

# **Does climate adjusted seed sourcing produce better restoration outcomes over local seed?**

## **Insights from provenance trials**

Siegy Krauss

Kings Park and Botanic Garden  
University of Western Australia



# Seed sourcing strategies for ecological restoration

## Local is best

Largely based on assumption that local seed are better adapted to local conditions  
Home-site advantage

## Challenges to Local is best

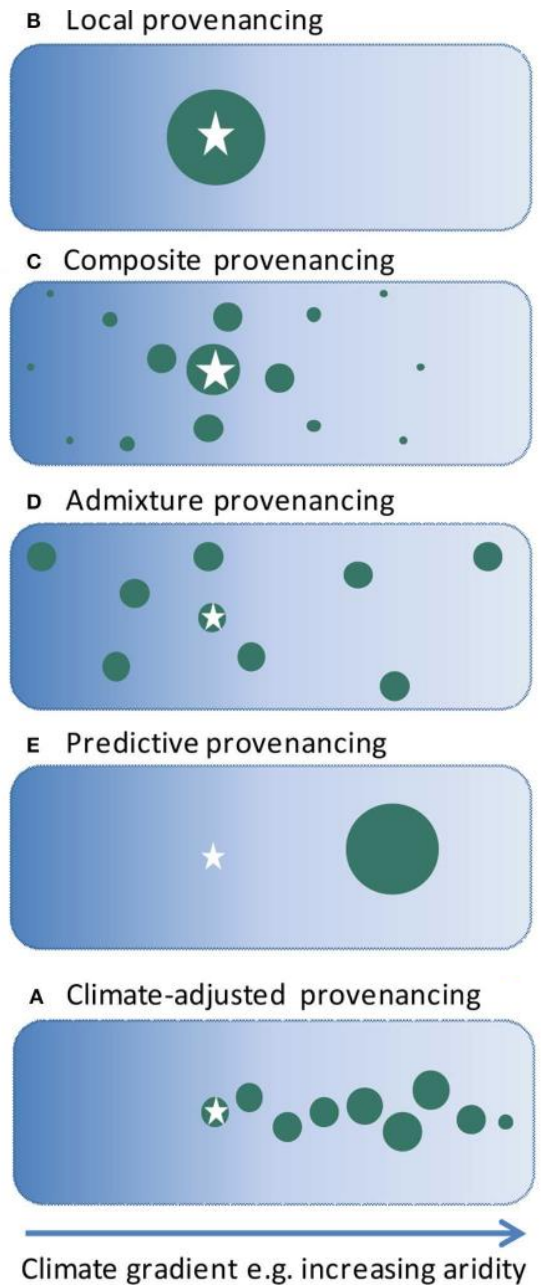
Increasing “evolutionary potential”  
Avoiding local small fragmented pops  
Composite provenancing  
Admixture provenancing

## Climate change –

Predictive provenancing  
Climate-adjusted provenancing

Ultimately, few studies have assessed provenance effects in an ecological restoration context

Provenance trials provide a powerful test



Direction of expected climate change at site

Adapted from Prober *et al* (2015) *Front. Ecol. Evol.* 3:65



# Local Provenance Trials in a Restoration Context

Journal of Applied Ecology



Journal of Applied  
Ecology 2007  
44, 583–593

## Provenance variation of ecologically important traits of forest trees: implications for restoration

ELEANOR K. O'BRIEN,\* RICHARD A. MAZANEC† and  
SIEGFRIED L. KRAUSS‡§

Restoration Ecology

THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION INTERNATIONAL

## Testing the Home-Site Advantage in Forest Trees on Disturbed and Undisturbed Sites

Eleanor K. O'Brien<sup>1,2</sup> and Siegfried L. Krauss<sup>3,4</sup> MAY 2010 *Restoration Ecology* Vol. 18, No. 3, pp. 359–372

## Local adaptation may not influence early survival and growth of a keystone forest tree: practical implications for ecological restoration (in prep)

Bradbury D, Ruthrof K, Veneklaas E, Krauss SL

## Local adaptation and seed sourcing for restoration (unpublished report 2012)

Smithson A, Krauss SL

## Ecology and Evolution

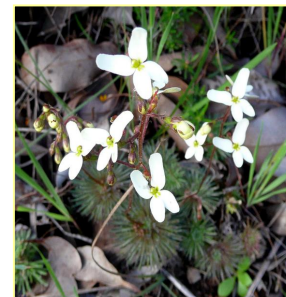
Open Access

## Inbreeding and outbreeding depression in *Stylidium hispidum*: implications for mixing seed sources for ecological restoration

Kristina M. Hufford<sup>1,2,3</sup>, Siegfried L. Krauss<sup>1,2</sup> & Erik J. Veneklaas<sup>2</sup>

## A genecological test of seed sourcing strategies for ecological restoration (in prep)

Krauss SL, Veneklaas E, Renton M



## Objectives

Conduct large-scale provenance trials, in an active restoration context, to ask:

1. Does success (germination, plant vigour, reproduction) vary with source?  
***“provenance effect”?***
2. Is success associated with **geographic distance** of source site from restoration site?  
*“home site advantage”?*
3. Is success associated with **climate distance** of source site from restoration site?  
*“home site advantage”?*
4. Are seed from hotter/drier sites more successful than those from cooler/wetter sites?  
***“predictive/climate adjusted provenancing”?***



# *Banksia menziesii*

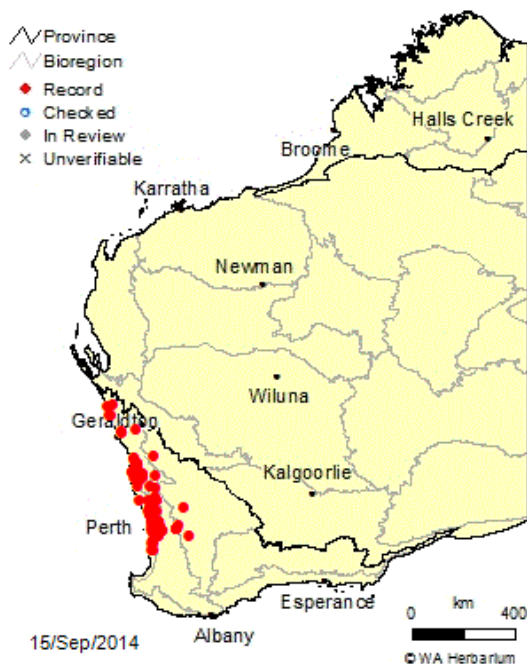
Widespread, dominant small tree of *Banksia* woodlands

Self-incompatible, bird pollinated, wide outcrossing, serotinous

Moderate genetic structure ( $F_{ST} = 0.18$ )

A key element of *Banksia* woodland restoration

Seeds are expensive!



# ***Banksia menziesii* provenance trial 1**

20 seed, from each of 10 plants, from each of 24 source populations,  
planted into each of 3 sites in May 2013 (14,400 seeds in total; 4,800 per site)



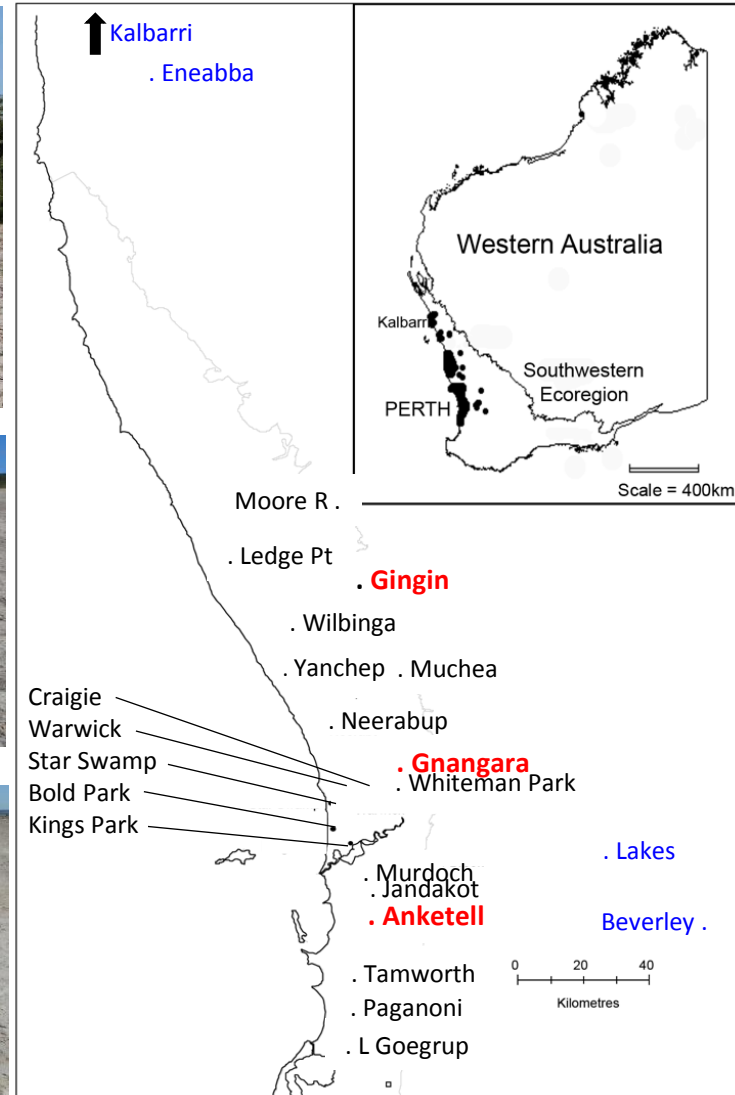
## **Trial sites:**

Within active post-sand-mining  
sites prepared for restoration

Each site = 2 replicate plots  
Each plot = 10 replicate blocks

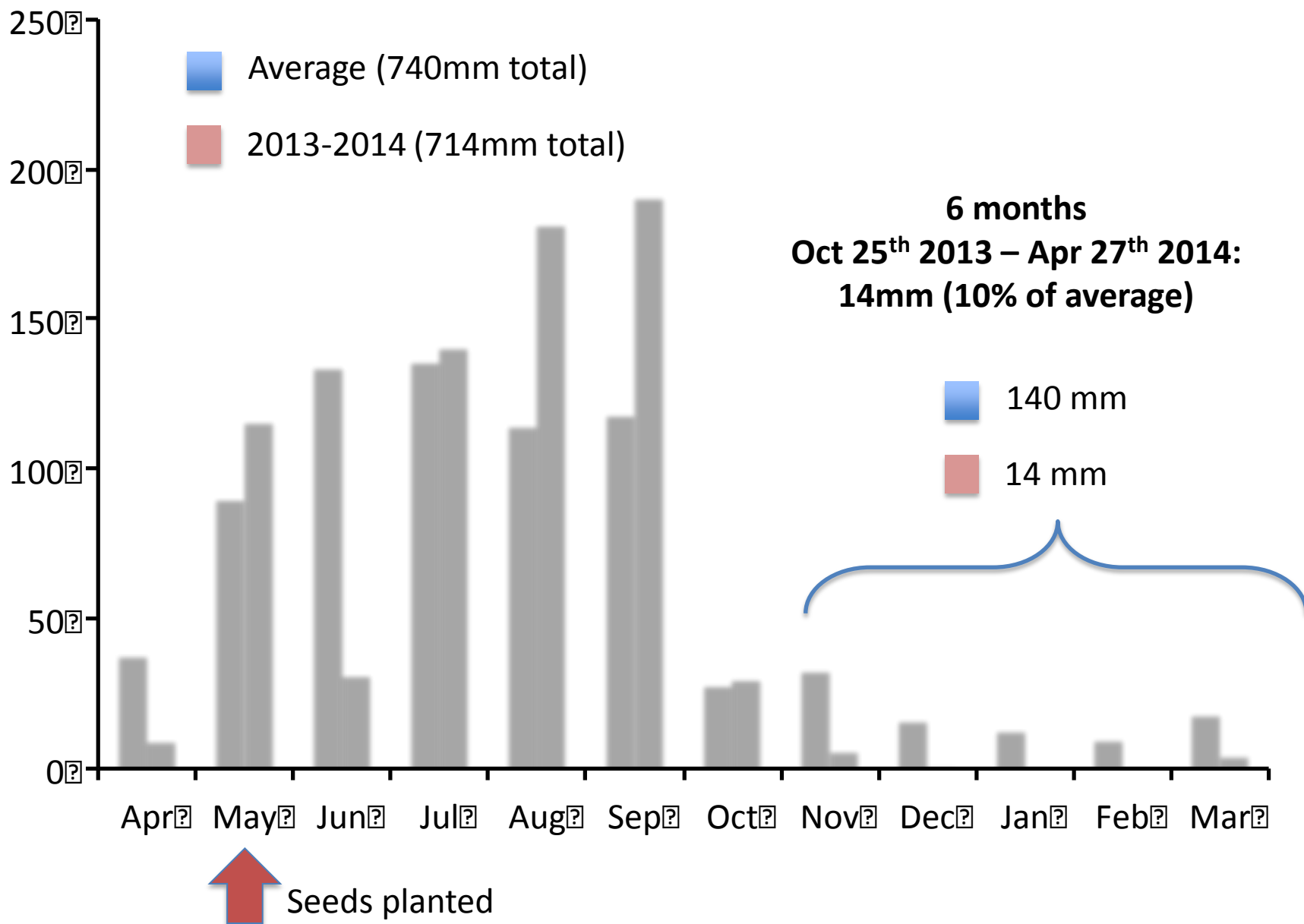
Each block = 10 seed from each  
of 1 maternal from each of  
24 source populations

Seed planted at 1m intervals





## Rainfall (mm) at Gnangara



**Very high seed germination**

**September 2013**

**Gnangara 74.6%**  
**(55% - 87%)**



**>99% mortality**  
**post-summer**

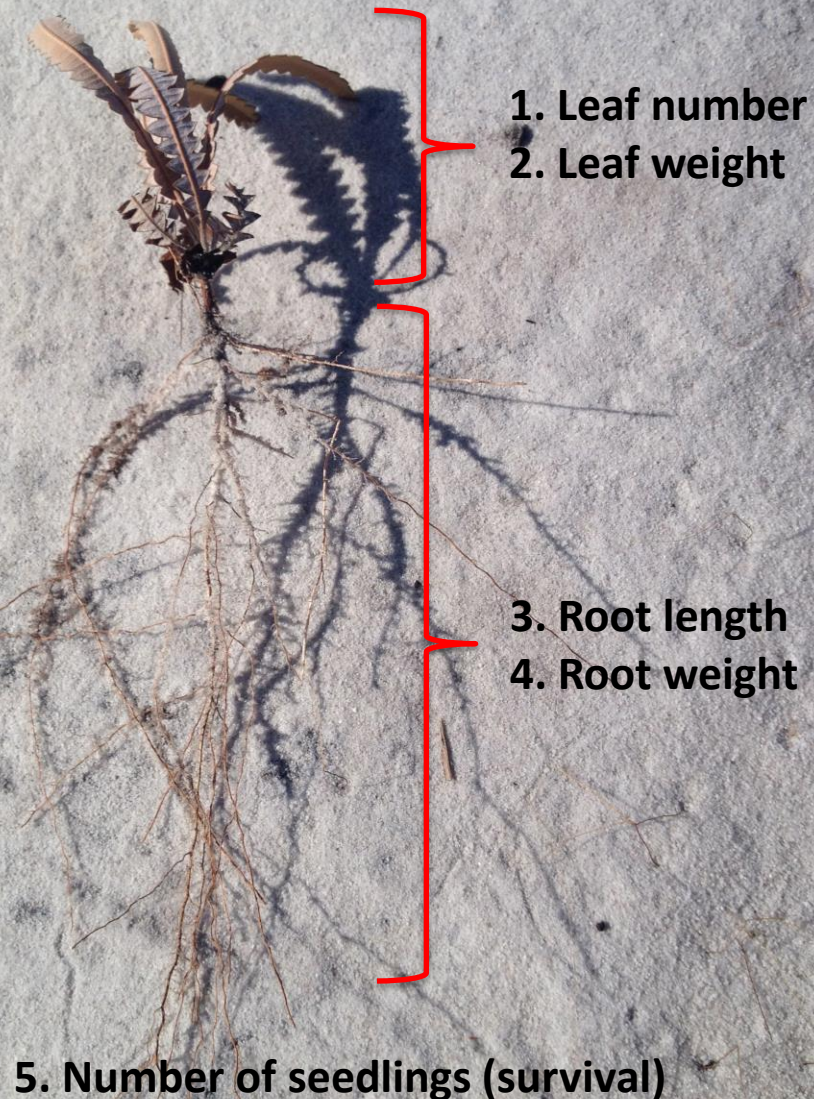
**Seedlings recovered**  
**April 2014**

**Gnangara 72.7%**  
**(53% - 89%)**

**n = 3490**



## Seedling vigour measurements

- 
1. Leaf number
  2. Leaf weight
  3. Root length
  4. Root weight
  5. Number of seedlings (survival)

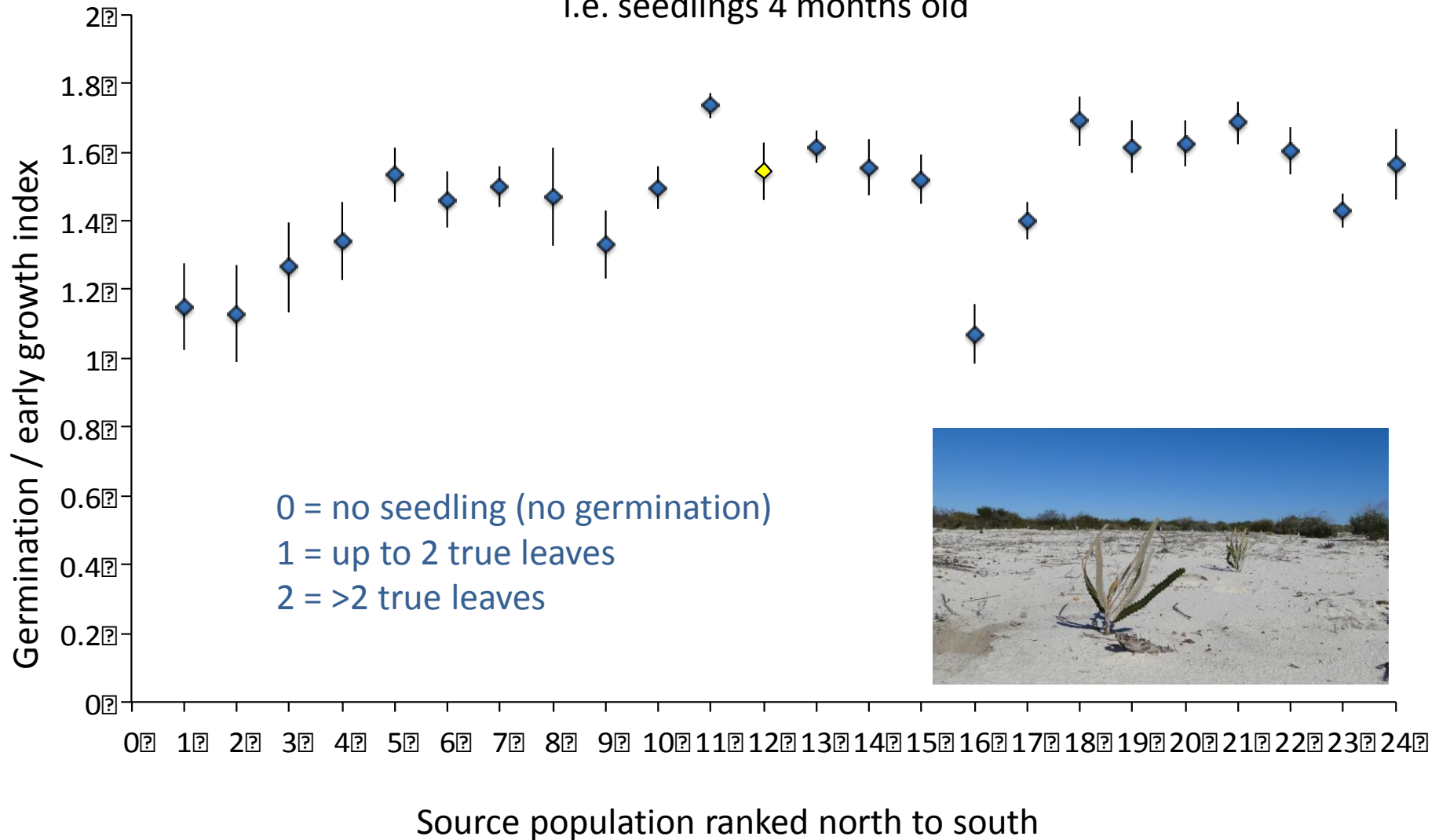
## A composite measure of seedling vigour

1. For each of 5 variables:  
*Leaf # : leaf weight : root length : root weight : survival*
2. Mean calculated for each of 24 source pops
3. Each variable standardised across source pops against max value (standardised max = 100)
4. Mean of 5 standardised variables for each source = composite measure

## Results

**All seedling vigour measures varied significantly among source populations  
at all trial sites**

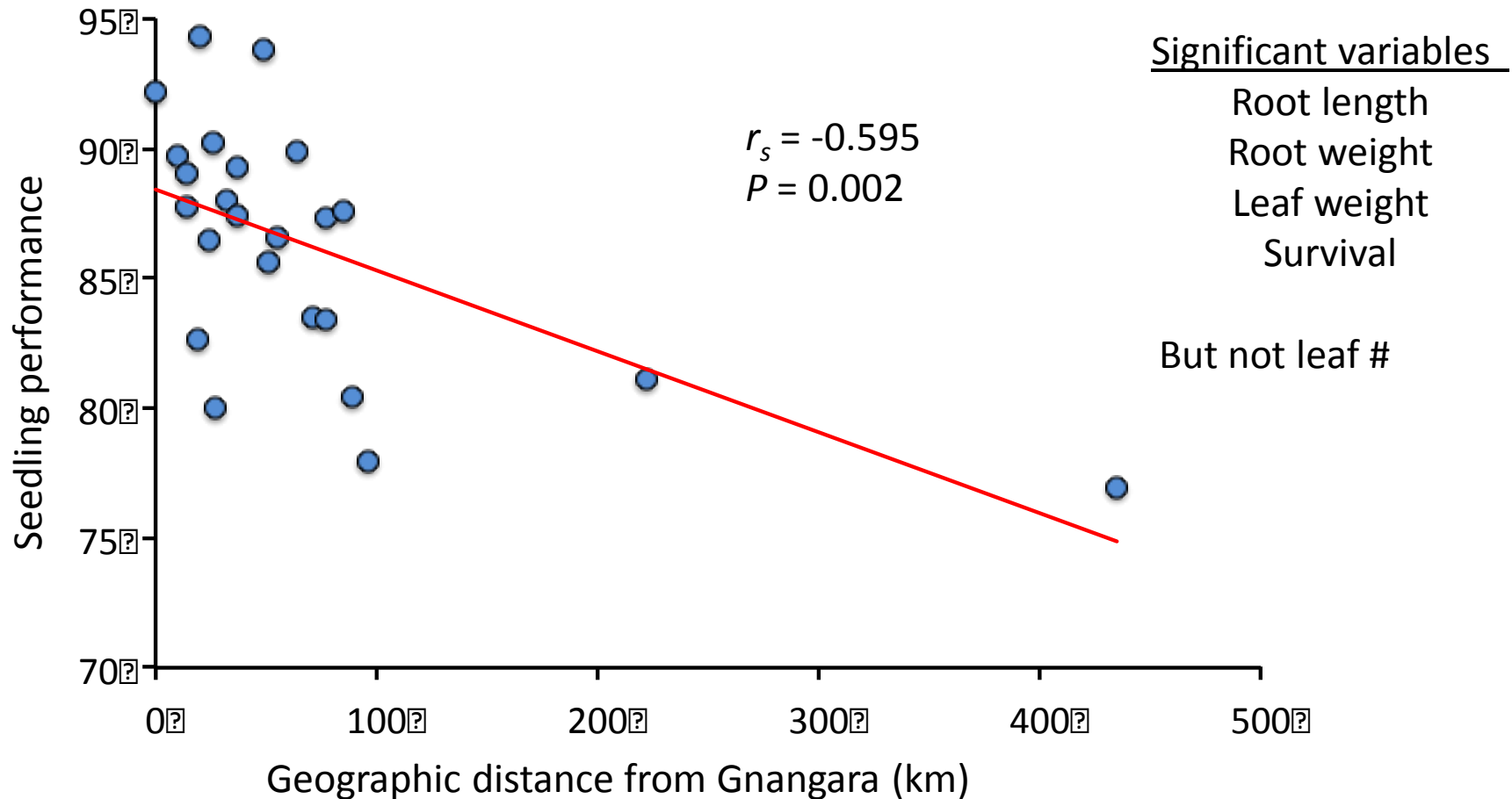
e.g. mean germination / early growth (pre-mortality) at Gngangara (Sept 2013)  
i.e. seedlings 4 months old



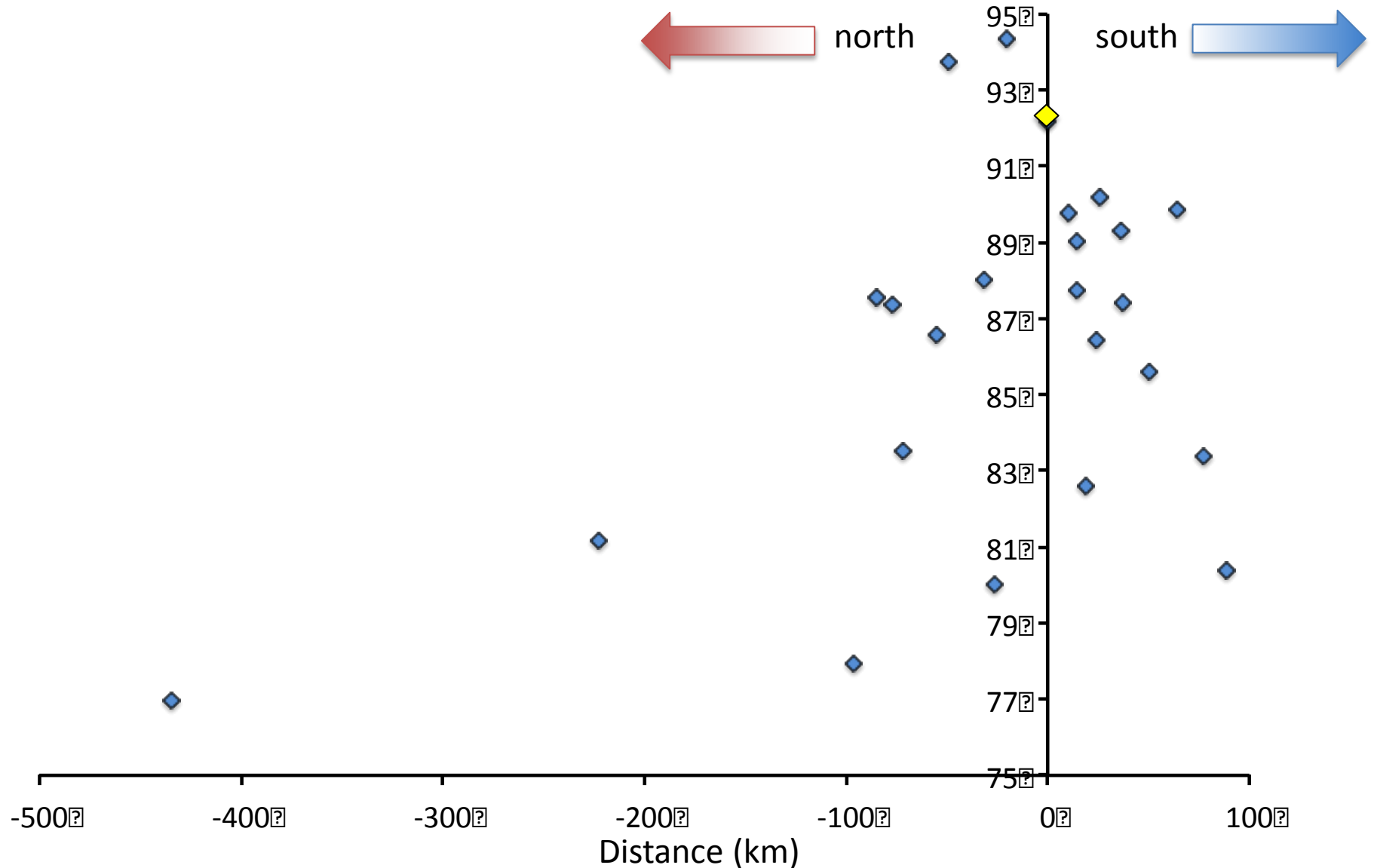


Significant association between  
composite measure of seedling vigour for each of 24 source sites  
against **geographic distance**  
at Gwangara

= on average, a 1% decline in seedling performance every 27km

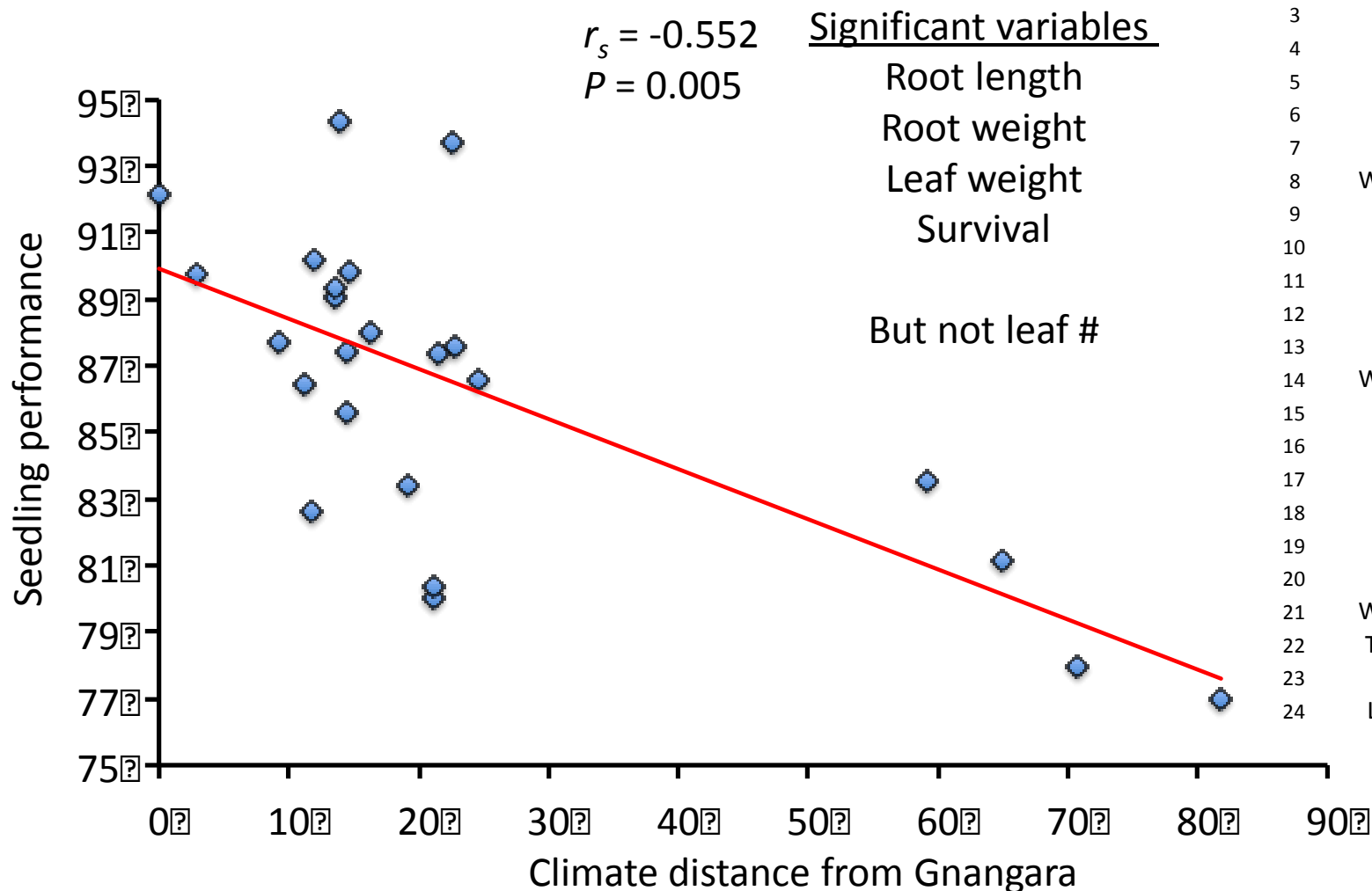


Significant association between  
composite measure of seedling vigour for each of **24** source sites at Gwangara  
against **geographic distance** from Gwangara, both north and south



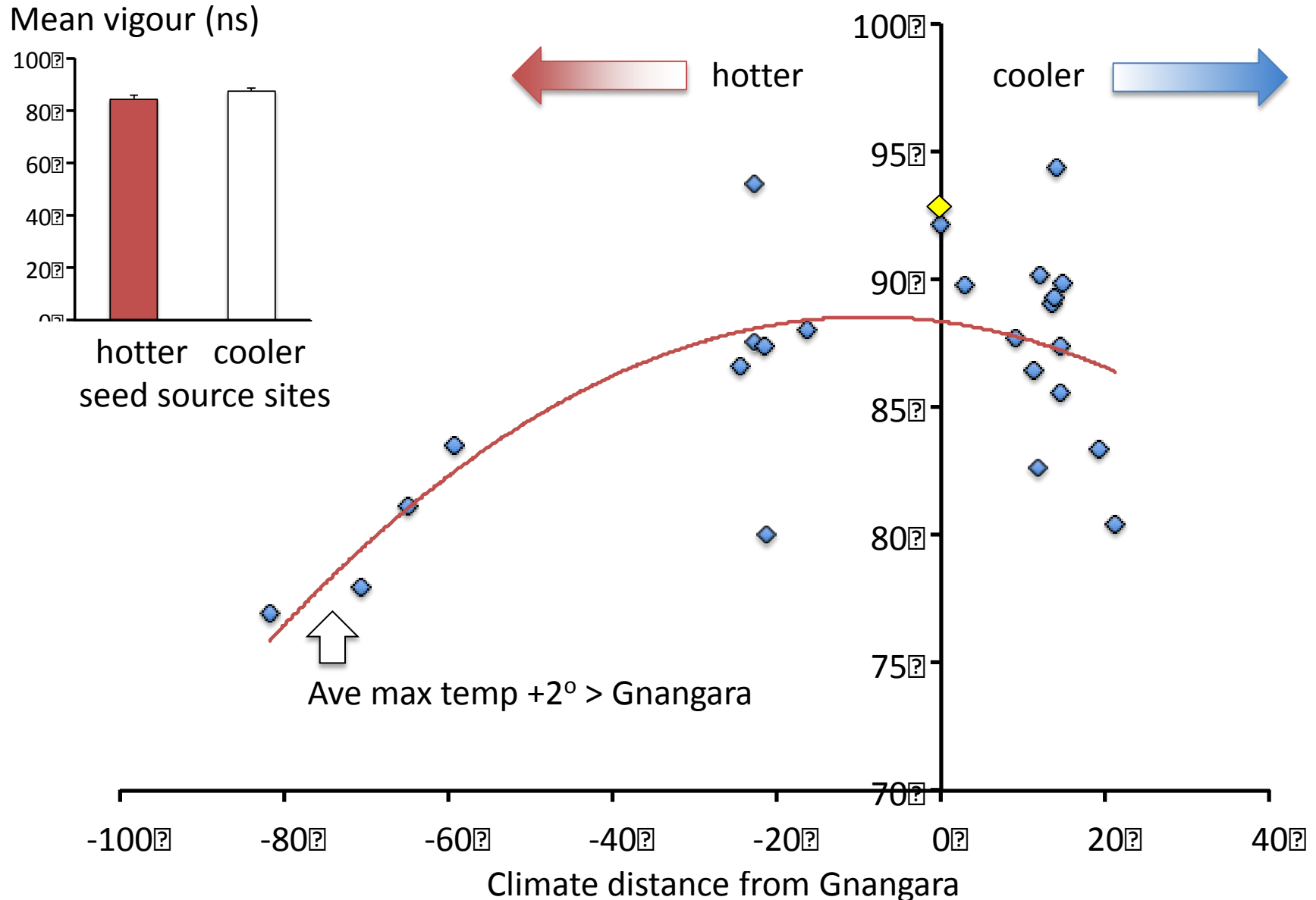


Significant association between  
 composite measure of seedling vigour for each of 24 source sites at Gngangara  
 against **climate distance (based on 15 climate variables)**  
 of each source site from Gngangara



|    | <u>Mean</u>    | <u>Annual</u> |
|----|----------------|---------------|
| 1  | Koolberr       | 443.7         |
| 2  | Encombe        | 523.3         |
| 3  | Lakes          | 544.0         |
| 4  | Beverley       | 446.0         |
| 5  | Moore River    | 618.8         |
| 6  | Ledge Point    | 652.2         |
| 7  | Gingin         | 639.1         |
| 8  | Wilbinga Grove | 690.5         |
| 9  | Muchea         | 707.3         |
| 10 | Yanchep        | 710.6         |
| 11 | Neerabup       | 747.5         |
| 12 | Gngangara      | 740.1         |
| 13 | Craigie        | 757.8         |
| 14 | Whiteman Park  | 752.3         |
| 15 | Warwick        | 766.1         |
| 16 | Star Swamp     | 743.4         |
| 17 | Bold Park      | 754.4         |
| 18 | Kings Park     | 774.9         |
| 19 | Murdoch        | 788.7         |
| 20 | Jandakot       | 805.7         |
| 21 | Wandi Reserve  | 813.9         |
| 22 | Tamworth Hill  | 797.2         |
| 23 | Paganoni Rd    | 824.8         |
| 24 | Lake Goegrup   | 830.9         |

Significant association between  
Composite measure of seedling vigour for each of **24** source sites at Gnangara  
against **climate distance** from Gnangara, both hotter and cooler

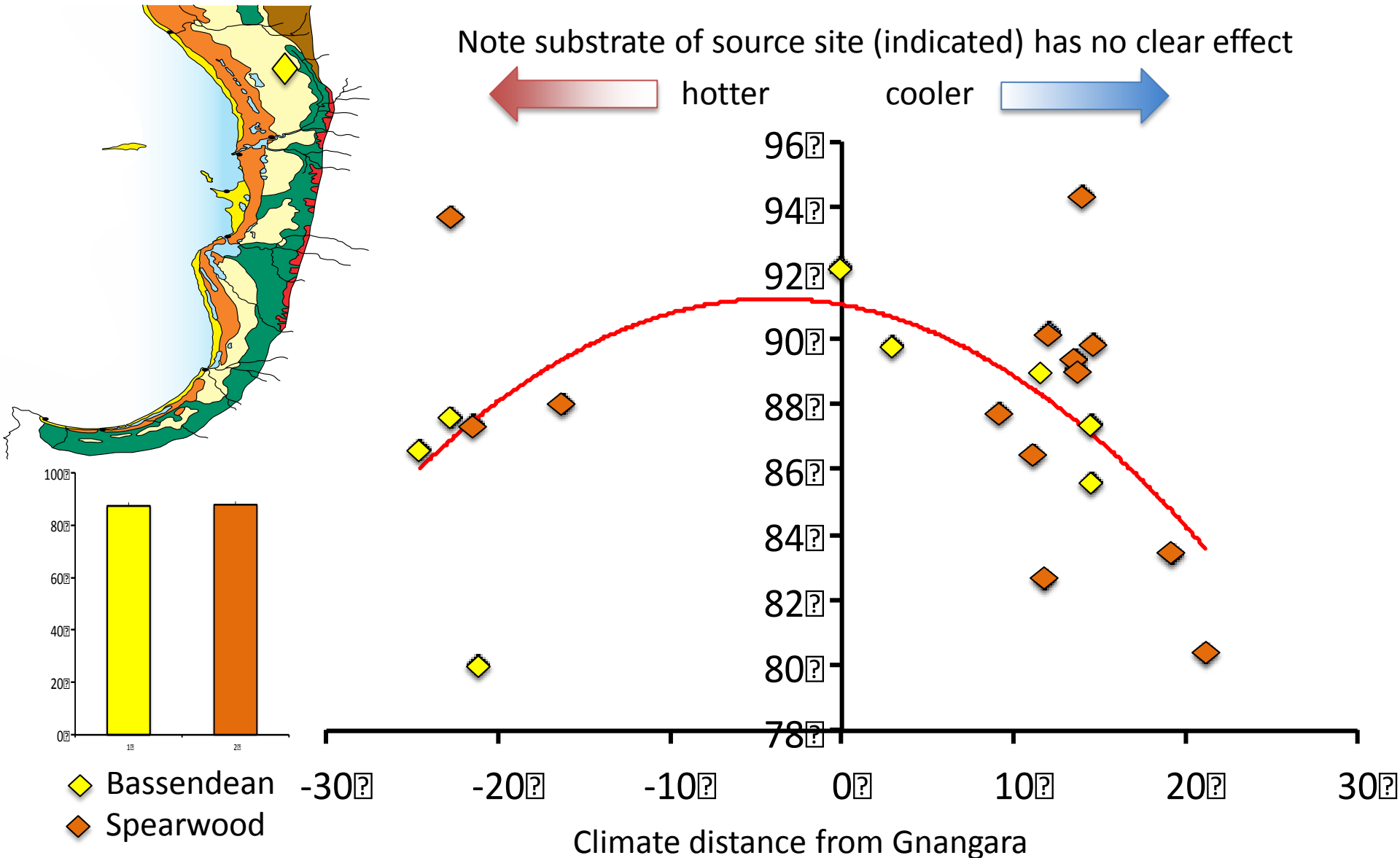




Significant association between  
Composite measure of seedling vigour for each of **20 SCP** source sites at Gnangara  
against **climate distance** from Gnangara.

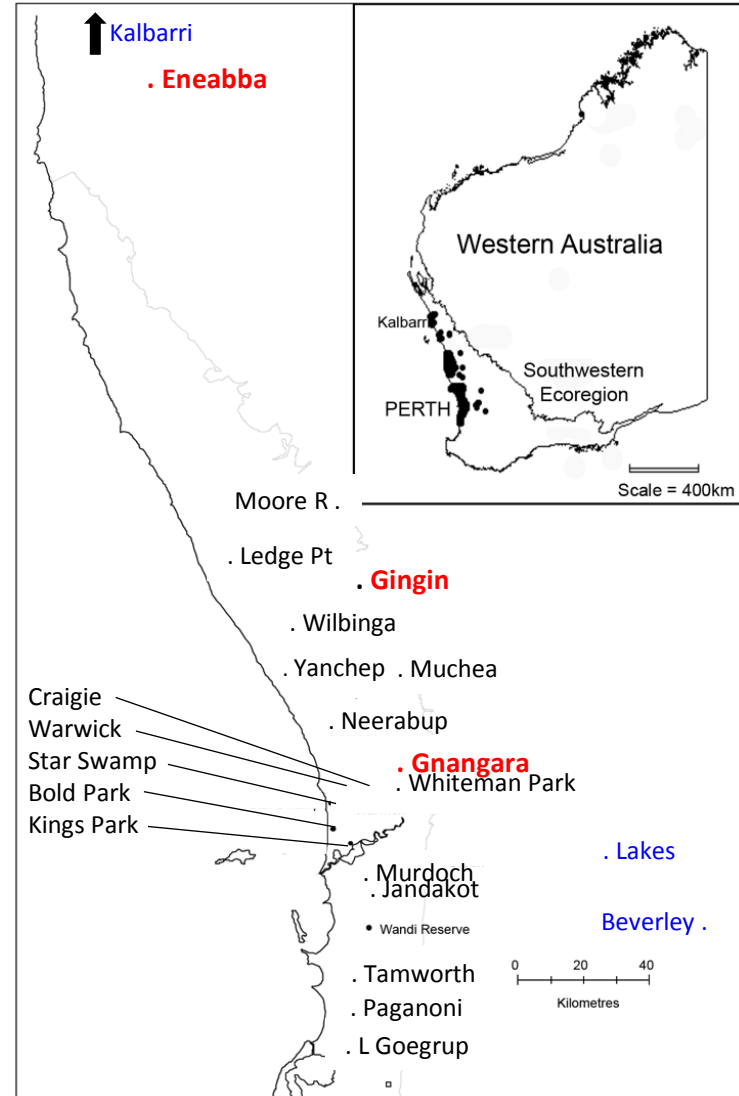
Note substrate of source site (indicated) has no clear effect

← hotter cooler →



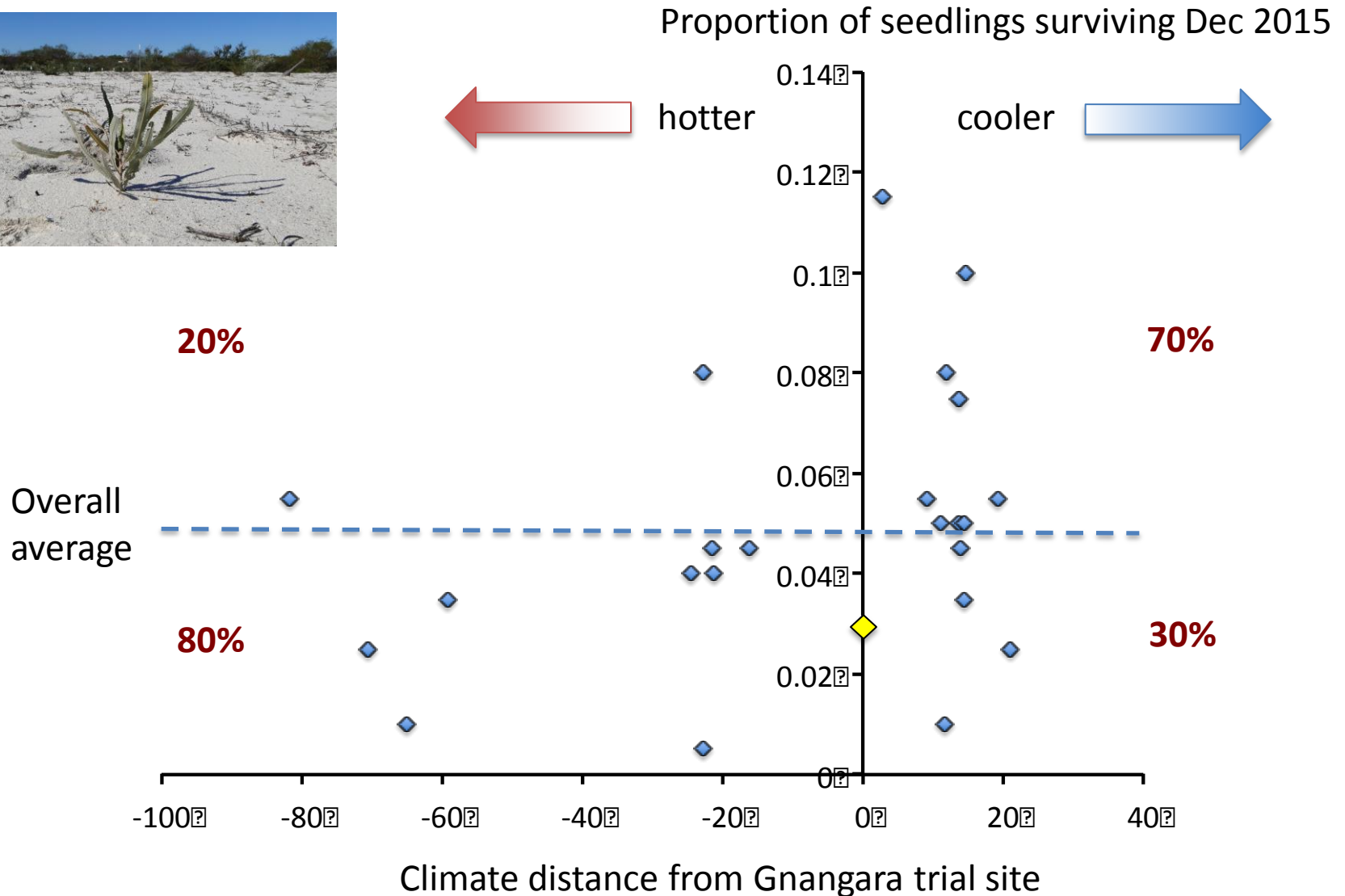
## *Banksia menziesii* provenance trial take II

20 seed, from each of 10 plants, from each of 24 source populations, planted into each of 3 sites in May 2015 (14,400 seeds in total; 4,800 per site)



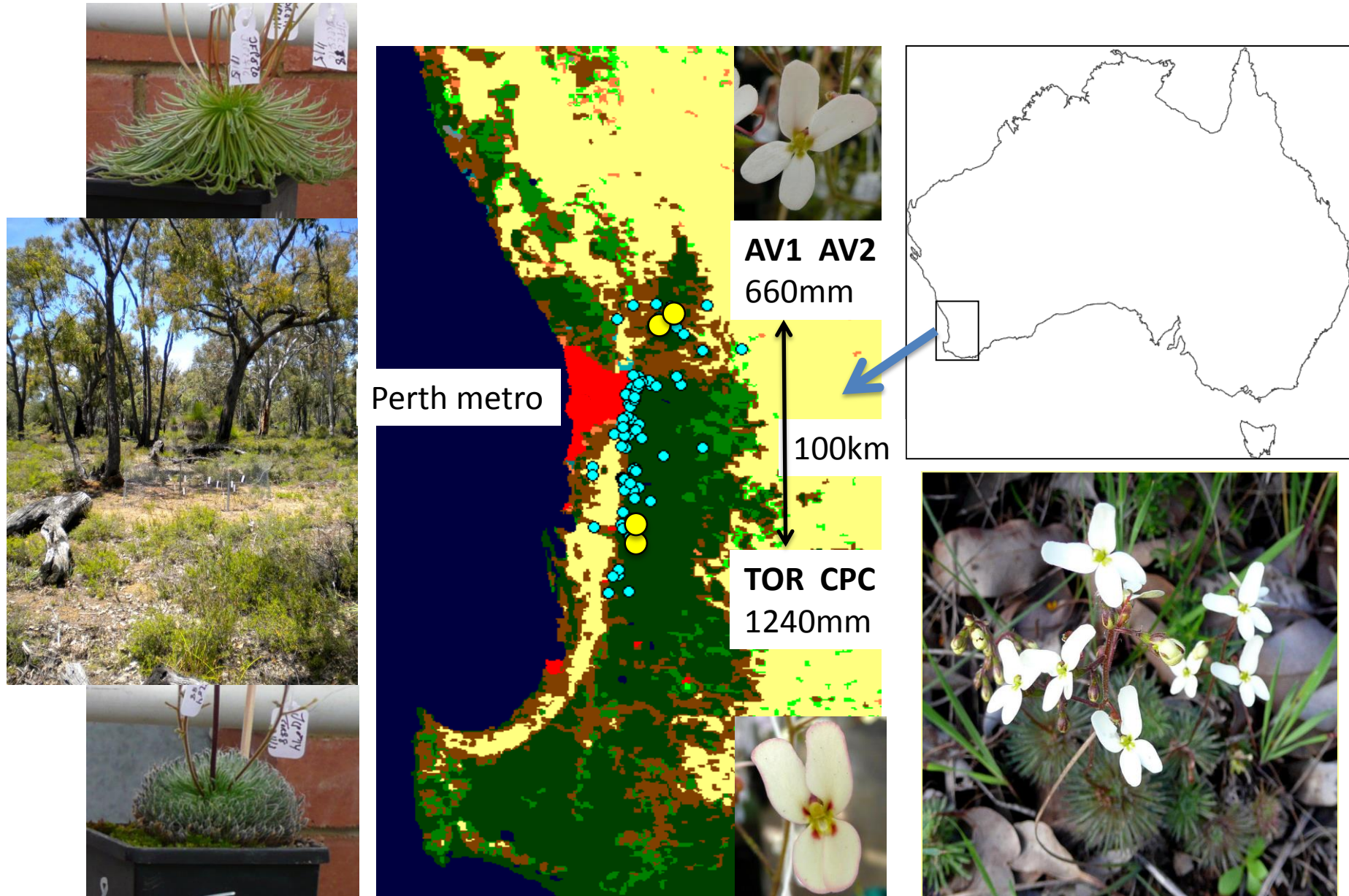
# Seedling survival as a function of climate distance of seed source from Gnangara trial site

Overall average = 4.8% (231 of 4800 seeds 8 months after sowing)





# A model system for measuring fitness in provenance trials - *Stylidium hispidum* distribution and provenance trial sites



## Glasshouse cross pollination trial



From each of 4 sites:

20 whole plants dug up  
at 10 m intervals in Oct  
2007

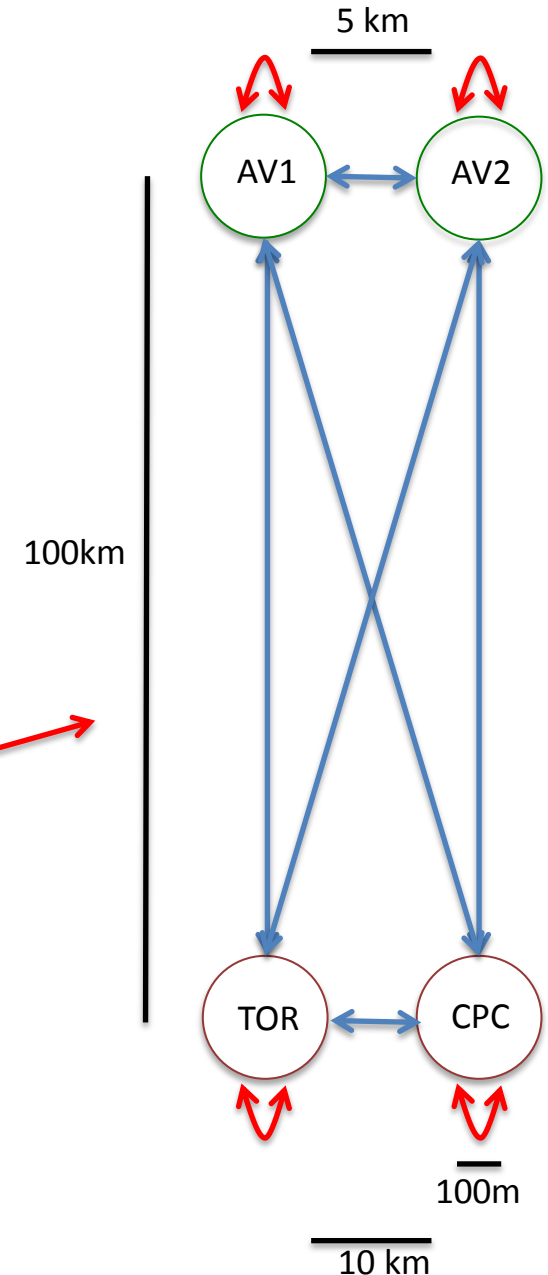
Grown in forestry pots  
at UWA glasshouse

Flowered Spring 2008

303 successful cross  
pollinations of 3 types

self-pollinations failed

Here I focus just on the  
within-pop crosses

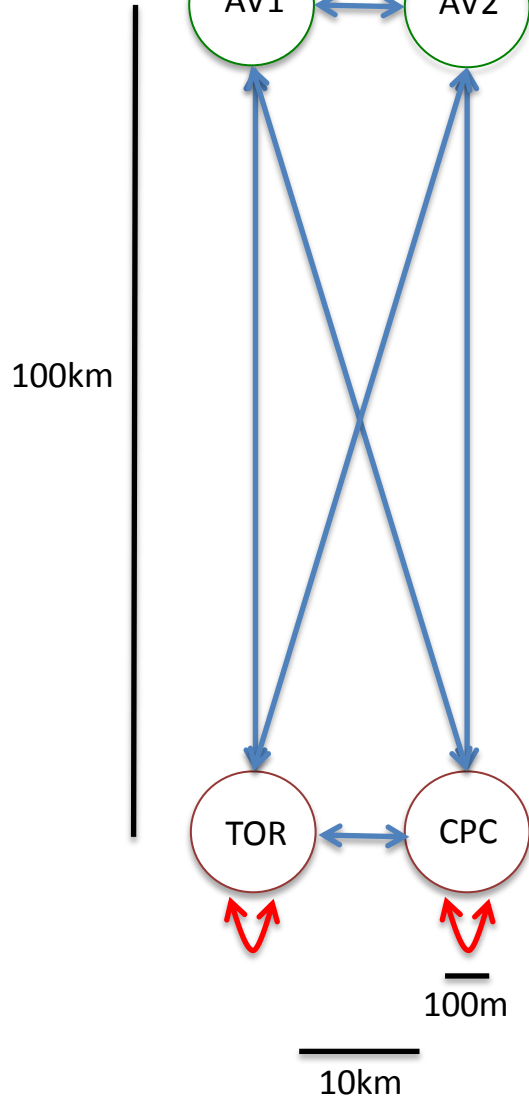








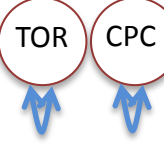
# F1 reciprocal field trial established July 2010

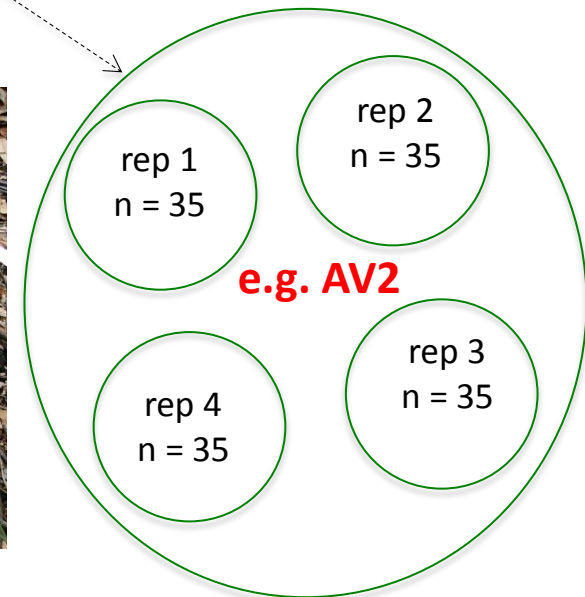
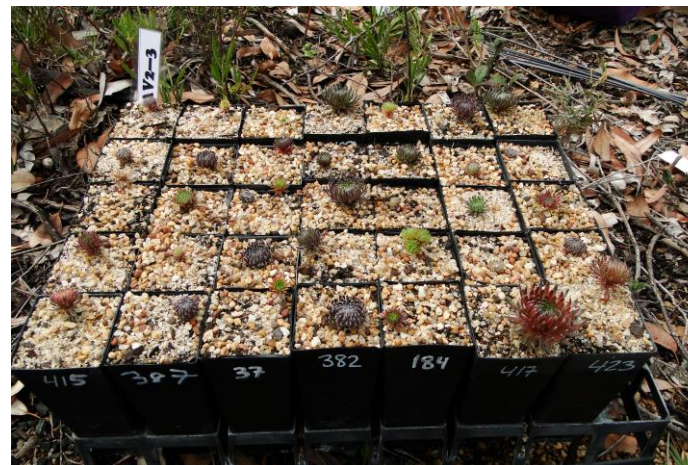
F1 trial sites

5 km



e.g. AV2

| cross source<br>of F1s  |               | # of plants | # of plants per<br>replicate plot | Cross type  |
|---|---------------|-------------|-----------------------------------|-------------|
|  | local x local | 20          | 5                                 | within pop  |
|  | local x near  | 20          | 5                                 | between pop |
|  | local x far   | 40          | 10                                | between pop |
|  | near x near   | 20          | 5                                 | within pop  |
|  | far x far     | 40          | 10                                | within pop  |
|   |               |             | 35                                |             |



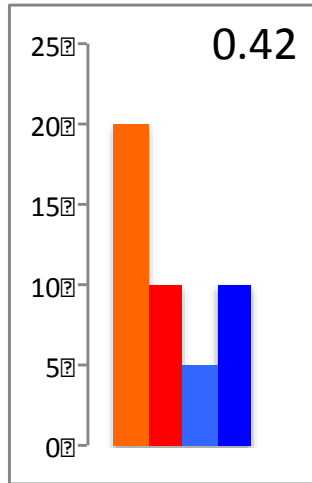


# Survival (%) in October 2015 by source at each trial site

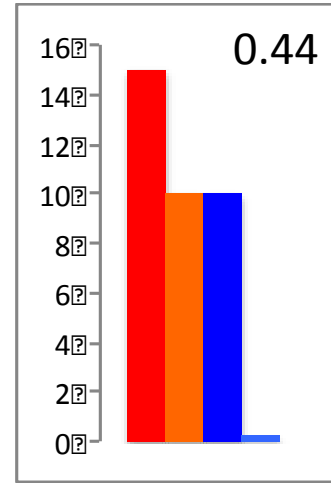
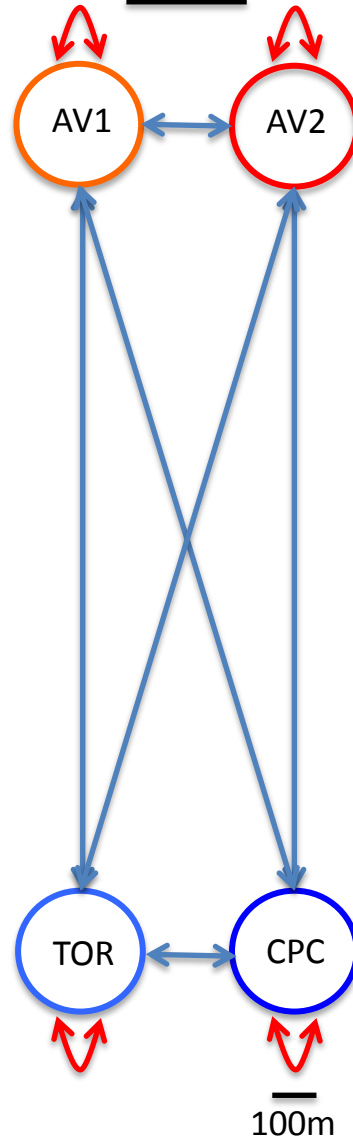
Local : mean nonlocal

F1 trial sites

5 km



100km



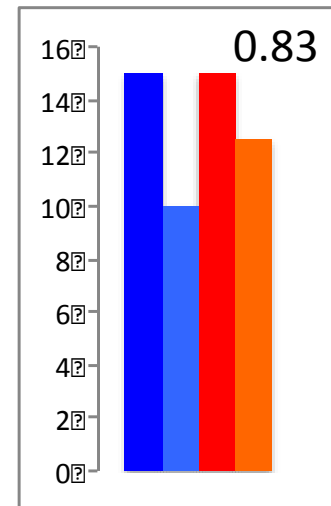
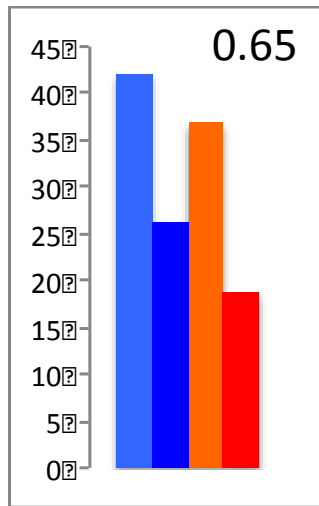
At each of 4 trial sites:

Survival 5 years post-establishment:

Overall

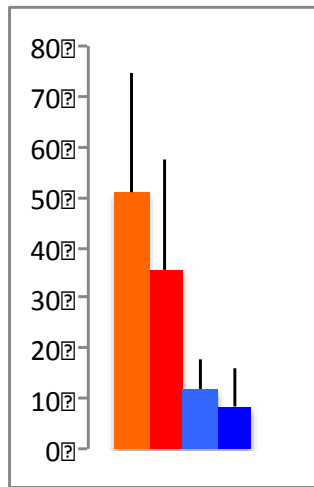
Local : non-local

**1 : 0.65**

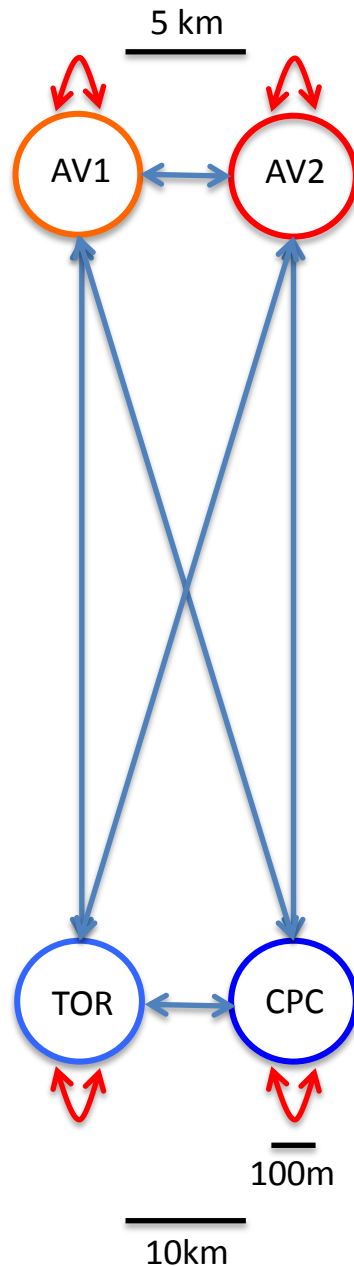
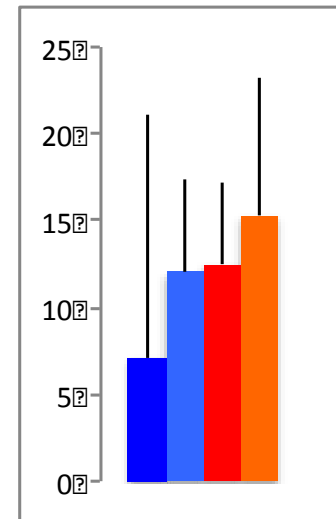
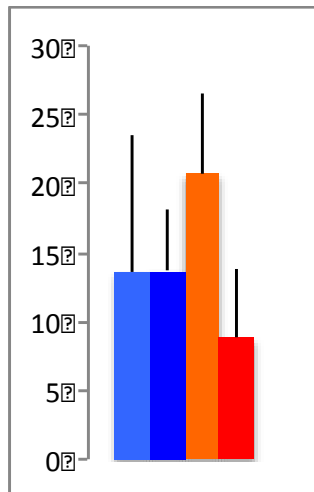
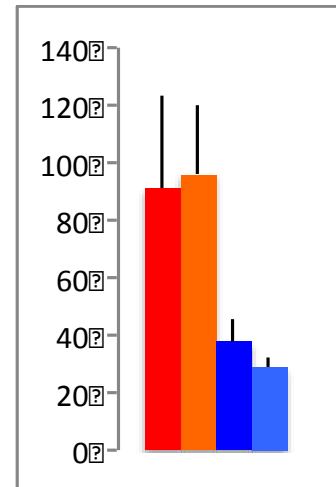


# Total lifetime fruit production per plant 2011 - 2015 by source at each trial site

## F1 trial sites



100km



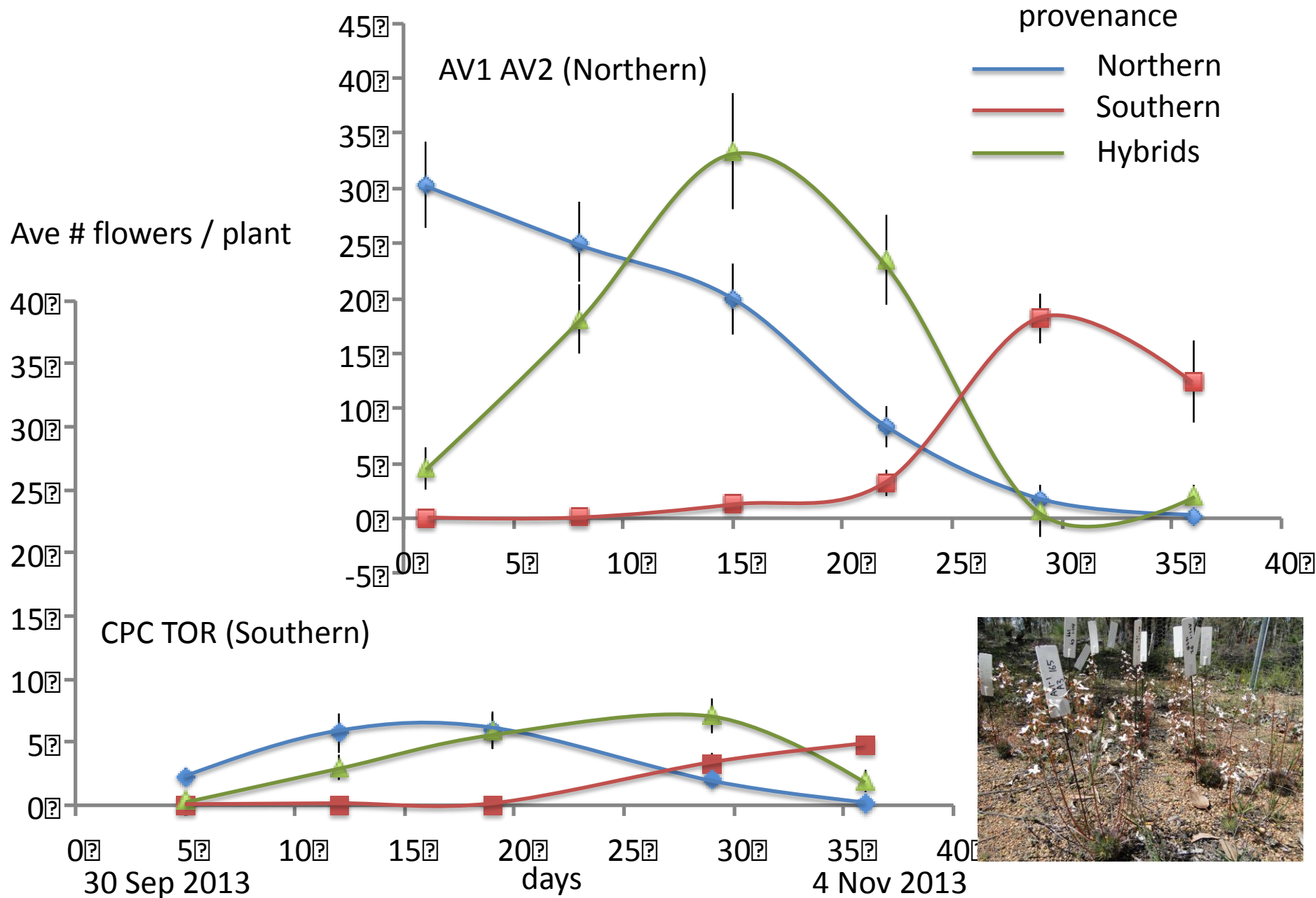
At each of 4 trial sites:

Reproductive output:

Local > non-local  
(northern)  
Equivalent  
(southern)



# Non-overlap in flowering of provenances 100 km apart (2013)





## Conclusions I

### For *Banksia menziesii* provenance trial:

Highly significant provenance effect on germination and vigour associated with geographic and climatic distance from the “home site”  
**“local is best”**

**No evidence for a benefit from predictive sourcing for climate change despite a harsh summer**

(+2°C seed source sites = -15% performance compared to home site in trial I)  
(80% of hotter/drier source pops were worse than the overall average in trial II)

### **Hypotheses for observed “home-site advantage”**

Wet winter selected against drier provenance genotypes?

Dry summer selected against wetter provenance genotypes?

## Conclusions II

### For *Stylidium hispidum* provenance trial:

Survival 5 years post establishment

**Local > non-local (1: 0.65)**

Total lifetime reproductive output

**Local > non-local (>2x)**

(For northern trial sites, equivalent for southern trial sites)

### Ultimately

From *Banksia menziesii* (I and II) and *Stylidium hispidum* provenance trials:

No support for a benefit from climate-adjusted provenancing

Strong support for “Local-is-best”