Building “climate future plots”: Trial design considerations

Brad Potts and Tanya Bailey

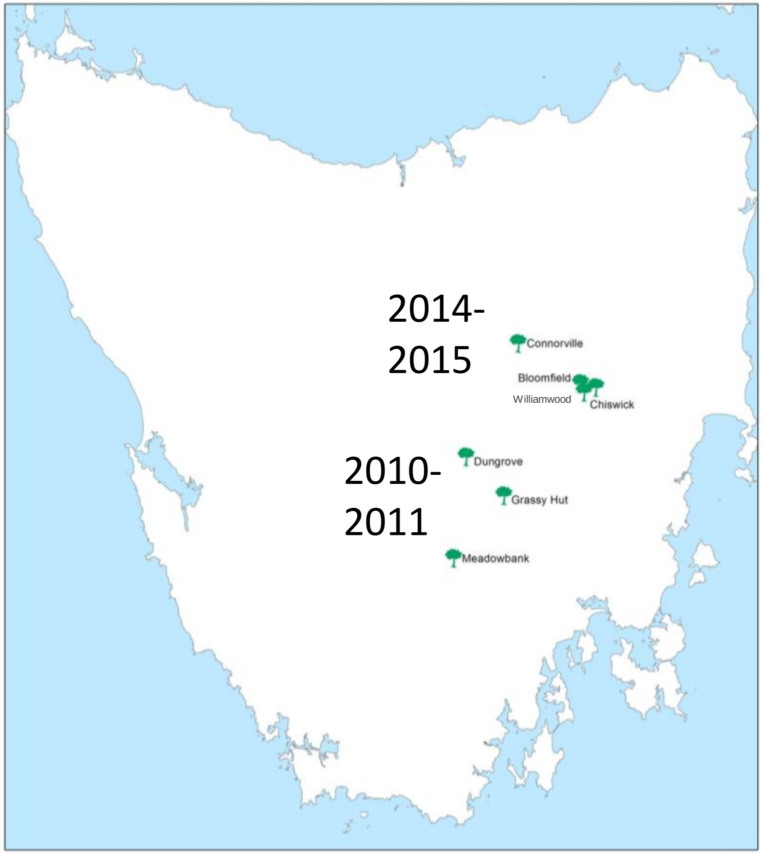
https://eucalyptgenetics.com/

Greening Australia   UNIVERSITY of TASMANIA   Australian Research Council CENTRE FOR FOREST VALUE

Potts BM and Bailey TG (2017). Building “climate future plots”: Trial design considerations. Presented at VICNATURE 2050 workshop on “Building “climate future plots: designing trials to usefully inform management”, 17th Feb 2017. Arthur Rylah Research Institute, Heidelberg Victoria.

Building a long-term research infra-structure within GAs restoration plantings in Tasmania

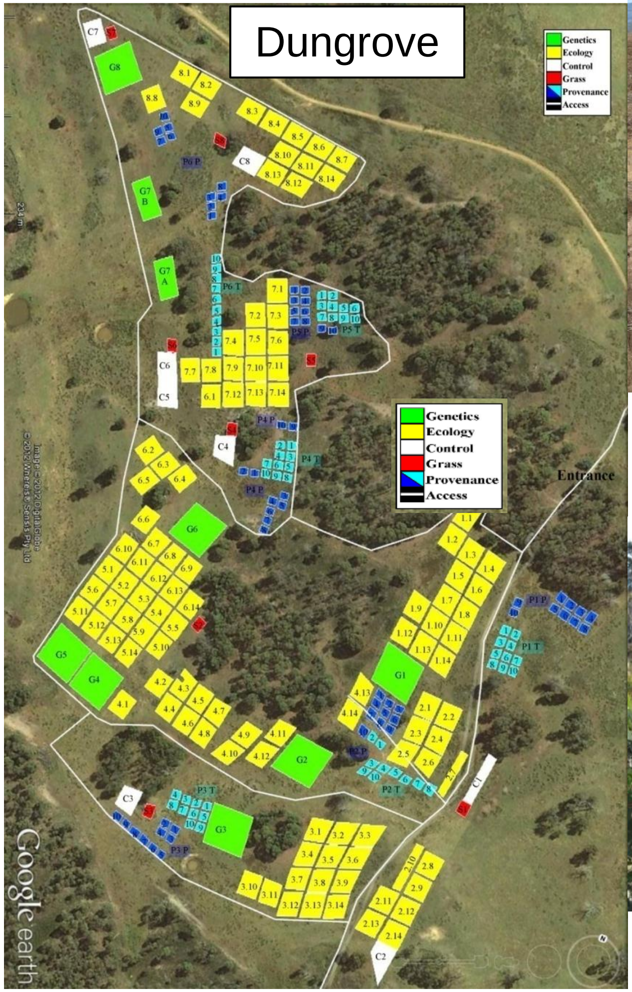
c. 20% of restoration plantings are pedigreed local, multi-provenance and multi-species trials



0 10 20 40 60 80 Kilometers

Map prepared by Laurie Kerr
Greening Australia Tasmania
Date: 7 October 2014

Datum: GDA94
Grid: MGA zone 55



Connorville est. 2014

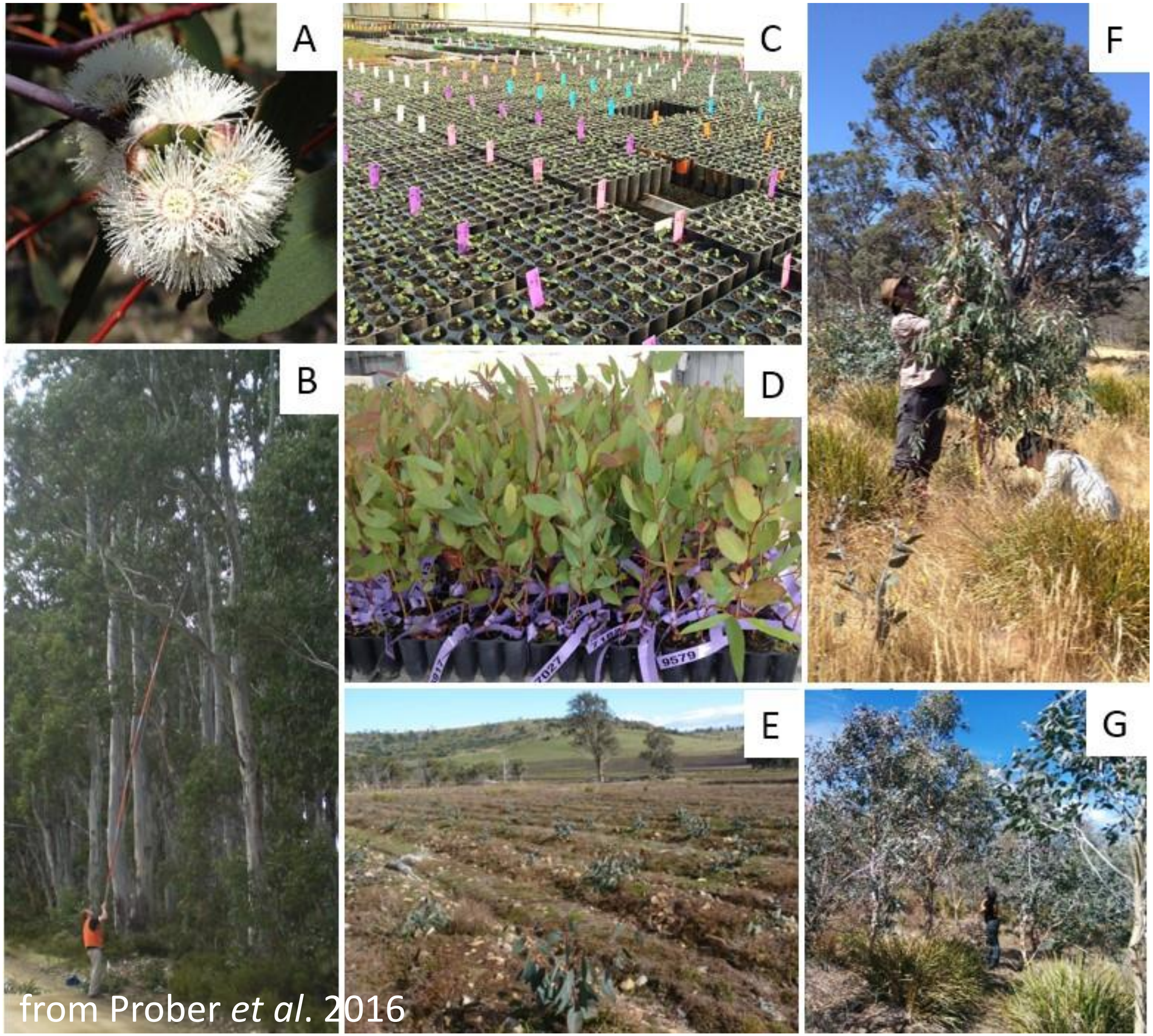
Dungrove est. 2010

Bailey *et al.* 2013, 2015
Gauli 2014

Australian Government
Australian Research Council

Greening Australia

Trial establishment and assessment



from Prober *et al*. 2016

A. *Eucalyptus* are our main genetics study species
B. Seed collection across species' Tasmanian ranges (800 trees)
C. Seedlots from each individual tree (family) grown in separate seedling trays and randomised within a commercial nursery
D. Individual seedlings labelled and sorted into experimental designs (c. 50,000 in total)
E. Planted in common garden field trials (8 sites)
F. Fitness measurements: survival, height, stem diameter and record biotic/abiotic events
G. Reproduction measurements from 2yrs

Testing local performance and climate-adjusted seed sourcing

Trials with increasing diversity

1. Local provenance only
   (E. ovata , E. pauciflora, E. tenuriamis)
2. Provenance blocks local/ non local
   (E. pauciflora, E. tenuriamis)
3. Mixed provenance
   (E. ovata , E. pauciflora)
4. Mixed species and provenance
   (E. ovata and *E. pauciflora)*
5. 5 eucalypt spp in caged wide-spaced plantings
   (E. ovata , E. pauciflora, E. viminalis, E. amygdalina, E. rodwayi)
   - which species grows best where?
6. 8 species/genera mixed
   (5 euc *spp*. plus *Acacia, Allocasuarina, Cassinia*)
   - are there better options?
7. Ecology trials
   pedigreed eucalypts +/- other genera/understorey

1. Life history stage: seedlings versus planted stock

Ross

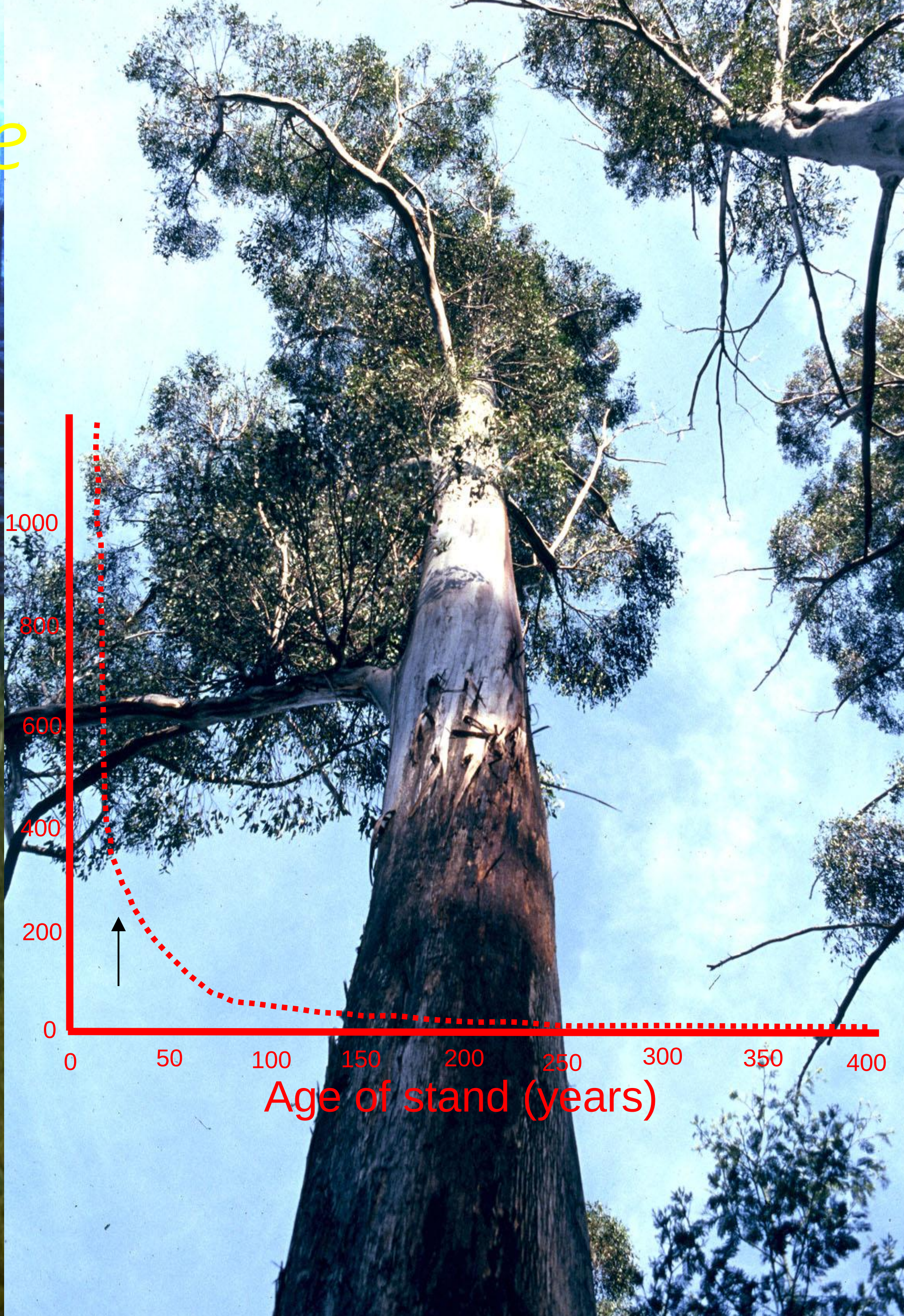
Oatlands

- TR116026 Polymer was laid down by machine in one pass at the same time as seeding with people walking behind and making sure soil was holding down the edges of the polymer
- Seed sown at a total of 420g/km

2. Establishment niche and competition: natural versus artificial

Fierce density dependent selection

Gilbert JM (1958) Forest succession in the Florentine Valley, Tasmania. *Proceedings of the Royal Society of Tasmania* **93**, 129-151.



3. Inference space/replication

- site level:
  - replication of environments
  - replication of planting seasons
  - non-contiguous replicates
  - lots of small versus several big trials

- genetic level:
  - individuals per family
  - families per provenance
  - provenance per species

4. Genetic treatments

- local controls:
  - local provenance
  - other local species
- non-local:
  - climate adjusted provenancing
    - testing provenances
    - testing provenance mixes
  - how local is local?
  - provenance transfer functions

5. Future climate predictions

Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

TECHNICAL ARTICLE

Integrating climate change and habitat fragmentation to identify candidate seed sources for ecological restoration

Peter A. Harrison[1,2], René E. Vaillancourt[1], Rebecca M. B. Harris[3], Brad M. Potts[1]

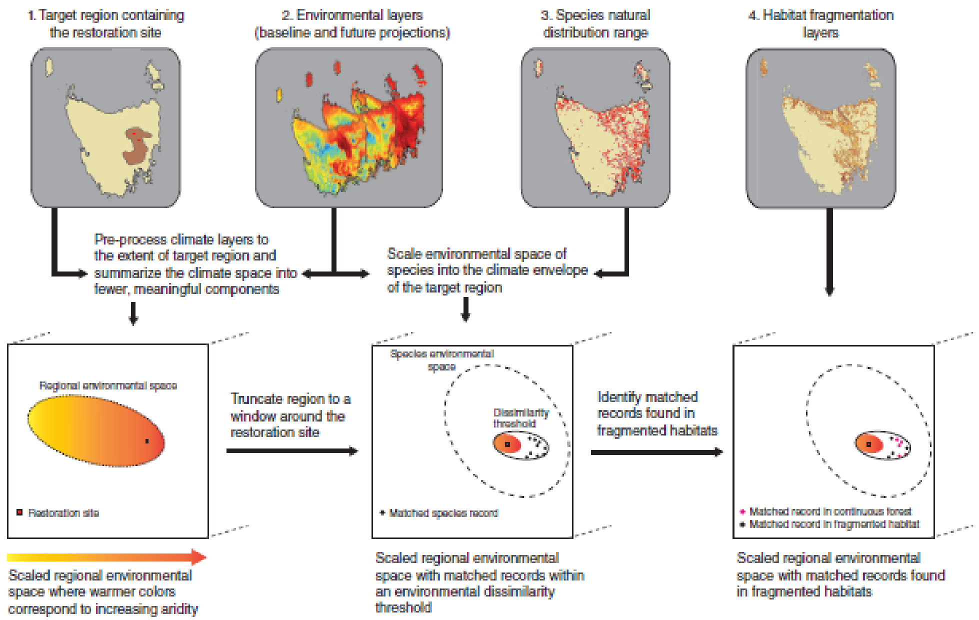


Figure 1. Generalized procedure of the Provenancing Using Climate Analogues (PUCA) framework. Shown are the four required datasets for PUCA to identify species records that are most analogous to the current and future climate for the restoration site by first summarizing the environmental variation of a region into fewer, meaningful components, then truncating the regional environmental space to a geographical buffer around the restoration site to limit the search area to match species records with the restoration site. The habitat fragmentation layer is then used to identify which matched species records occur in disturbed landscapes where genetic integrity may be compromised (Young et al. 1996).

Provenancing using climate analogues (PUCA)

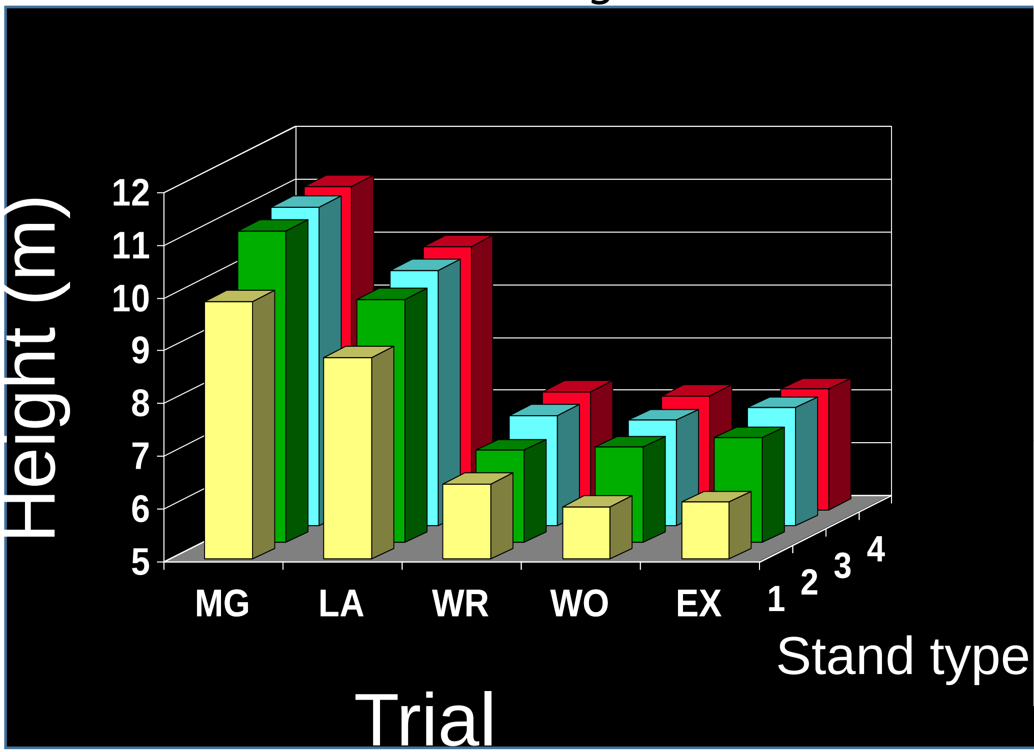
Harrison *et al.* 2017 Restoration Ecology

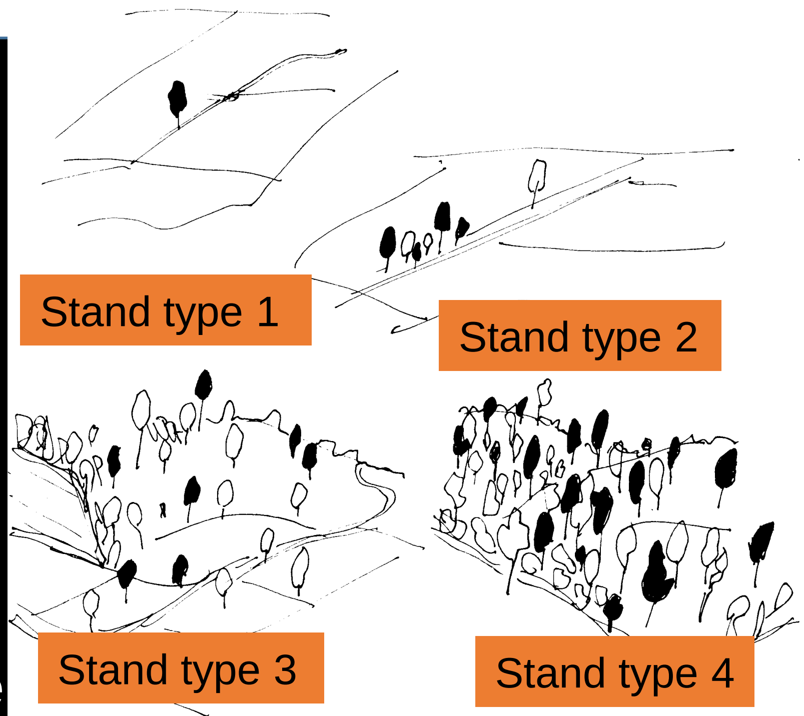
6. Local adaptation versus inbreeding

Seed source an issue:

open-pollinated families may be selfed to various degrees

The effect of parental stand type on 4 year height in five trials of *E. globulus*





Borralho and Potts 1996, New Forests 11: 53-64

7. Size and scale of experiments

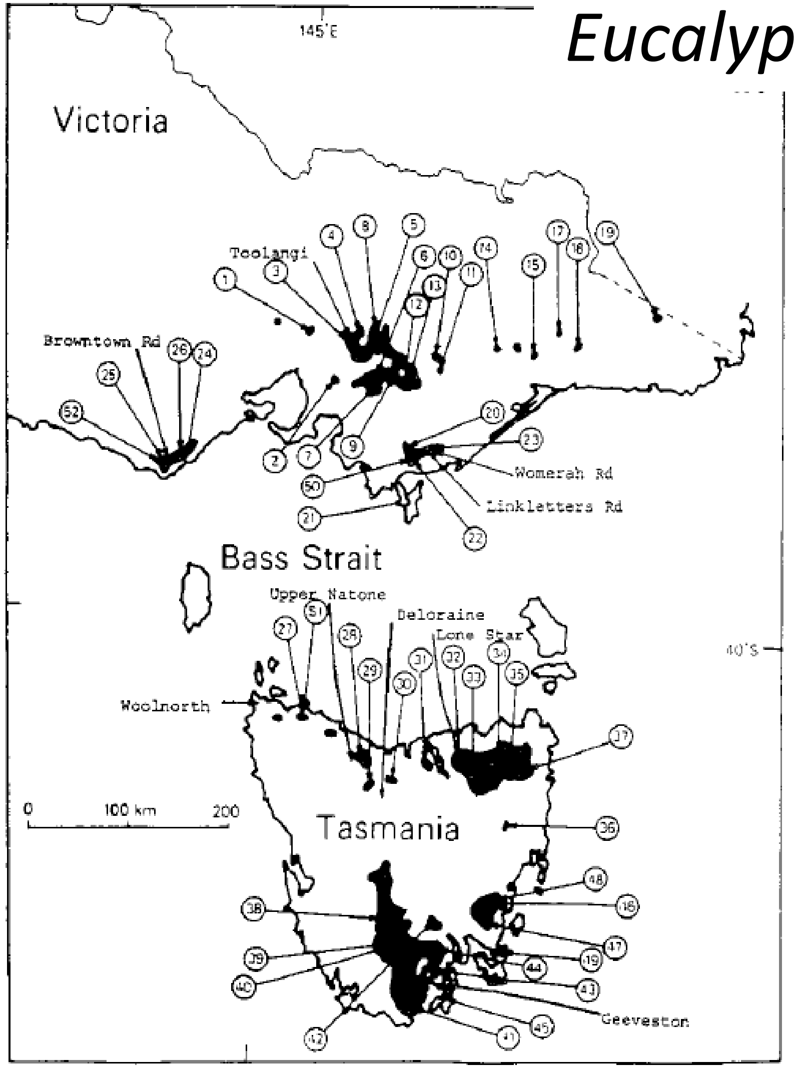


Figure 1. Distribution of provenances of *Eucalyptus regnans*

Eucalyptus regnans provenance trials

Established: 1977/78

Design

- 49 provenances
- 3 to 55 trees per provenance
- 9 sites
- 44 provenances on all sites
- ‘local’ assigned for all sites

Monitored: 9 – 13 years

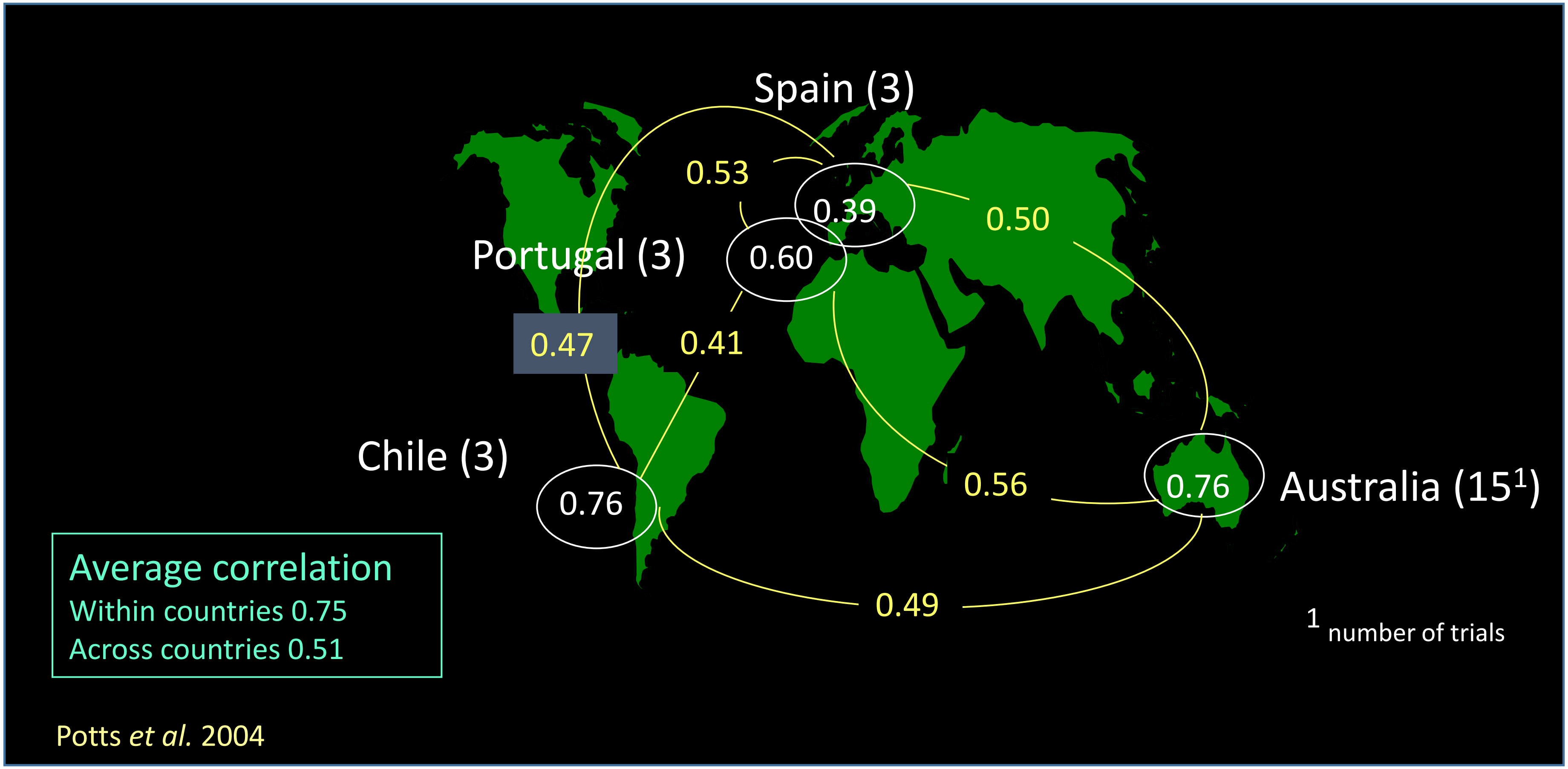
Local provenances did not perform among the best at 8 of the 9 sites

Raymond *et al.* (1997) *Forest Genetics* **4**, 235-251.

8. Pedigree connectivity

Key to unravelling genotype by environment interactions and demonstration of differential adaptation

Average across site correlation of *Eucalyptus globulus* provenance performance (stem diameter ages 3-6 years) between and within countries



9. Competition and facilitation

- large plots versus single entries (single-tree plots)
- inter-plant interactions:
  - provenance level
  - species level
  - (species co-adaptation)
- biotic versus abiotic environment

10. Do we need to move communities?

OIKOS
SYNTHESISING ECOLOGY
Explore this journal >

Research

Local biotic adaptation of trees and shrubs to plant neighbors

Kevin C. Grady, Troy E. Wood, Thomas E. Kolb, Erika Hersch-Green, Stephen M. Shuster, Catherine A. Gehring, Stephen C. Hart, Gerard J. Allan, Thomas G. Whitham

First published: 5 December 2016 Full publication history

DOI: 10.1111/oik.03240 View/save citation

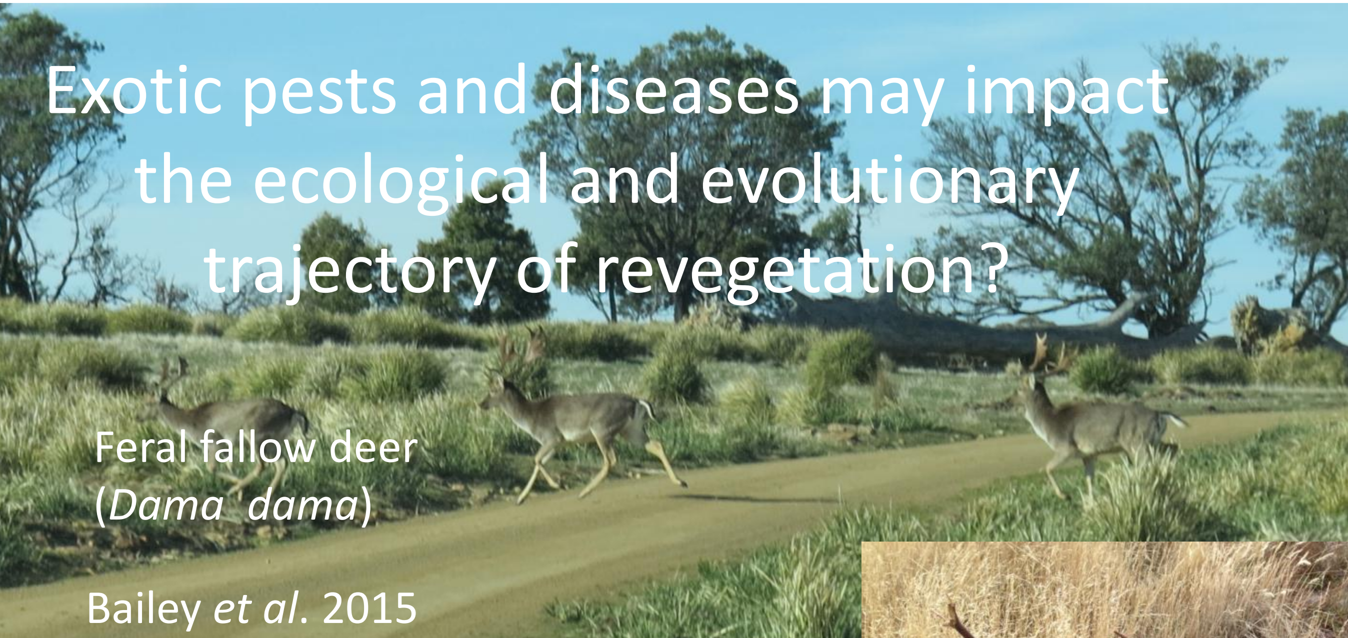
Species co-adaptation

Co-occurring willow and poplar species sampled and tested in co-occurring and non-co-occurring combinations

62 of 88 genotypes grew faster with same site neighbors than different site neighbors
Fitness determined by adaptive interactions among multiple plant species

11. The wildcards: exotic pests and diseases

Protect or not protect?



Exotic pests and diseases may impact the ecological and evolutionary trajectory of revegetation?

Feral fallow deer (*Dama dama*)

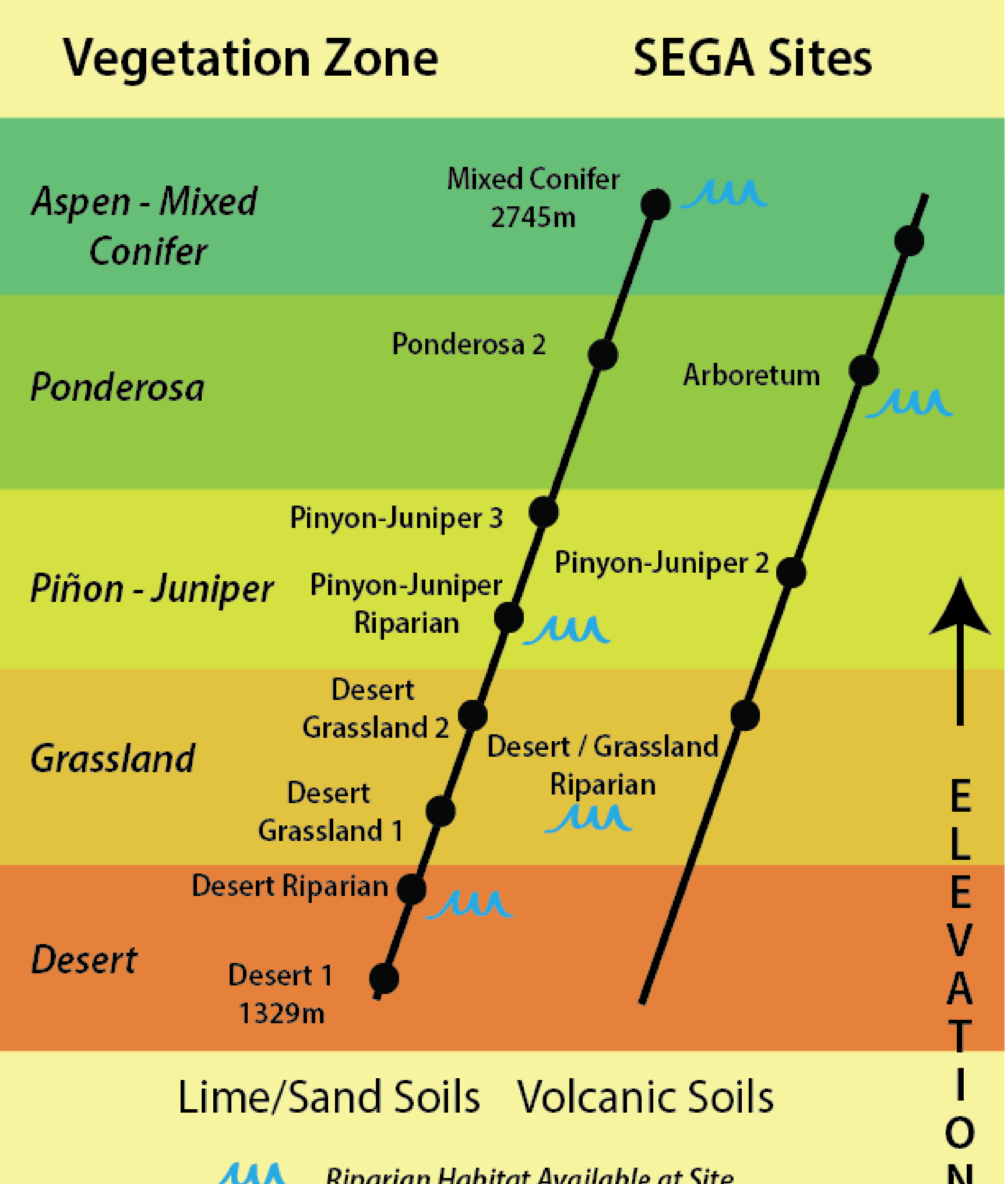
Bailey *et al.* 2015

photo: Jeremy Brawner

E. pauciflora

Potts *et al.* 2016

from Karanjeet Sandhu



Slide provided by Tom Whitham

Southwest Experimental Garden Array

sega.nau.edu

SEGA provides next generation genetics-based infrastructure to conserve biodiversity, community structure and ecosystem function with the challenges of:

1. **climate change,**
2. **invasive species, and**
3. **other global changes.**

$4.5 million NSF/NAU

GO and NGO Participants: USFS, NPS, BLM, BOR, TNC, AZ Game & Fish, Babbitt Ranches, Grand Canyon Trust, & The Arboretum at Flagstaff

Key factors that affect cottonwood performance for inclusion in models and restoration.

1. **Use genetically appropriate stock for future climates** (Grady et al. 2011 Global Change Biology, 2013 Functional Ecology, 2015 Restoration Ecology)
2. **Use genetically appropriate stock for each ecoregion** (Ikeda et al. 2017 Global Change Biology).
3. **Use genetic stock that does best in exotic (tamarisk) altered soils** (Grady et al. unpub. data).
4. **Inoculate with appropriate mycorrhizal mutualists** (Gehring et al. 2014 Molecular Ecology).
5. **Plant adjacent to willows that act as nurse plants** (Parker et al. unpub. data).
6. **Use intact communities that are coevolved** (Grady et al. 2017 Oikos).
7. **Select for root architecture to reach a deeper water table** (Parker et al. unpub. data)
8. **Use genotypes that support high biodiversity, stability & network interactions** (Keith et al. 2010 Ecology, Ikeda et al. 2014 Functional Ecology, Lamit et al. 2015 Journal of Ecology, Lau et al. 2015 Ecology).

Slide provided by Tom Whitham

"Recommendations to land managers who own all the sites. Such recommendations are key to their participation and involvement."

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