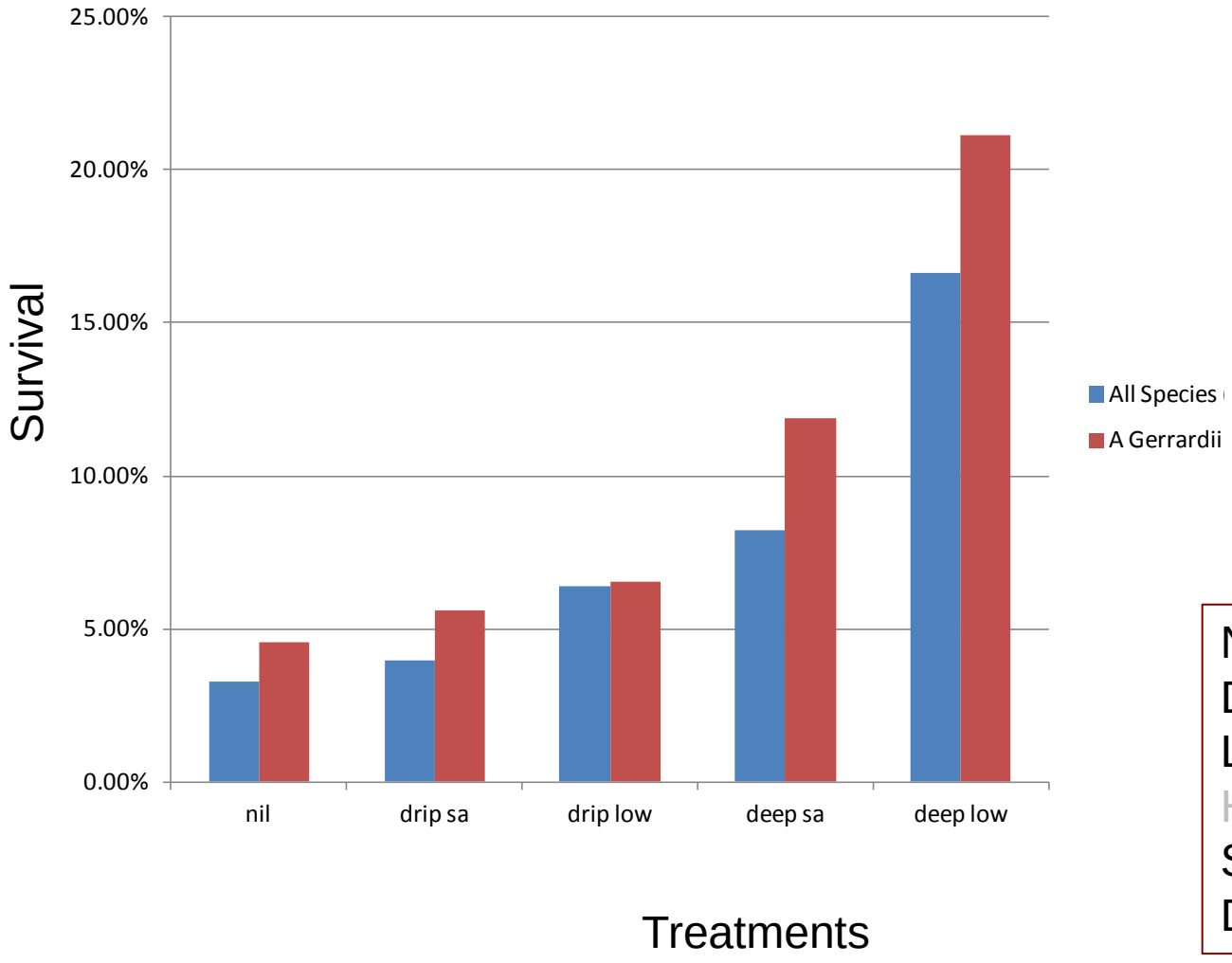
Direct seeding of wild species

All species (blue) and *Acacia gerrardii* (blue).



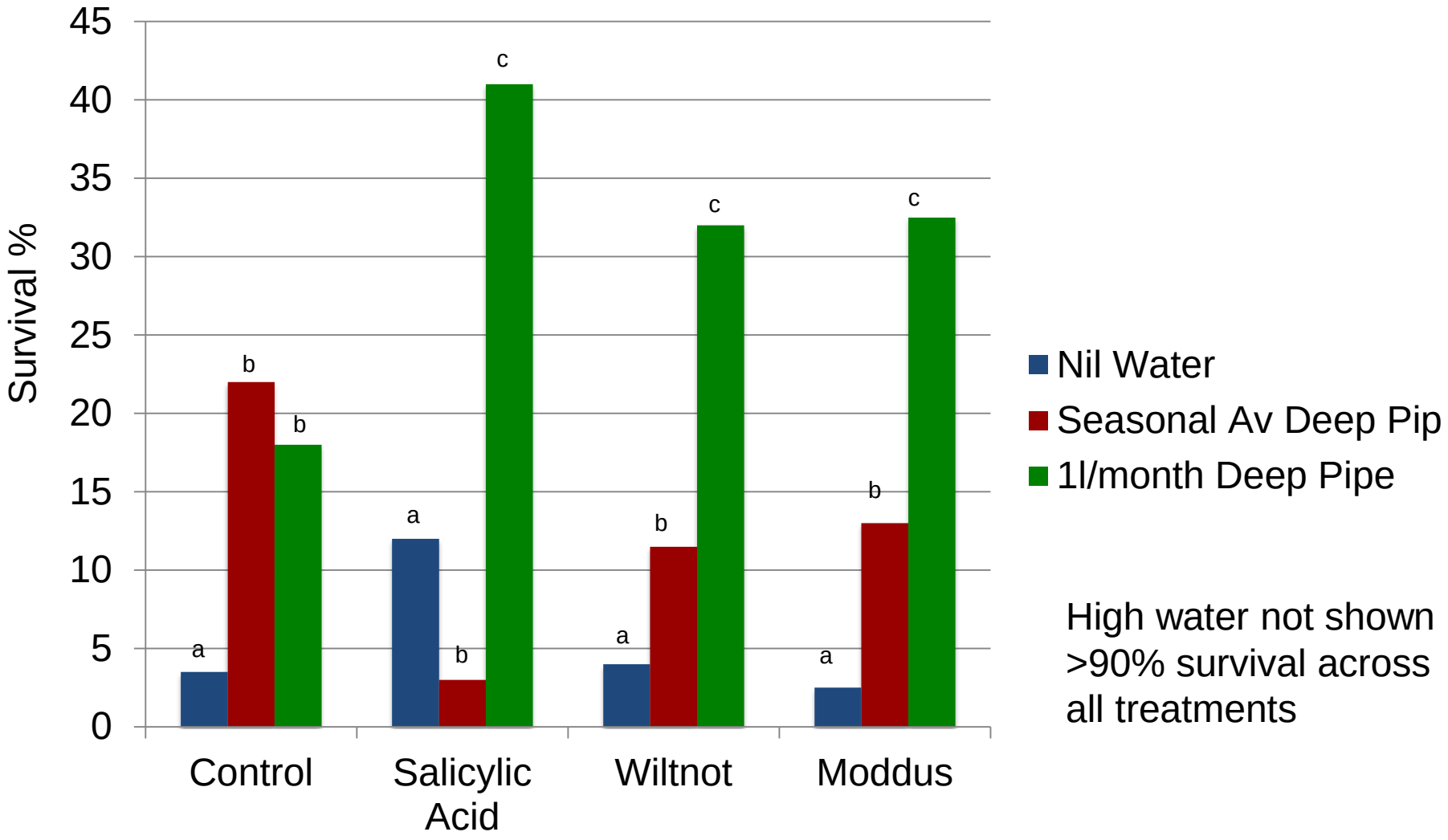
Nil
Drip (surface)
Low (1l/month)
High (24l/month)
Seasonal Av (SA)
Deep (20cm pipe)

All species (blue) and *Acacia gerrardii* (blue).



Nil
Drip (surface)
Low (1l/month)
High (24l/month)
Seasonal Av (SA)
Deep (20cm pipe)

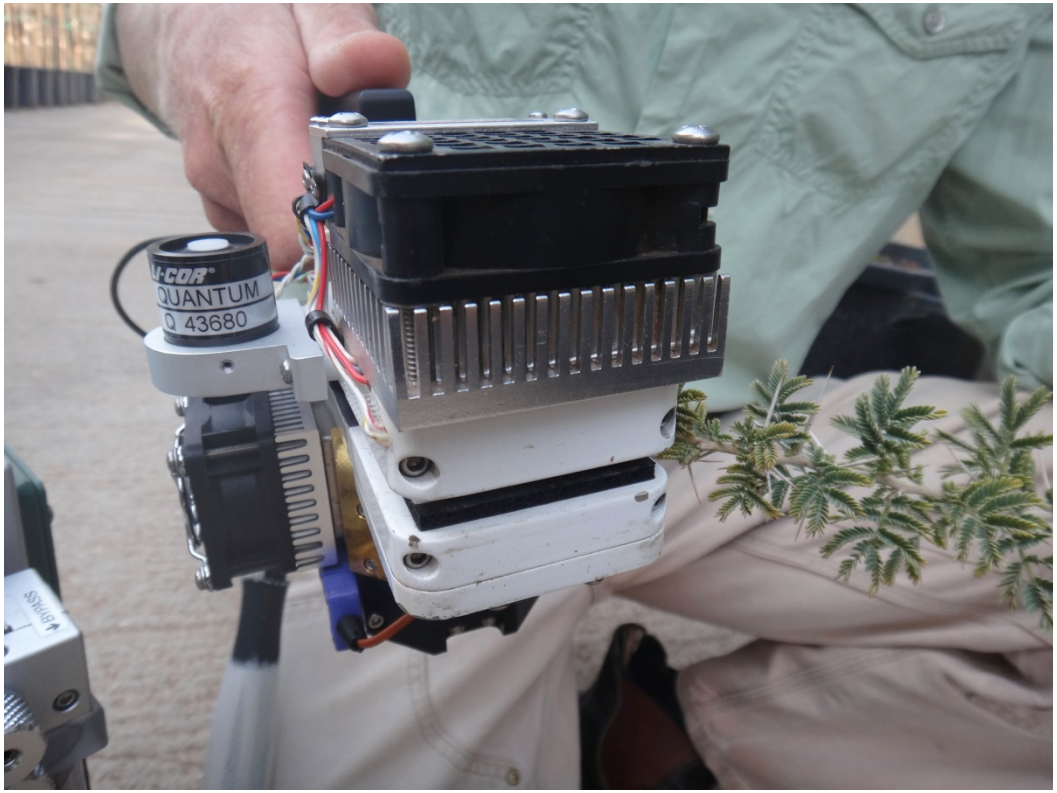
Acacia gerrardii



High water not shown >90% survival across all treatments

Knowledge based decisions

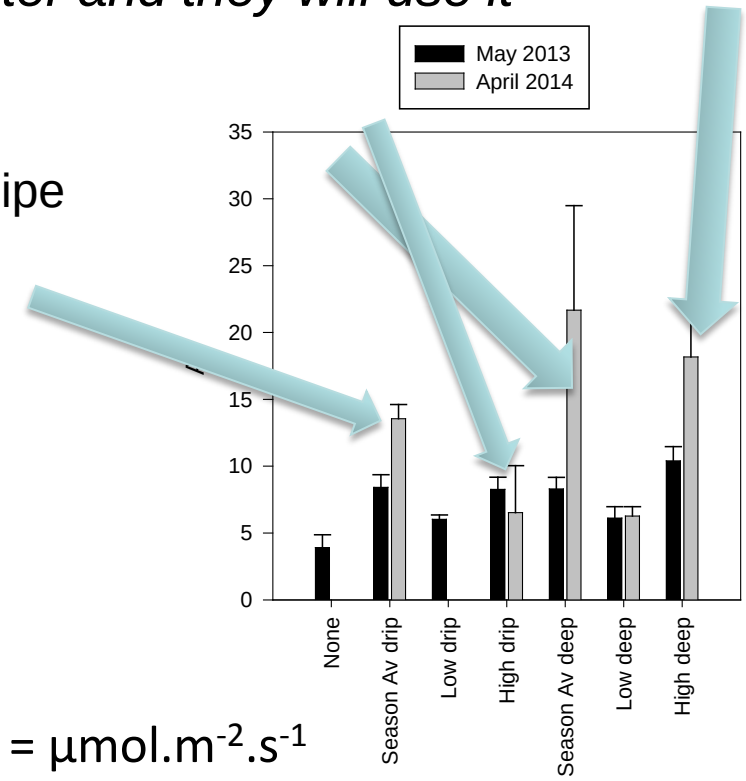
Predicting restoration success – using Restoration Ecophysiology



Ecophysiology informing plant capability – Greenstock plantings

Give plants access to more water and they will use it

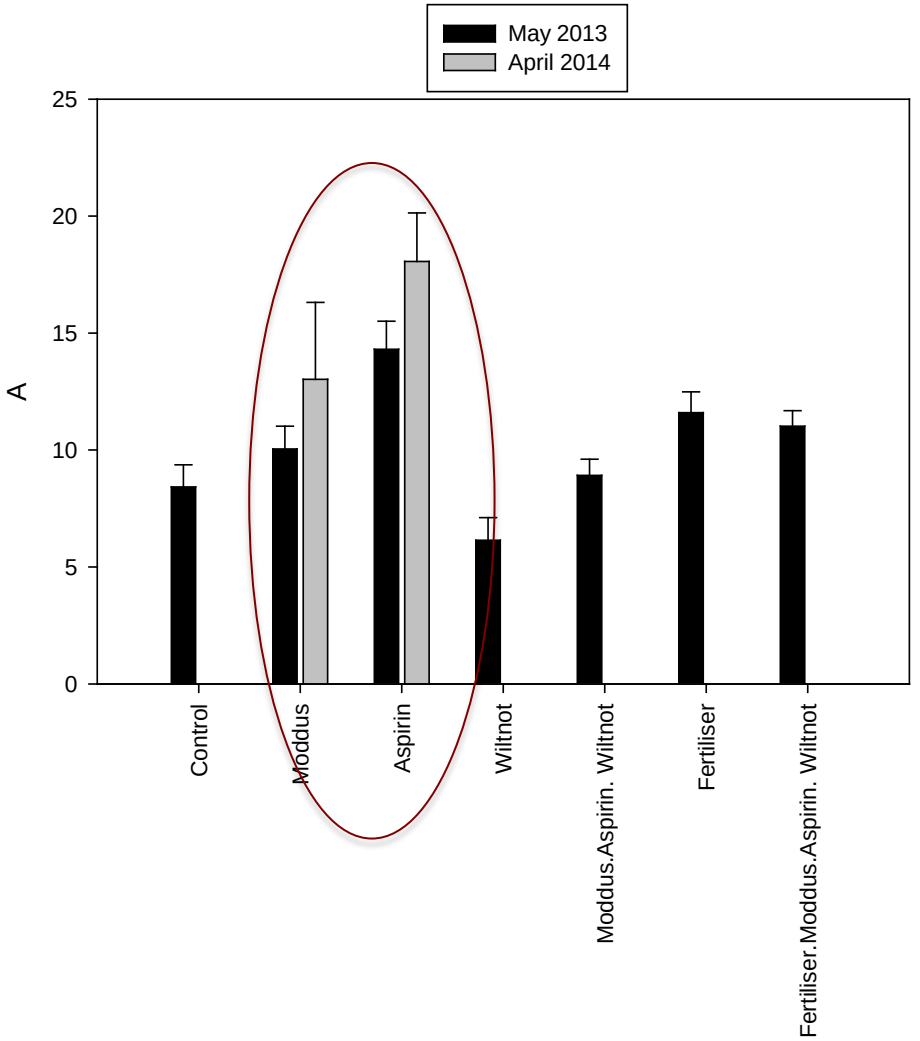
Benefit of deep pipe



A (Photosynthetic rate) = $\mu mol.m^{-2}.s^{-1}$

Take home messages: Greater water application allows for more growth potential (photosynthesis), a reduced amount of water stress but also allows plants to have a less efficient water use strategy. Deep pipe irrigation reduces water stress.

Ecophysiology informing plant capability – Anti-stress compounds



A (Photosynthetic rate) = µmol.m^{-2}.s^{-1}

Key Take Home Messages

Precision in water delivery is more important than quantity

Nutrient amendments were detrimental (low rainfall systems)

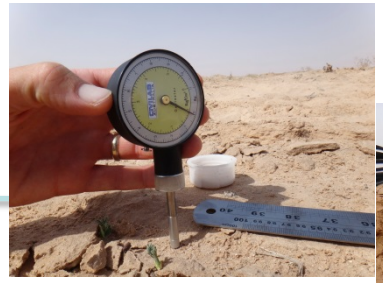
Salicylic acid is a cost-effective plant growth and survival improver

NEXT STEPS:

- Business case – cost:benefit analysis
- Refine natural catchments that deliver water to depth.
- Slow release SA
- Expand trial to range of soils, environments in the Middle East

Precision Seeding

- Soil texture
- Moisture retention
- Impedance
- Infiltration rate
- Seed burial depth



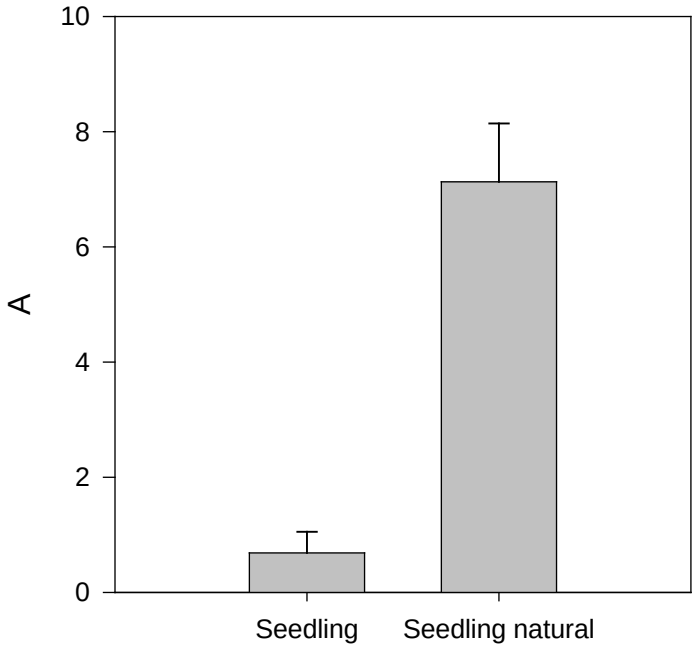
Outcome: sand dominated soils matter – low impedance, water infiltration to depth, emergence free from soil crusting

	Suitability for germination, emergence and recruitment		
Parameter	Low	Medium	High
Sand content	Poor	Moderate	Good
Infiltration	Poor	Moderate	Good
Surface crusting	Good	Moderate	Poor
Surface penetration resistance	Moderate	Good	Poor
At-depth penetration resistance	Good	Moderate	Poor
Water shedding	Good	Moderate	Poor
Mobile surface conditions	Good	Moderate	Poor
Rock content	Moderate	Good	Poor


MM
CM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Ecophysiology informing micro-site capability – direct seeding

Take-home message: direct seeded plants have 14% of the PS capacity of natural recruits



A (Photosynthetic rate) = µmol.m^{-2}.s^{-1}

Deep ripping improves emergence in direct seeding

Microsites possible using boxed microcosms

Broader benefits for the Middle East

- More effective water use in restoration (50 liters per plant per week vs 2 liters per month).
- Use of native species for water wise landscapes
- Up-scaling of cost-effective restoration

Globalising dryland restoration

The Dryland Restoration Initiative (DRI)

Linking SER with science leaders, leading global institutions, the UN, national governments

- Build the science and practice toolkit.
- Enhance ecological restoration capacity and networking with dryland champions.
- Liaise, collaborate and seek funding with individuals, communities, governments and industry partners.
- Be a restoration innovation hub.