Sustainable Ecological Communities on Mine Rehabilitation

Case study: Ravensworth Operations, Hunter Valley, Australia.

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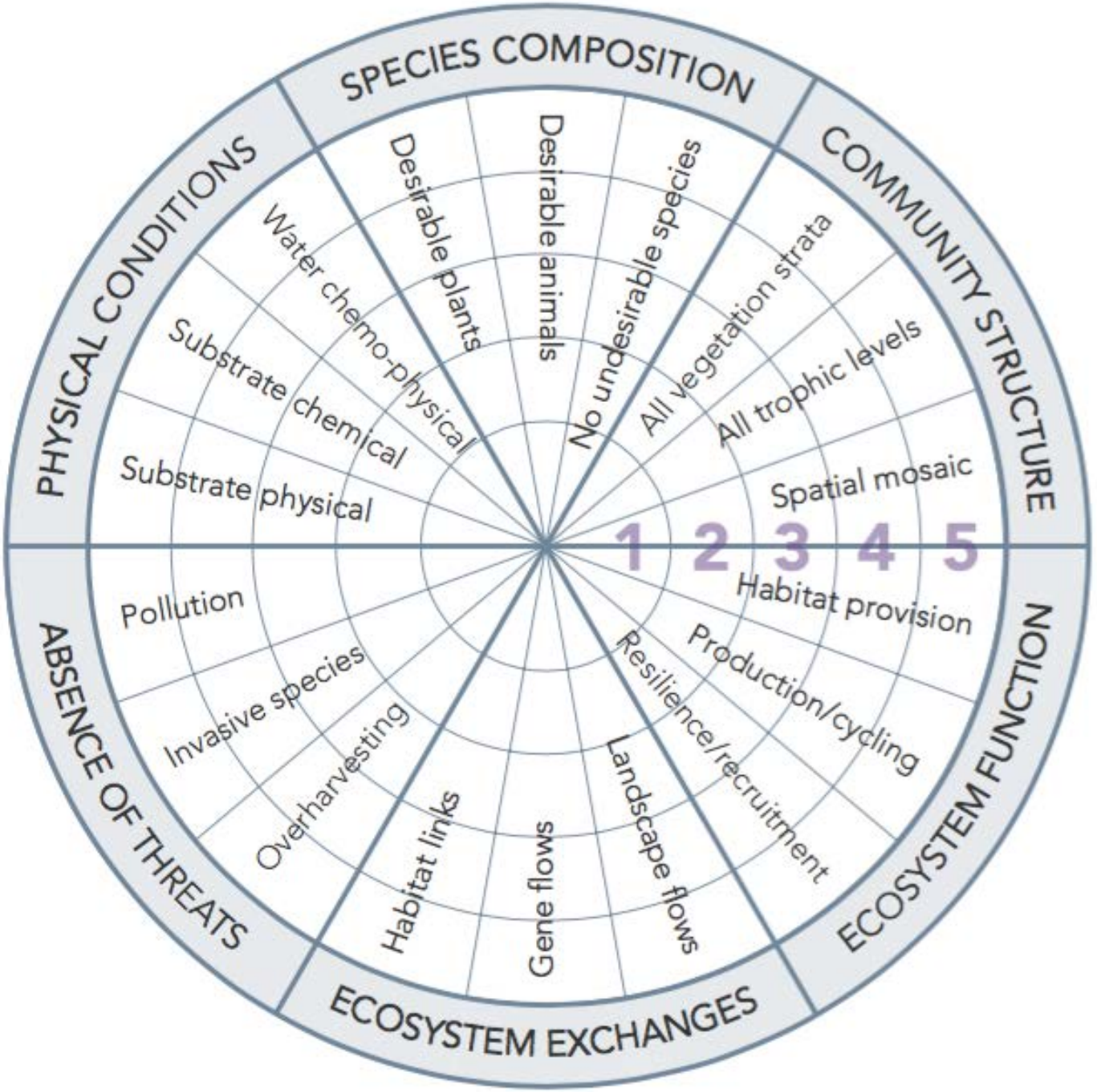
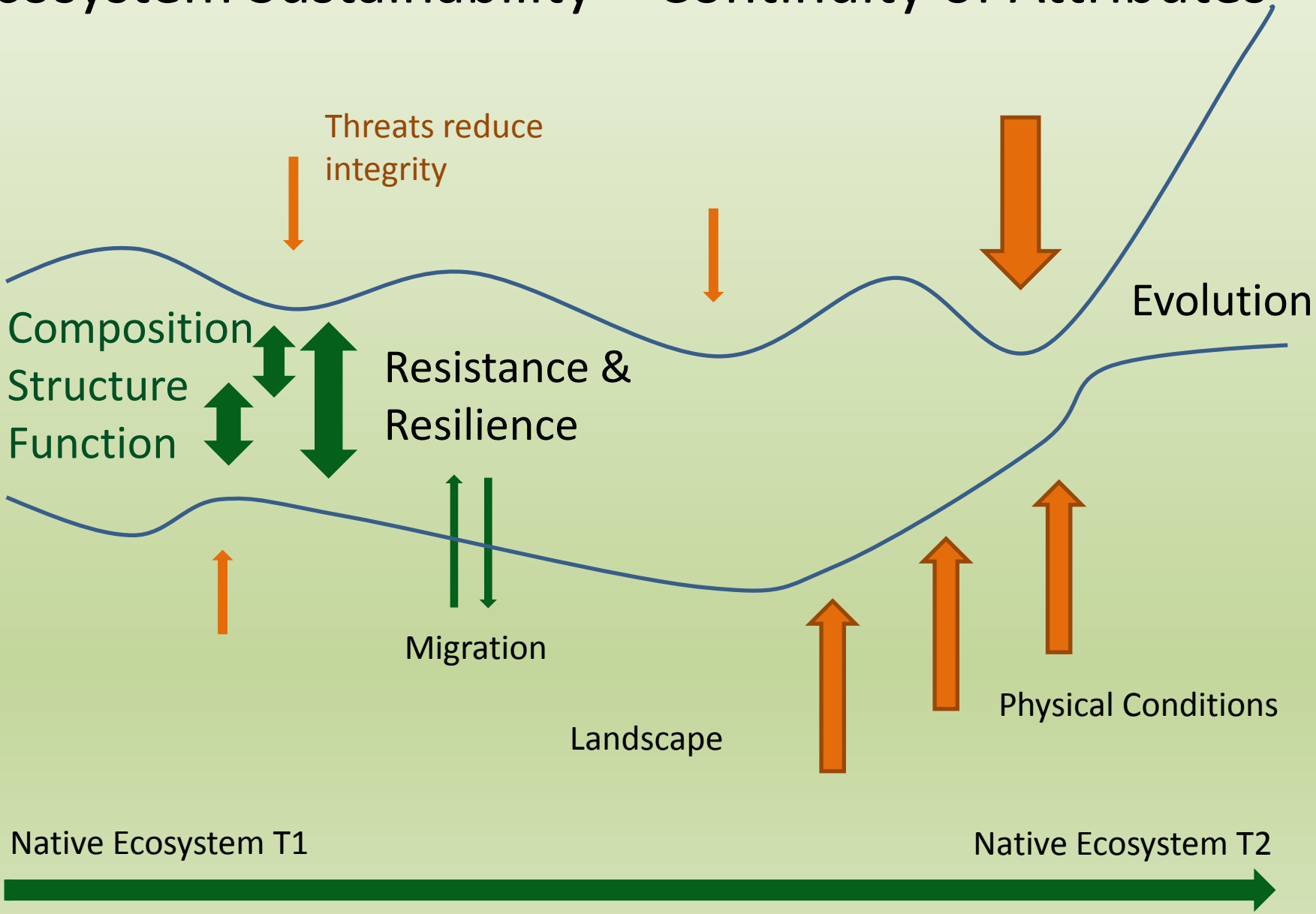
Best Practice Ecological Rehabilitation - Mine Rehab Conference 2017 - Muswellbrook

Ecosystem Attributes SERA 2015

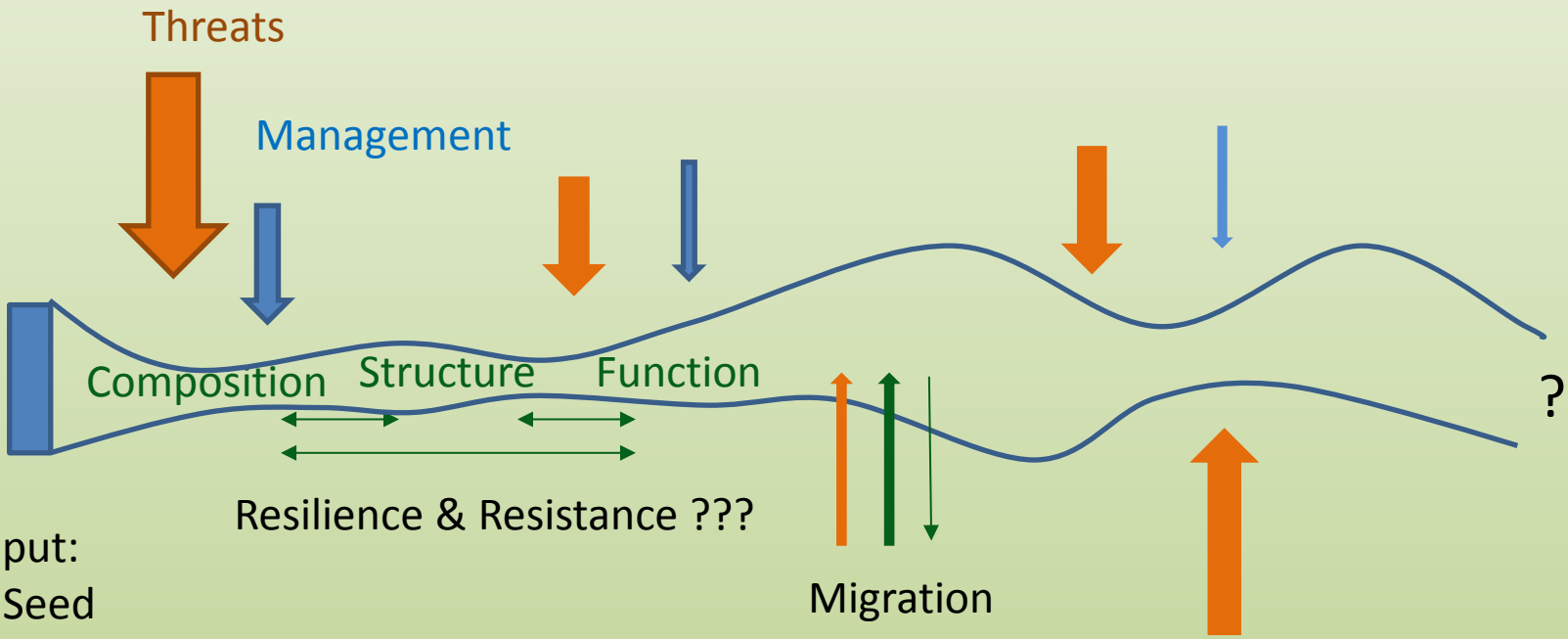


Soil Biota?

Ecosystem Sustainability = Continuity of Attributes



Mine rehabilitation



Input:

- Seed
- Substrate

? microbes

? animals

- Native
- Novel
- Exotic

No Ecosystem

Indicators of Sustainability ???

- Many items on SERA Attribute Circle
- SMART Indicators – cost/benefit
- What underpins continuity of populations and interactions?
- And how soon can we evaluate

Early Indicators of Sustainability ???

Life cycling and diversity

- Successful Life-cycling of plants a proxy for additional processes:
    - pollination,
    - soil building,
    - nutrient cycling…
- Diversity a proxy for interactions??? Probably but also time

Background For Project

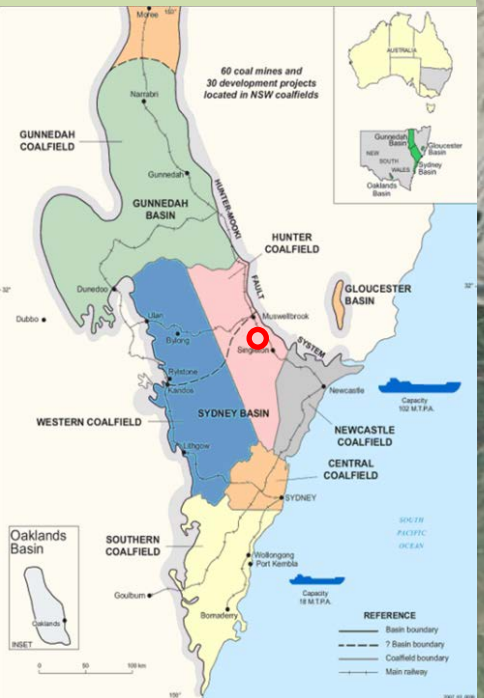
- Many mines now need to revegetate to native sustainable ecosystems – often EECs
- Spoil dumps are rehabilitated by seeding a limited number of species sometimes in combination with a seed bank from a topsoil or with soil ameliorants.
- Current monitoring methods don’t address variables which could help determine if a community is sustainable

to Muswellbrook

Ravensworth Operations
December 2013

Rehabilitation area

Ravensworth Pit



Study site

to Singleton

Note: change in land use

Hunter Ironbark Communities

Mine Commitment: Construct **EEC**'s on Rehabilitation area.

CH I SG GB F = Central Hunter Ironbark Spotted Gum Grey Box Forest

CH GB I W = Central Hunter Grey Box Ironbark Woodland

Species list development

312 species				C. Hunter Grey Box-Ironbark Woodland				C. Hunter Ironbark-Spotted Gum-Grey Box Forest				
		Number of quadrats:		10	7	70		2	1	38		
Taxon.	Fam.	Species	North Offset	CHBIW-Rav	CHBIW-Bul	MU10	**CHGBIW-OEH**	CHISGGBF-Rav	CHISGGBF-Bul	MU27	**CHISGGBF-OEH**	life form
1	Adi	*Cheilanthes distans*	1	1	1	1	1	1		1		fern
1	Adi	*Cheilanthes sieberi*	1	1	1	1	1	1	1	1	1	fern
2	Cup	*Callitris endlicheri*				1	1					tree
2	Zam	*Macrozamia sp.*							1			subshrub
3	Aca	*Brunoniella australis*	1	1	1	1	1	1		1	1	f
3	Aca	*Brunoniella pumilio*								1		f
3	Aca	*Rostellularia adscendens*	1	1		1						f
3	Ama	*Alternanthera* sp A		1								f
3	Api	*Centella asiatica*	1									f
3	Api	*Daucus glochidiatus* forma F			1					1		f
		Number of species in list	112	118	95	163	38	45	25	116	43	

Seeding list development

Species	North Offset	CHBIW-Rav	CHBIW-Bul	MU10	CHGBIW-OEH	CHISGGBF-Rav	CHISGGBF-Bul	MU27	CHISGGBF-OEH	life form		
Callitris endlicheri				1	1					tree	frost & drought tolerant	
Angophora floribunda	1		1	1	1					tree	flw: Dec-Feb	
Corymbia maculata							1	1	1	tree	flw: May-Sep	
Eucalyptus blakelyi			1							tree	flw: Nov-Dec	
Eucalyptus canaliculata								1		tree		koala
Eucalyptus crebra	1	1	1	1	1		1	1	1	tree	flw: Apr; Sep-Nov	
Eucalyptus fibrosa						1		1	1	tree	flw: Mar-Aug	
Eucalyptus glaucina									1	tree		koala
Eucalyptus melliodora	1									tree	flw: Aug-Dec	koala, honey
Eucalyptus moluccana	1	1	1	1	1		1	1	1	tree	flw: Mar-Jun	koala
Eucalyptus tereticornis	1	1	?					1	1	tree	flw: jun-nov	koala
Brachychiton populneus subsp populneus		1	1	1	1					tree		fruit

Choosing species to target: canopy

Final Seed List - Availability

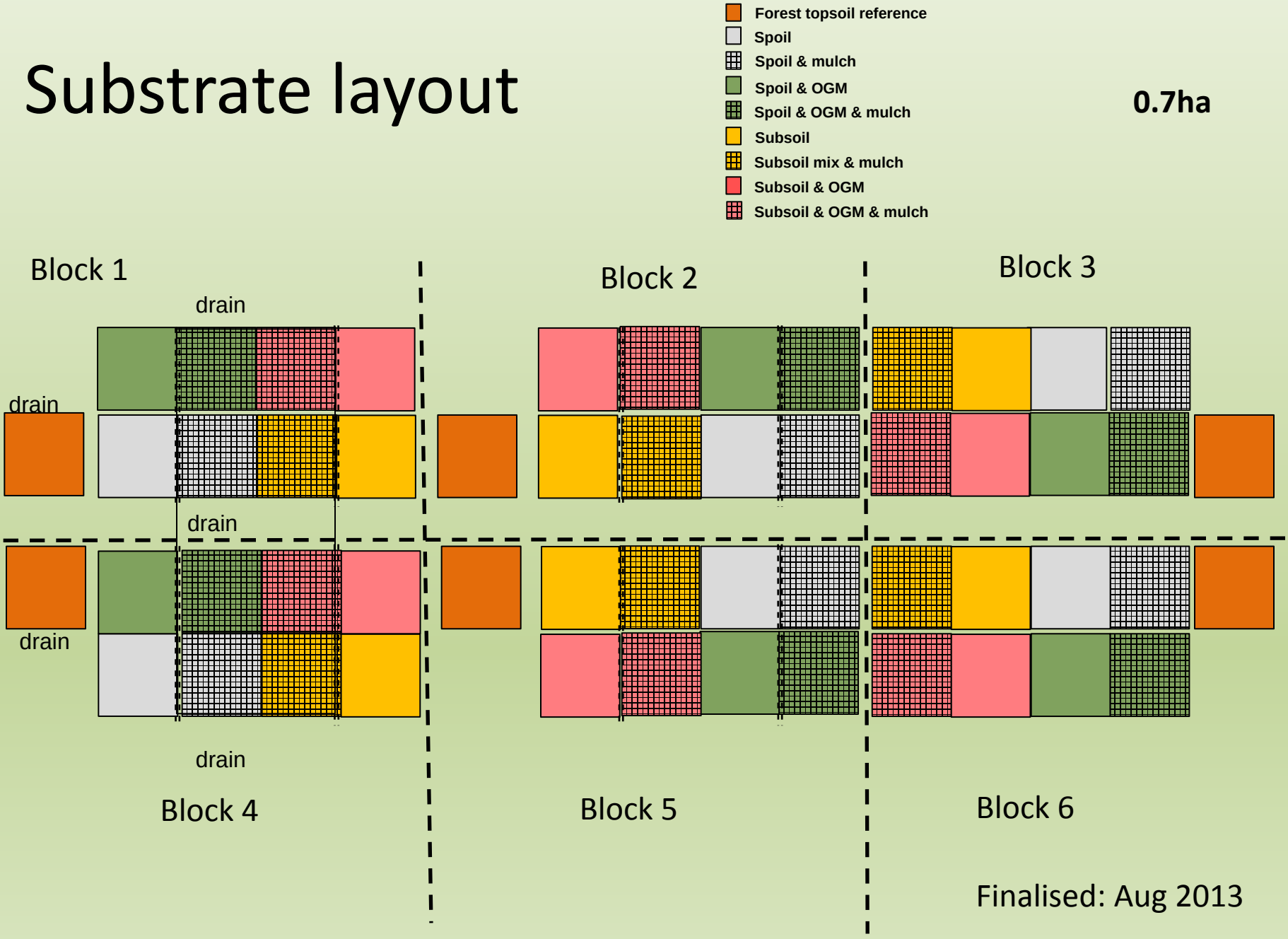
Group A	Group B = "hot spots"	Group C = heat treated
Allocasuarina luehmannii	***Cymbopogon refractus***	*Acacia amblygona*
Angophora floribunda	*Einadia trigonos subsp. leiocarpa*	*Acacia decora*
Aristida ramosa	*Enchylaena tomentosa*	***Acacia falcata***
Atriplex semibractata	***Eragrostis leptostachya***	*Acacia implexa*
Austrodanthonia fulvum	***Eremophila debilis***	***Acacia parvipinnula***
Austrostipa scabra	***Glycine clandestina***	*Acacia salicina*
Austrostipa verticillata	*Glycine latifolia*	***Brachychiton populneus***
Bursaria spinosa var. spinosa	***Glycine tabacina***	*Daviesia genistifolia*
Callitris enlicherii	***Solanum cinereum***	***Daviesia ulicifolia***
Cassinia quinquefaria	***Whalenbergia spp.***	*Hardenbergia violacea*
Chloris truncata		*Indigofera australis*
Corymbia maculata		*Kennedia rubicunda*
Dichondra repens		*Pultenaea microphylla*
Dodonaea viscosa		*Senna artemisiodes ssp. zygophylla*
Eragrostis brownii		
Eucalyptus crebra	**Group D = planted**	
Eucalyptus fibrosa	***Calotis lappulacea***	56 final species
Eucalyptus moluccana	***Chrysocephalum apiculatum***	
Eucalyptus tereticornis	*Desmodium brachychiton*	*Canopy: 9*
Kunzea ambigua	***Einadia nutans spp.***	*Mid-storey: 18*
Microlaena stipoides var. stipoides	***Hypericum gramineum***	*Ground layer: 29*
Olearia elliptica var elliptica	*Swainsona galegifolia*	
Ozothamnus diosmifolius		
Panicum effusum		31/66 EEC species
Themeda australis		
Vittadinia spp.		

Hunter Ironbark Communities Experimental Site

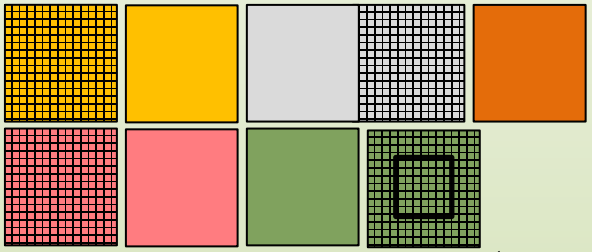
Substrates Trial:

- Forest topsoil
- Spoil
- OGM: Organic Growth Medium
- Mulch: wood chip
- Subsoil

Substrate layout

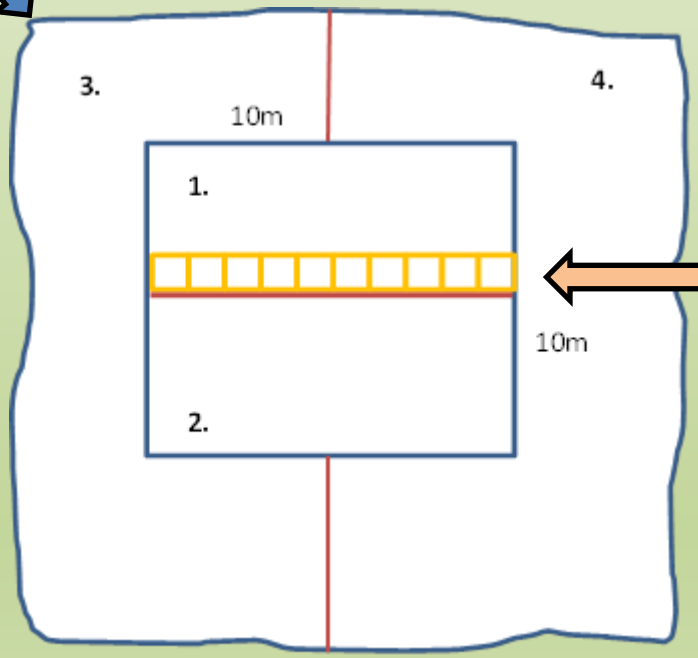


Seeding



Block 6

Group A & C



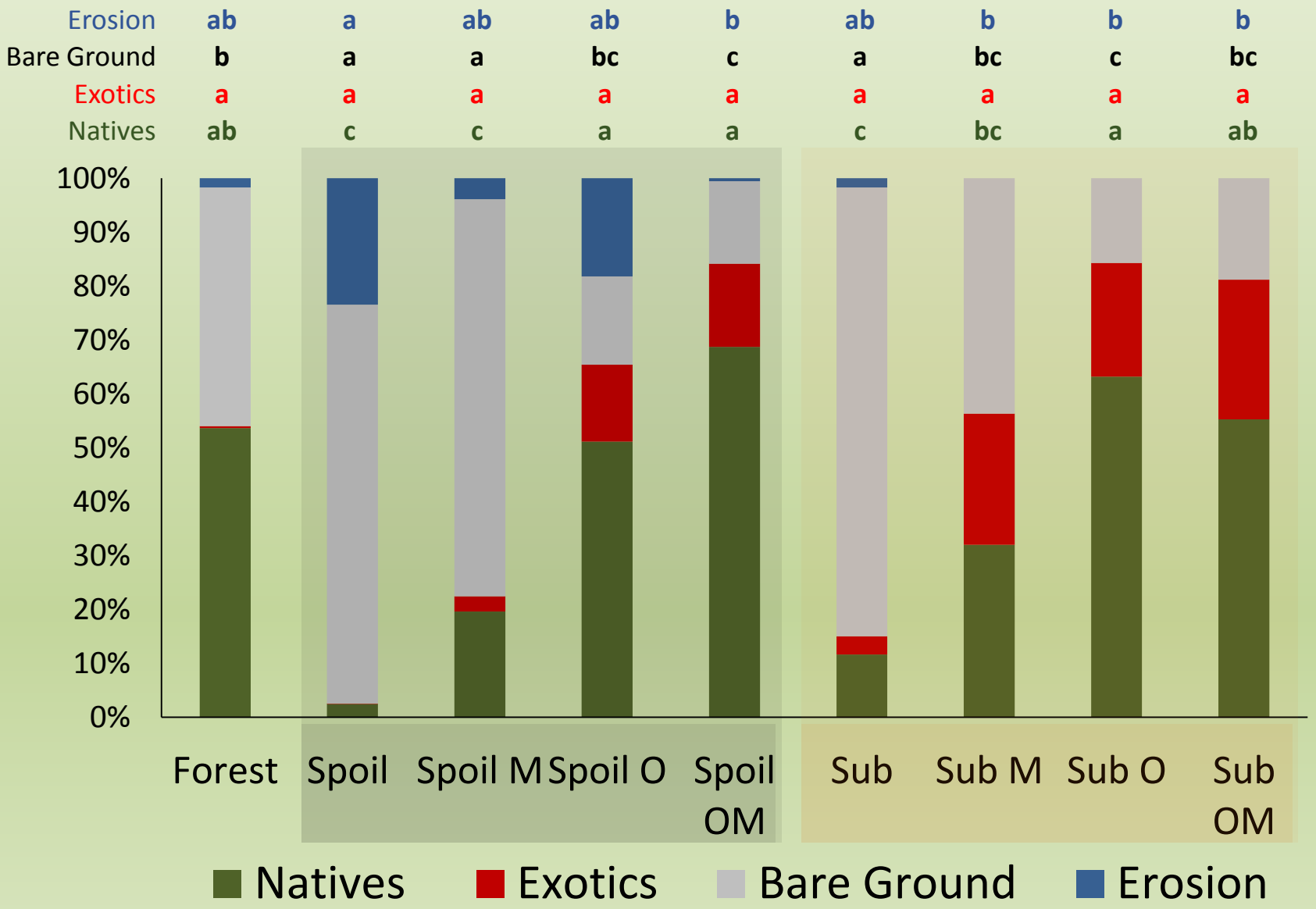
Group B – Hot Spots

Finalised: Nov 2013


June 2014
N
Late 2015

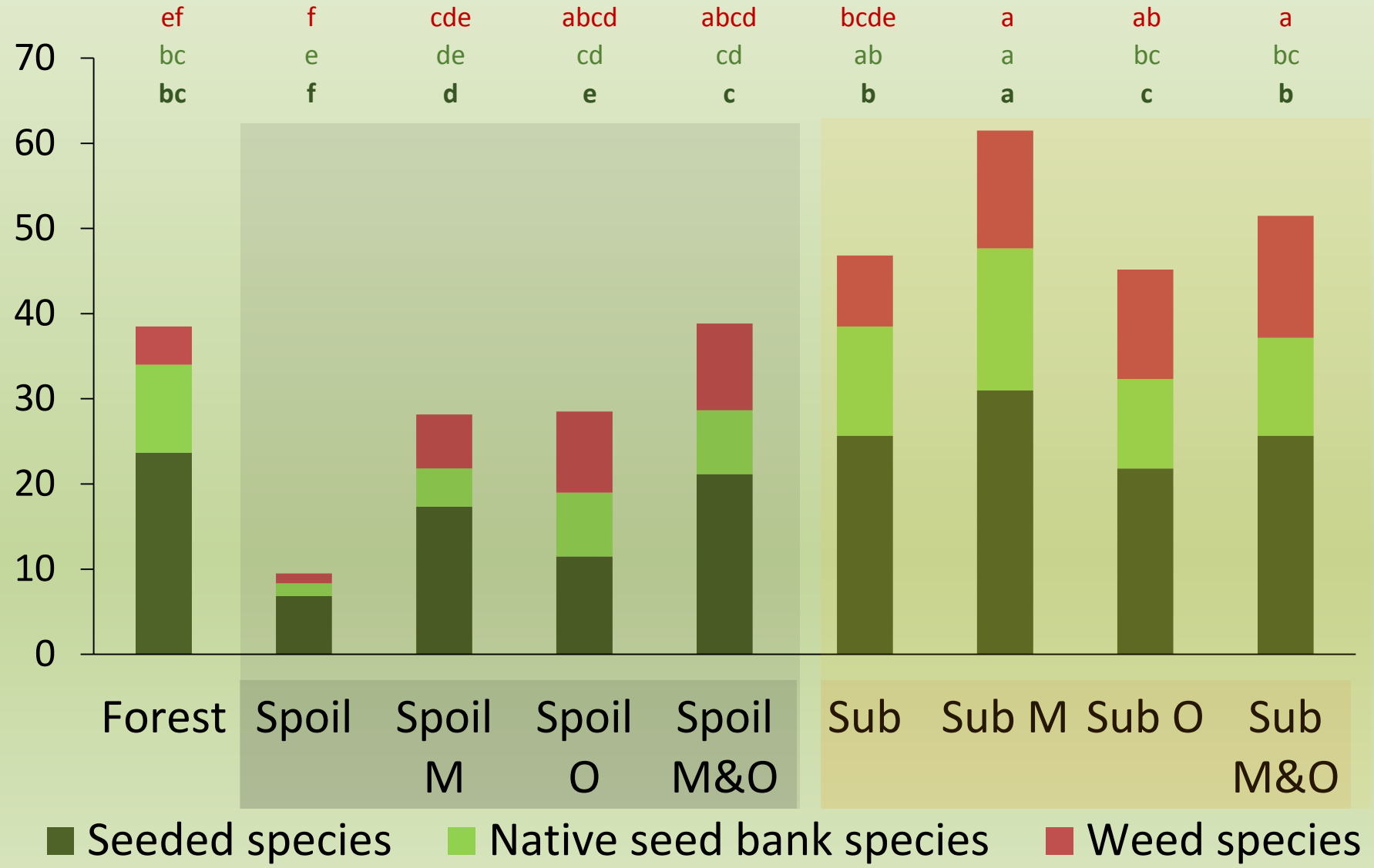
Plant Cover

At 24 months from seeding – Nov. 2015

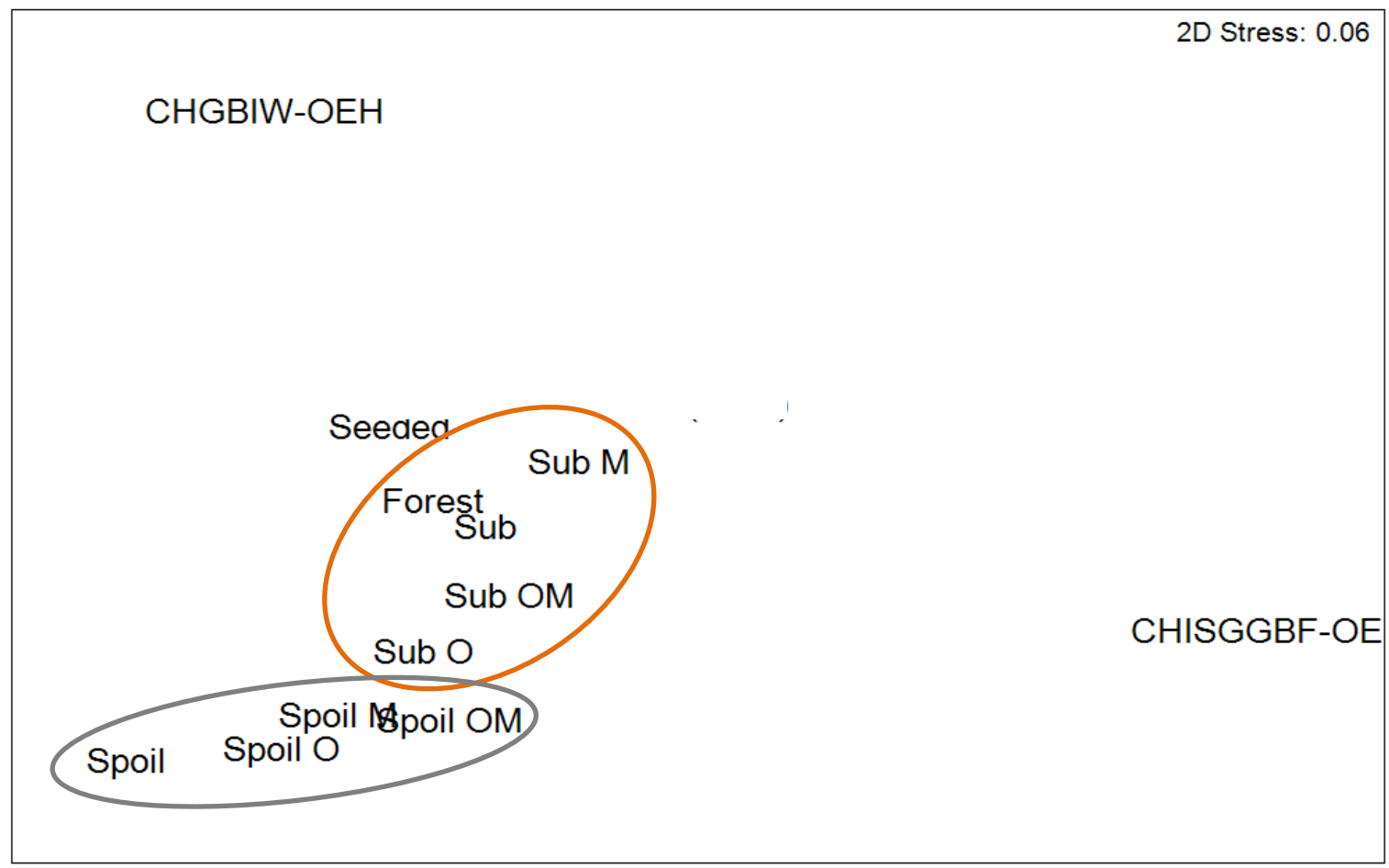


Diversity

Average number of species at 2yr



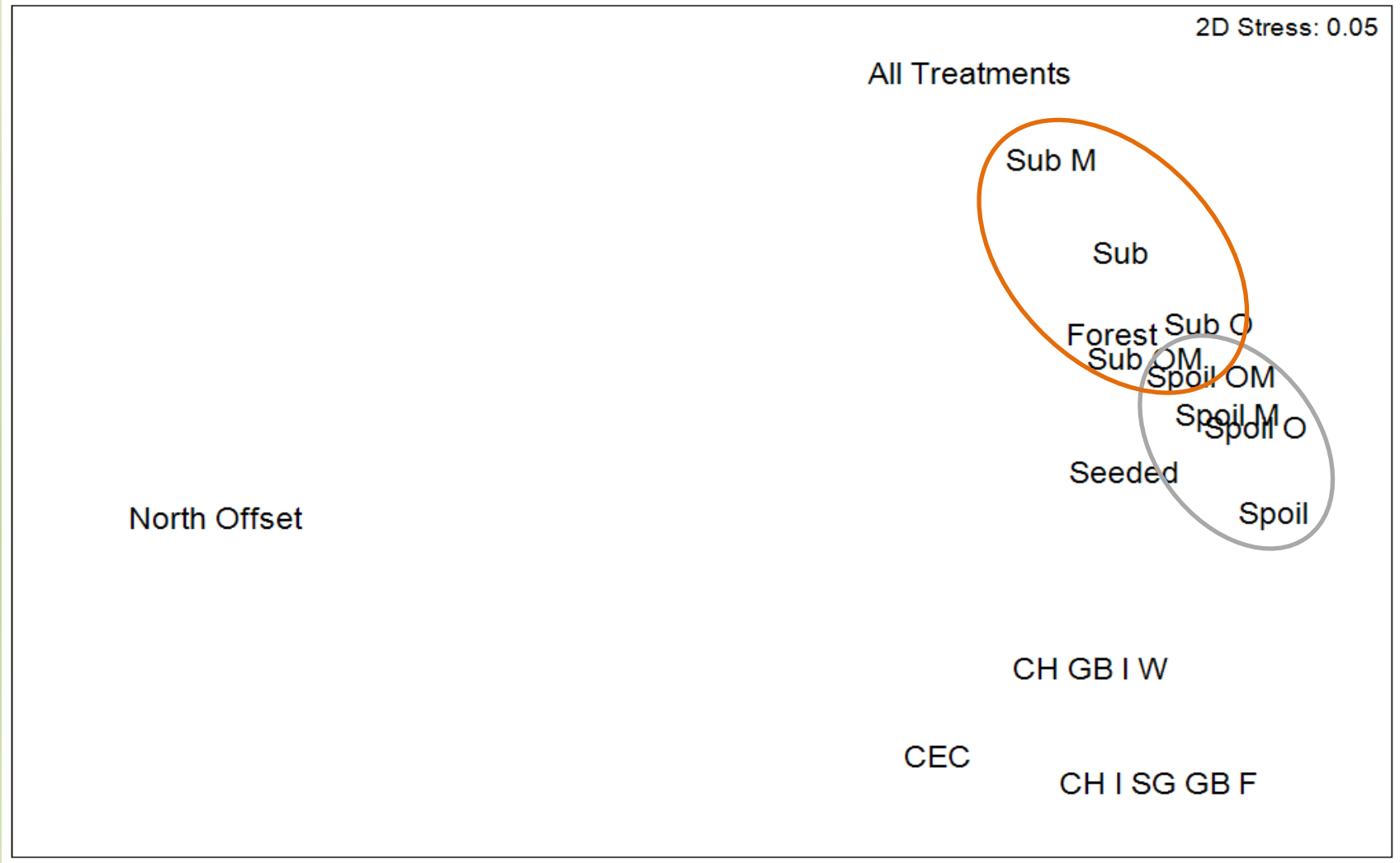
How Similar are the Species lists on the treatments to the EEC lists?



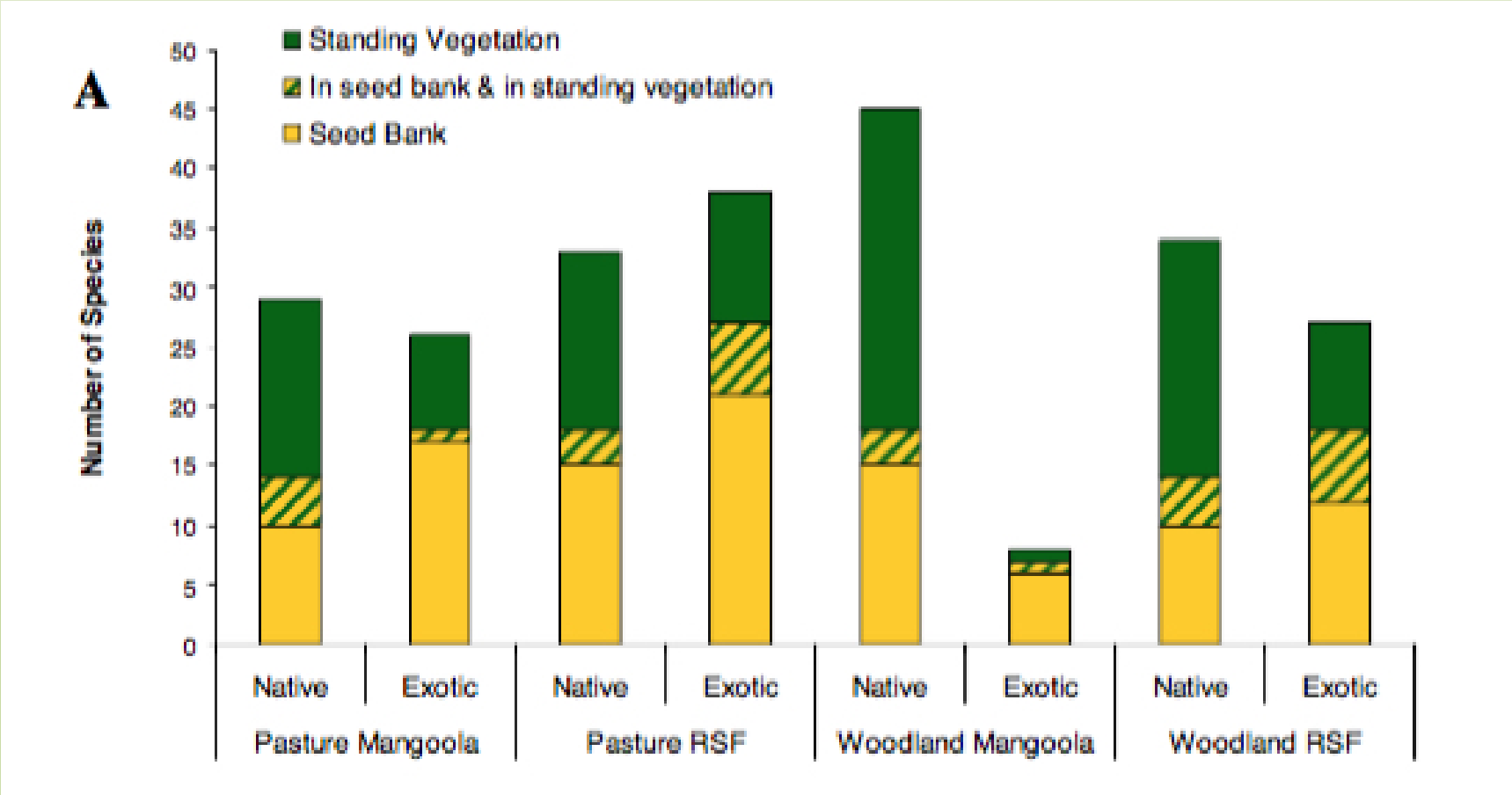
Multiple Dimensional Scaling (Primer 6): Compares lists of data to each other

But…

Characteristic EEC species are not the only components of communities

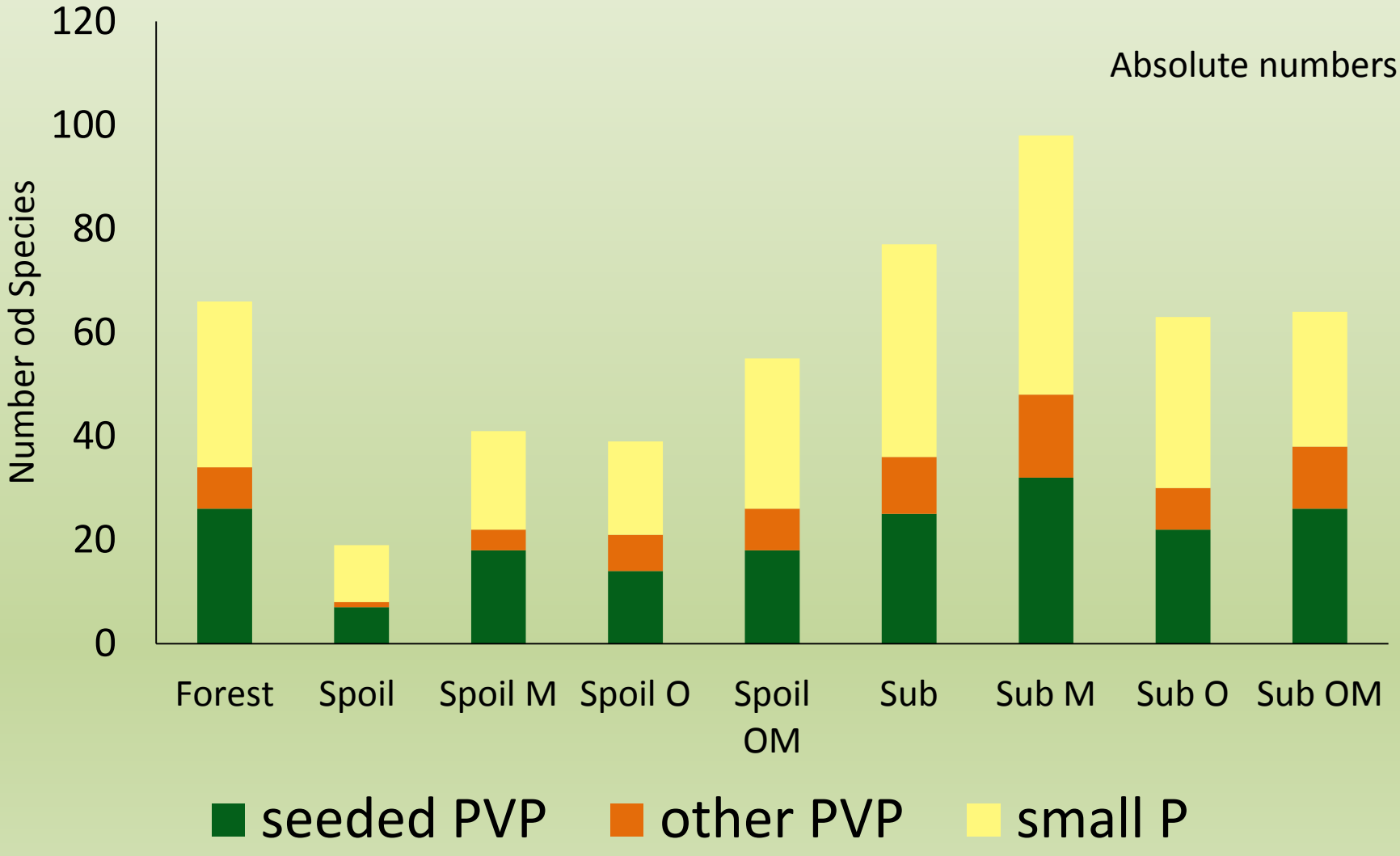


Comparing ”Standing Vegetation” to seed banks: what we see in the “bush”



- Nussbaumer, Y., **Castor, C.,** and Cole M., **2012**, “Establishing Native Vegetation: Principles and Interim Guidelines for Spoil Placement Areas and Restoration Lands” produced by The University of Newcastle and Xstrata Coal NSW.

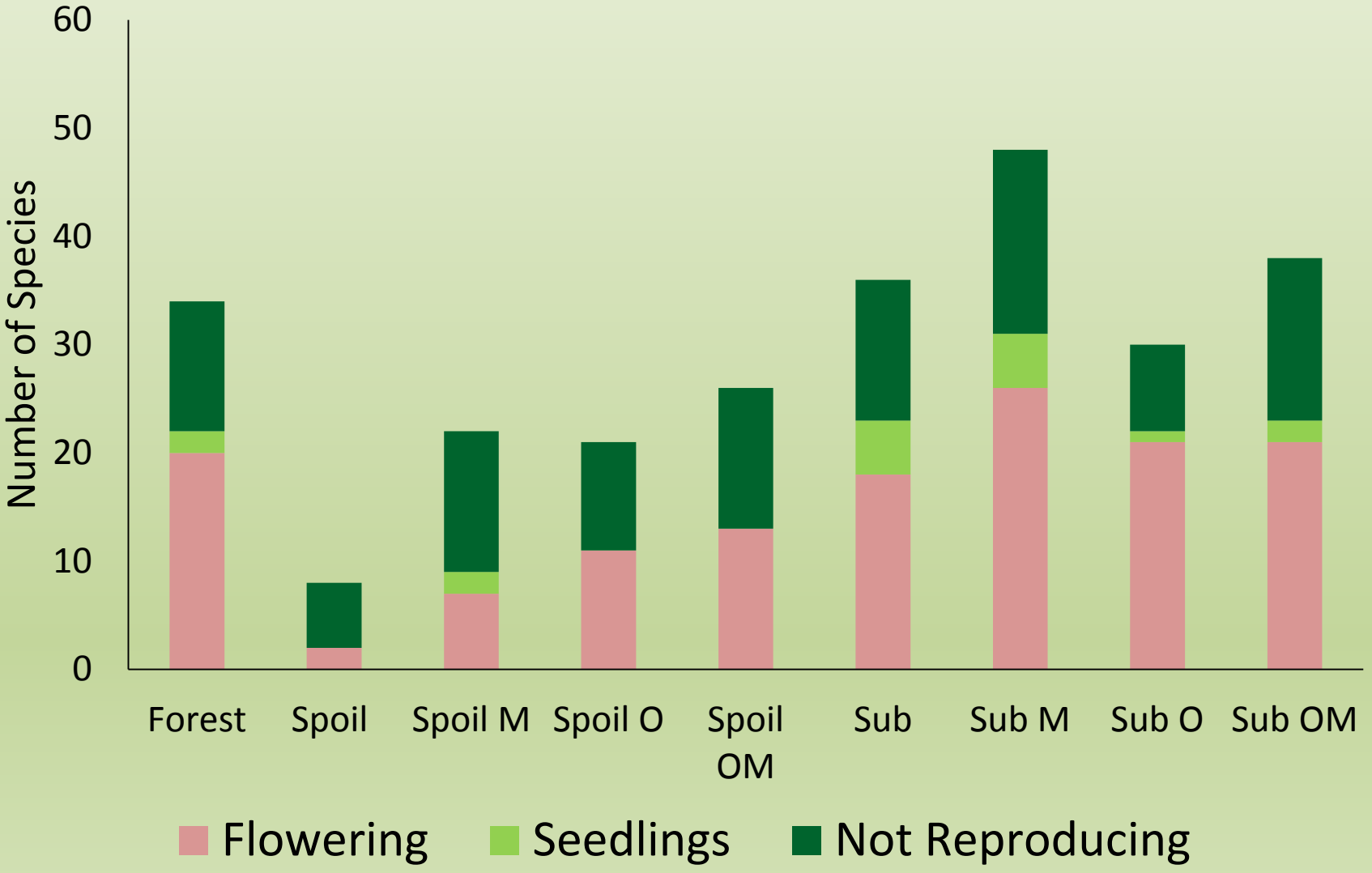
Diversity and Reproductive Potential



PVP = Possibly Viable Populations n: >= 36 individuals

0.3 ha surveyed

Reproduction in Populations >=36



Phase 2 - Herbaceous Plant Population Sustainability Study

- Planting of target species
- Evaluate survival on different substrates & effect of competition
- Evaluate existence of life cycling barriers: viability of seed, predation by ants, germination microsites.

See Poster !

R. Scanlon 2015 Honours Thesis

GLENCORE

Effect of Soil Type on Plant Survival

Robert Scanlon* and Carmen Castor*^
*University of Newcastle, ^CSER Research

Introduction

Soil is of great importance to the survival of plants, not only providing a stable location to live but also providing the essential nutrients required to grow and reproduce. Similarly, the plants of the ground layer are very important to an ecosystem providing ground cover to reduce erosion and accounting for 70% of the plant diversity in local EEC's in the Hunter Valley.

Methods

Our study examined the survival of six perennial species (mostly forbs) over one and a half years and has related their survival to combinations of soil types and treatments used; spoil, subsoil, OGM and mulch.

Results

Each of the species studied showed a different preference for soil type which allowed them to reproduce and maintain their population (Figure 1). However, even with the various combinations of soil types, some species still had poor survival (eg *H. gramineum*). The strongest result was from the addition of mulch which increased the survival of 5/6 species but decreased survival in 1 species (Table 1).

Table 1. Soil type on plant survival

Scientific name	*Calotis lappulacea*	*Chrysocephalum apiculatum*	*Desmodium brachypodum*	*Einadia nutans*	*Hypericum gramineum*	*Swainsona galegifolia*
Common name	Yellow Burr-Daisy	Yellow Buttons	Large Tick-trefoil	Climbing Saltbush	Small St. John's Wort	Smooth Darling Pea
Spoil	✗	—	✗	—	✗	—
Subsoil	✓	—	✓	—	✓	—
Mulch	✓	✓	✓	✗	✓	✓
OGM	✓	✗	—	✓	✗	✓

Conclusion

Each species has a niche that it is best suited to and therefore, even though all species come from one community, they will survive best in different soil conditions. Therefore a simple way to help increase plant diversity is to increase soil type diversity over the 10-100m scale and create a series of patches across the landscapes (Figure 2).

Figure 2. **Conceptual** patchy soil landscape over a 10-100m scale

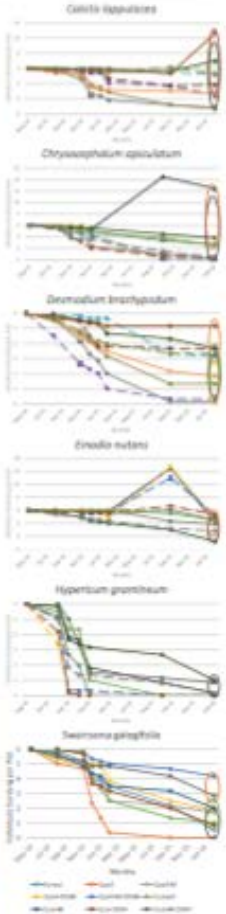


Figure 1. Survival of species. Each population started at 6. Any increase is due to new seedlings and juveniles.

Acknowledgements: Thank you to Glencore for funding and the staff at Ravensworth Operations for site assistance as well as Mike Cole from CSER Research and Michael Bonanno at Global Renewables for advice.

Robert has been working for the last two years as a research assistant at CSER Research and the University of Newcastle. He was recently accepted as a PhD candidate at the University of Newcastle and is looking forward to learning more about the interactions between soils, plants, microbes and their implications for restoration.

For information regarding study methods contact:
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Conclusions - 1

- The more **“natural” substrates have best diversity** and reproduction (despite low CNP)
- **High nutrient substrates encourage vegetative cover.**
- Getting **seed for EECs** is still problematic
- Getting communities resembling EECs is problematic
- Reproduction potential is 30% at 2 years
- Some species already are producing viable seedlings
- Herbaceous species each respond differently to substrates indicating that **heterogeneity on a rehabilitation site will maximise overall diversity.**

Conclusions 2

Early indicators of sustainability:

- Diversity and reproductive status: increases survey time by a minimal amount.
- Abundance data: 0.27 ha (54 10x10m plots) = 80 person/hours
- Validation in the long term and predictive models

Later indicators of sustainability need to be tested

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