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Characterizing Mojave Desert Shrub Ecotypes to Establish Seed Transfer Zones for Military Range Restoration

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Characterizing Mojave Desert Shrub Ecotypes to Establish Seed Transfer Zones for Military Range Restoration

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TEXAS STATE UNIVERSITY

DEPARTMENT OF DEFENSE LEGACY PROGRAM

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Overview

1. The restoration challenge
2. Seed Transfer Zones
3. A common garden study
   - Approach to analysis
   - Experimental design
   - Results
4. Implications for restoration

1) The restoration challenge

Need for restoration

Disturbance

Slow natural recovery

Introducing plant materials can hasten recovery

Challenges

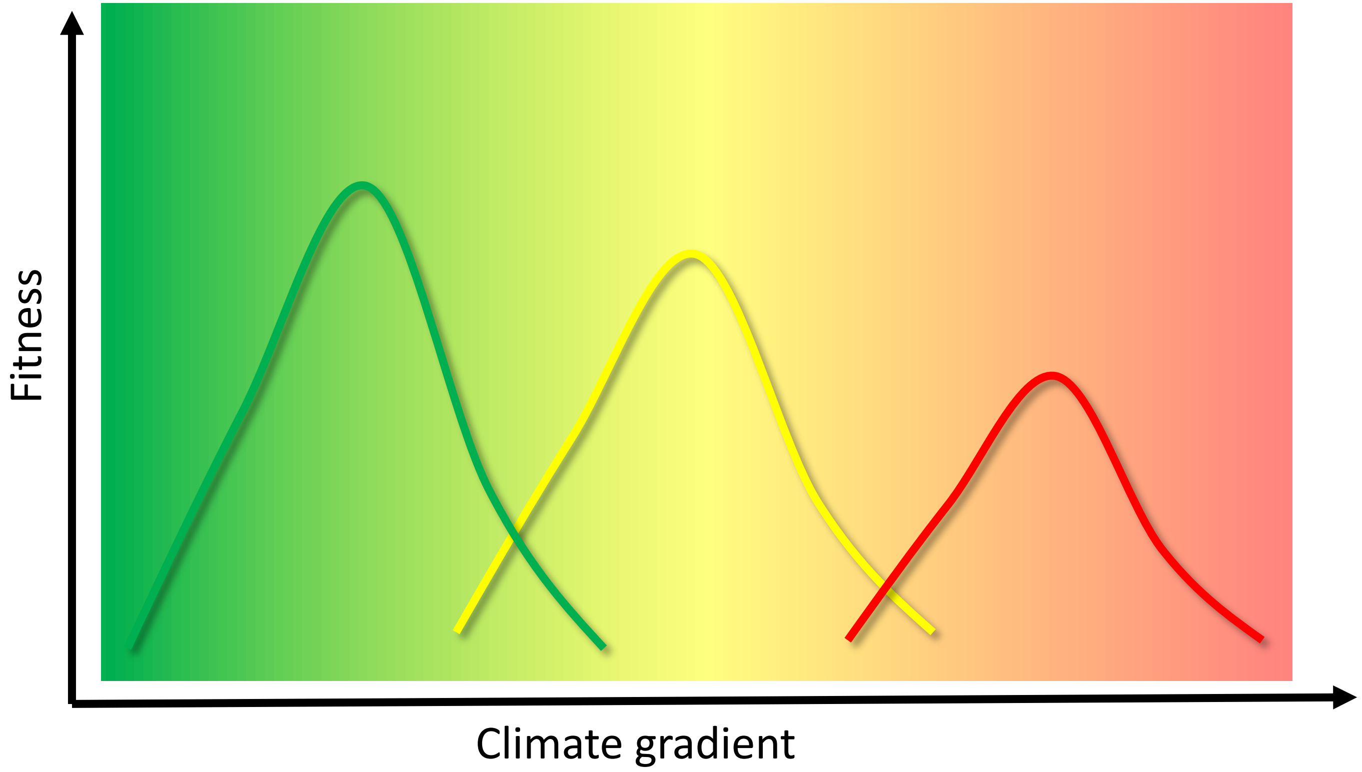
Low seedling establishment

Transplant shock

Plant material sourcing and the potential for maladaptation

L. tridentata seedling

The ‘local is best’ paradigm



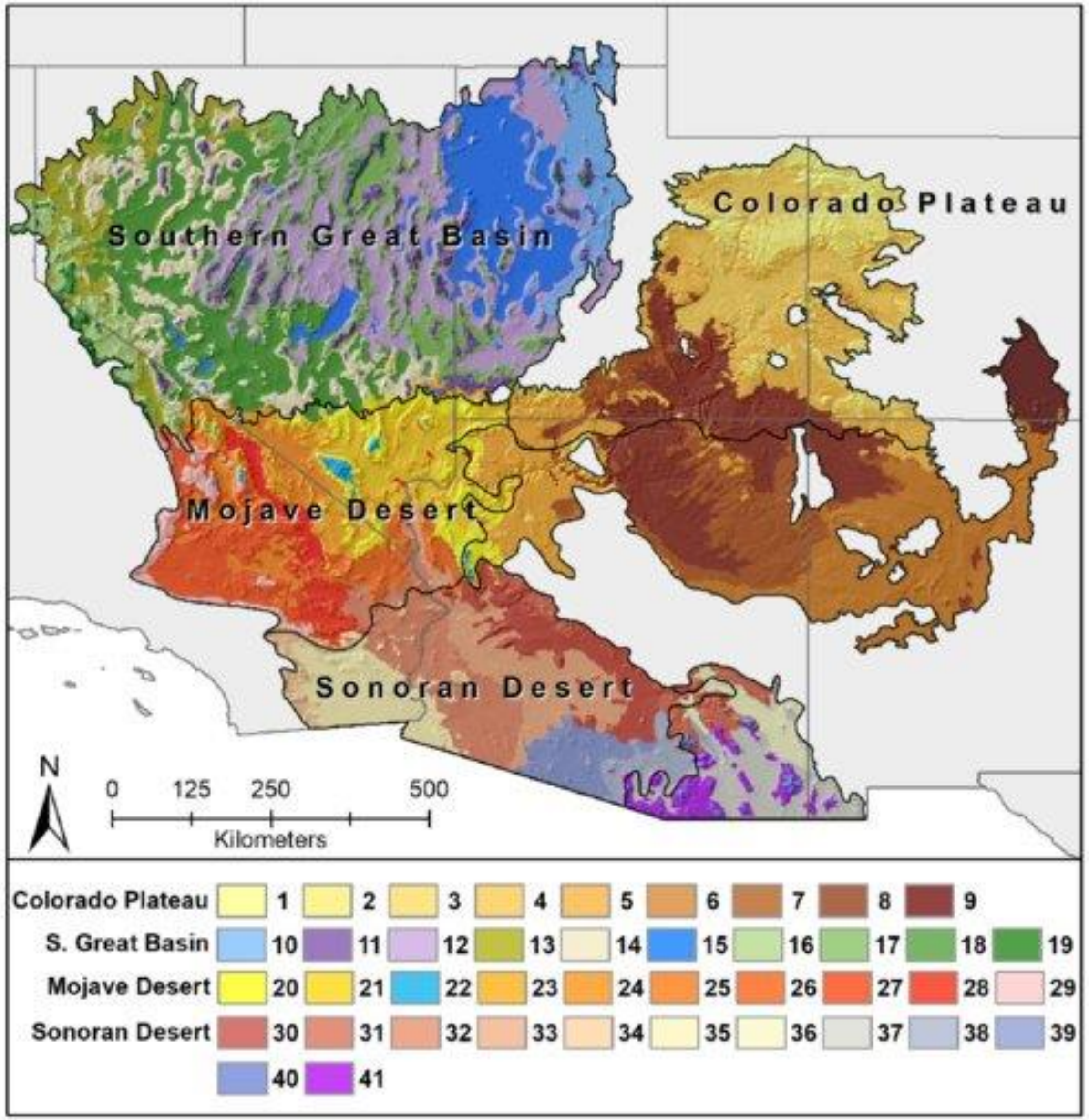
2) Seed transfer zones

Seed transfer zones (STZ)

= maps that illustrate regions of similarity

Empirical STZ use genetic and climate information to map similarity (Shryock et al. 2017; https://doi.org/10.1002/eap.1447).

Provisional STZ use only climate data to map similarity (Shryock et al. 2018; https://doi.org/10.1002/ecs2.2453).

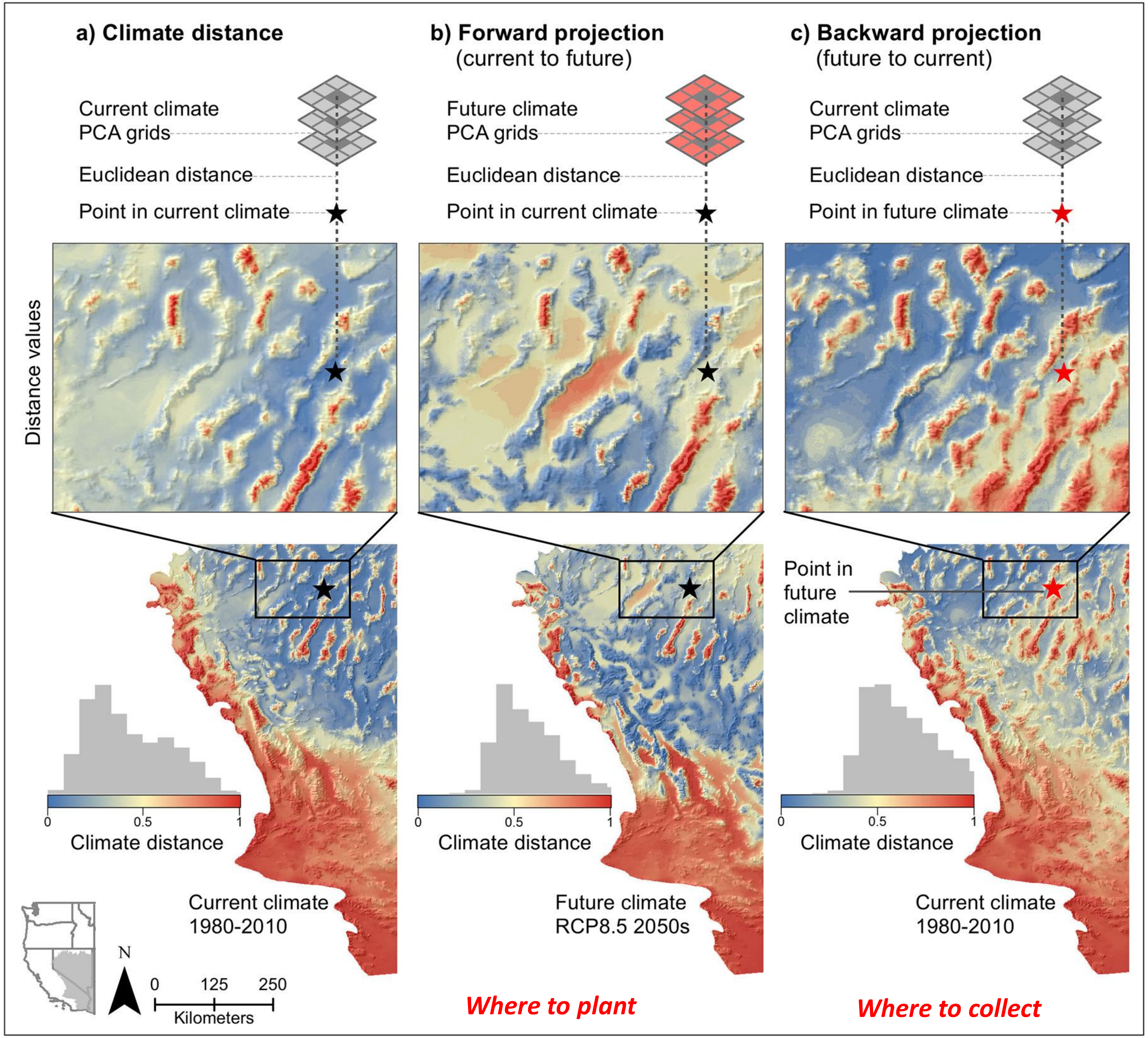


(From Shryock et al. 2018, Ecosphere 10, e02453)

Select for tomorrow's climate

Future Climate Distance Mapper

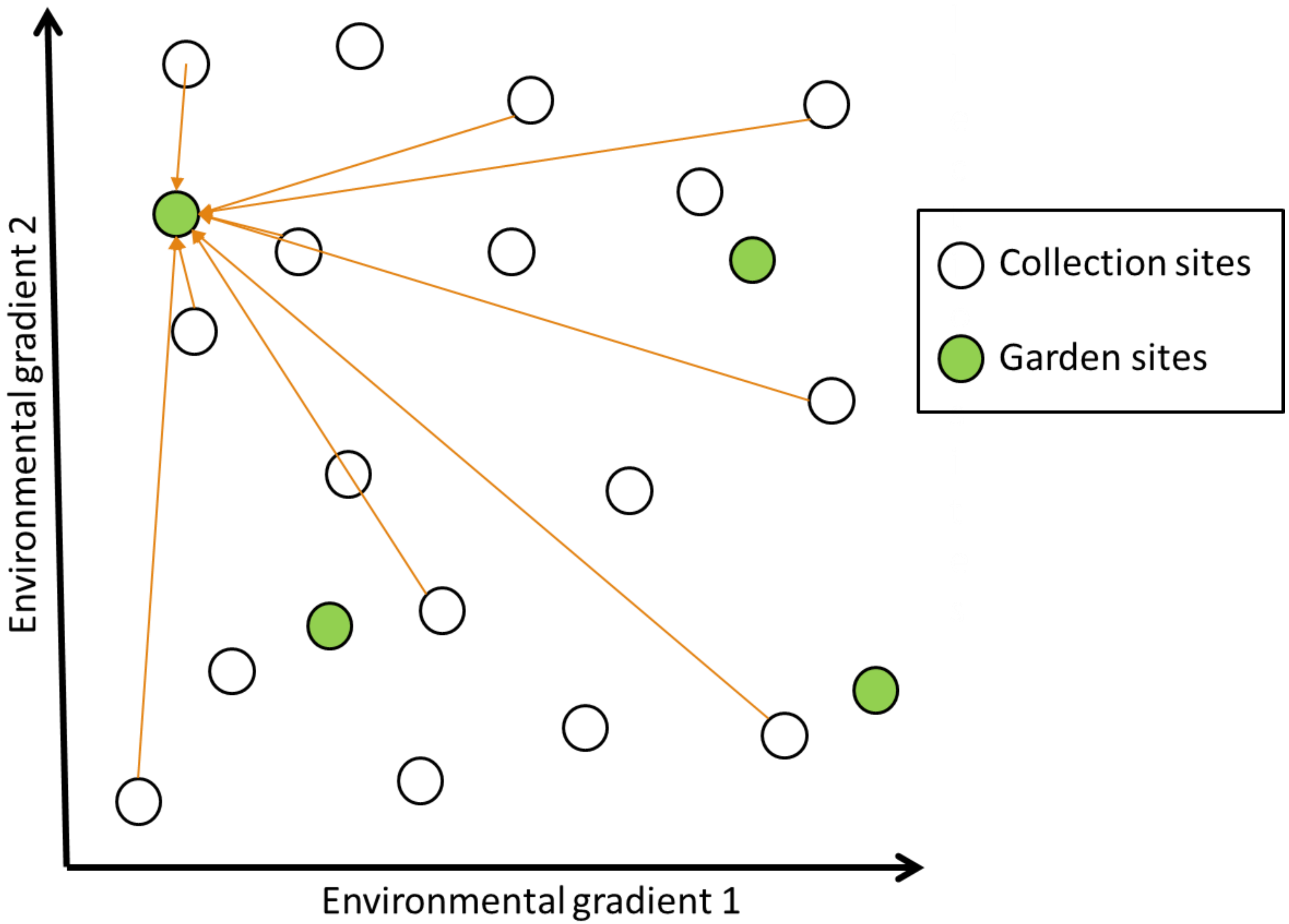
https://usgs-werc-shinytools.shinyapps.io/Climate_Distance_Mapper/



Common Garden Studies

Links genetic with phenotypic data for STZ development:

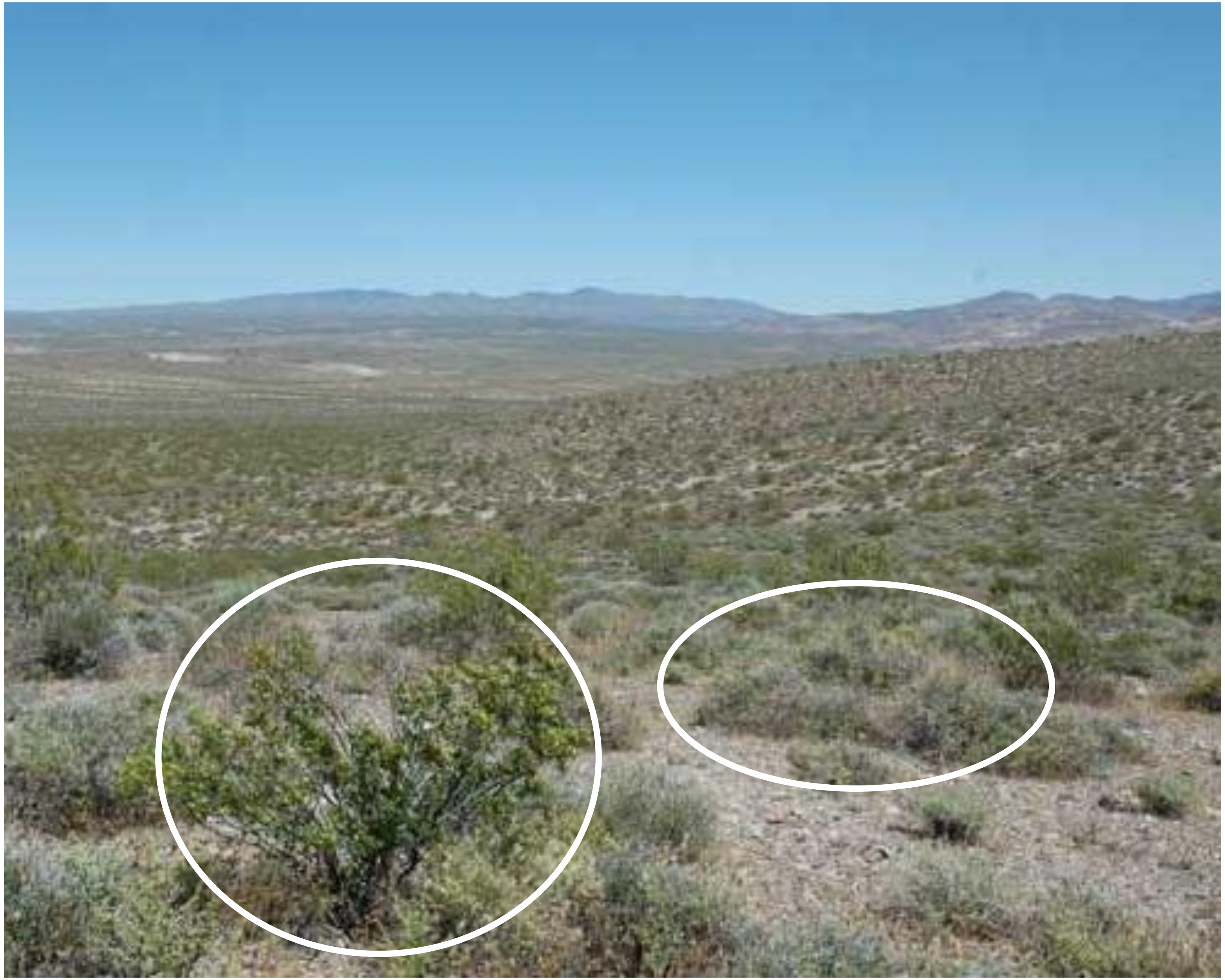
- Fitness components (growth, survivorship reproduction)
- Trait values



3) A common garden study

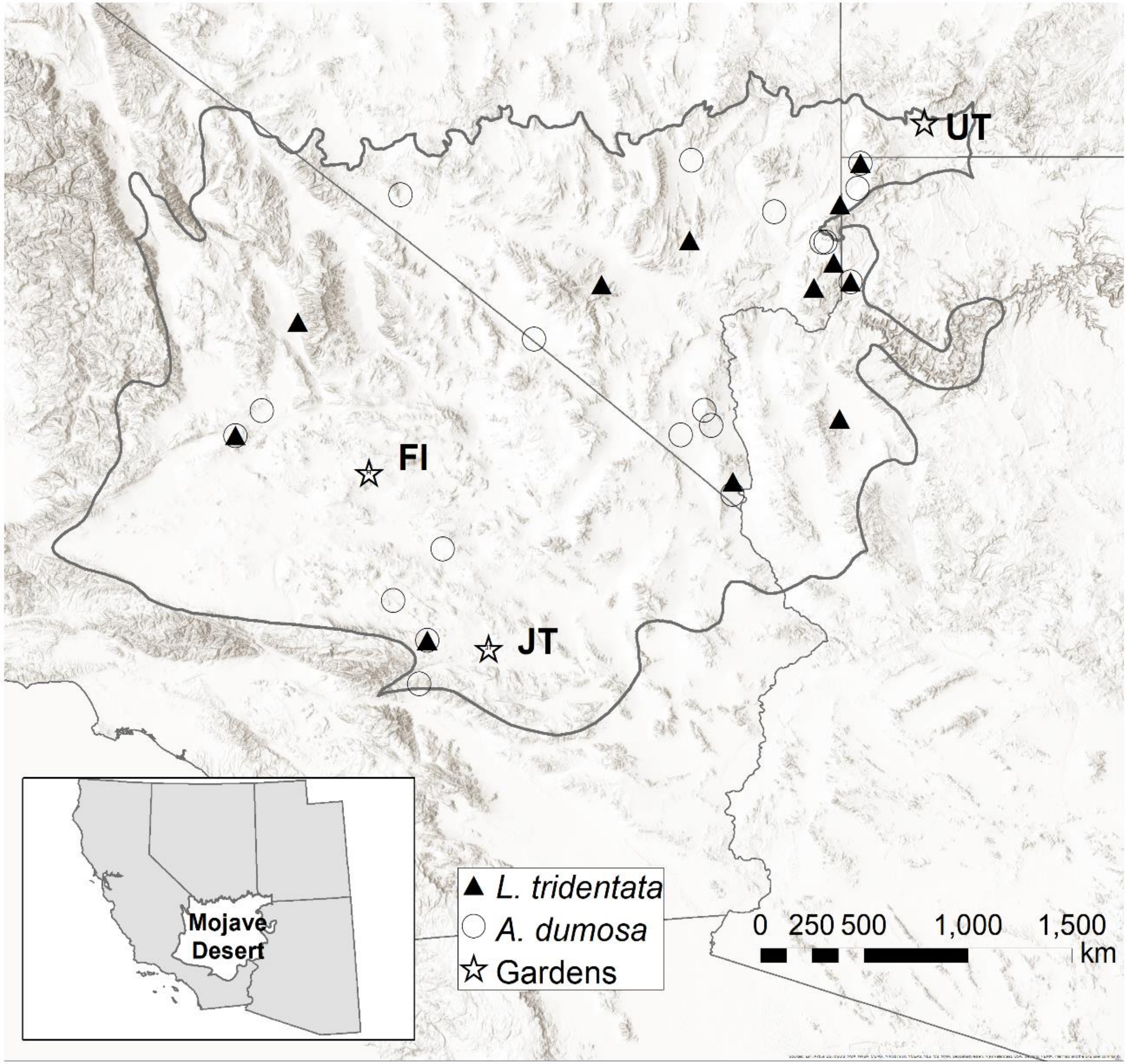
Larrea tridentata
Creosotebush
evergreen, long-lived
deep-rooted shrub

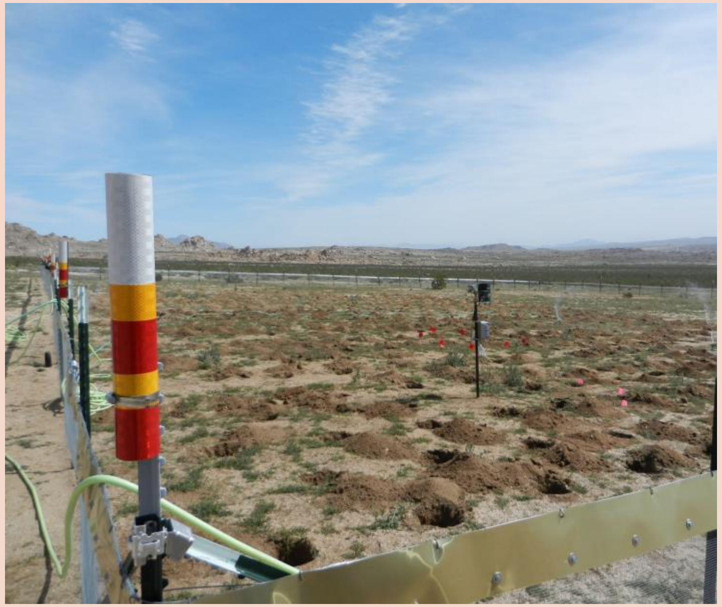
Ambrosia dumosa
white bursage (burro-weed), shallow-rooted, drought-deciduous shrub with shorter life span



Seeds collected from many geographic locations in 2010/11

Gardens selected to capture the range of climates



Utah garden near St George (UT)	Fort Irwin garden (FI)	Joshua Tree garden near Twentynine Palms
		
1269 m elev	1068 m elev	608 m elev
307 mm MAP (act. 318 mm)	140 mm MAP (act. 104 mm)	93 mm MAP (act. 65 mm)
-0.5/35.6 ^{o}C T_{min}/T_{max}	3.0/36.2 ^{o}C T_{min}/T_{max}	2.4/39.9 ^{o}C T_{min}/T_{max}

Seedlings raised in a greenhouse in Henderson, NV, 2013-14

Heights measured in January 2014

Yearlings cold hardened outside for a month, before …

… transplanted into gardens in March 2014

Irrigated monthly until July/August 2014

Starting 2015, monthly censuses

In 2016, trait values measured

Gardens secured by fences

Plants about a meter apart

Weeds periodically removed

Weather stations

Periodic measurements (2015 -)

<u>Monthly status:</u>

- live or dead
- if live: reproductive or not
- canopy dimensions
- relative leaf and reproductive cover in 6 visual categories:
- < 1%, 1-10%, 10-25%, 25-50%, 50-75% >75%
- reproductive cover : buds, flowers, fruits

<u>Annually in March:</u>

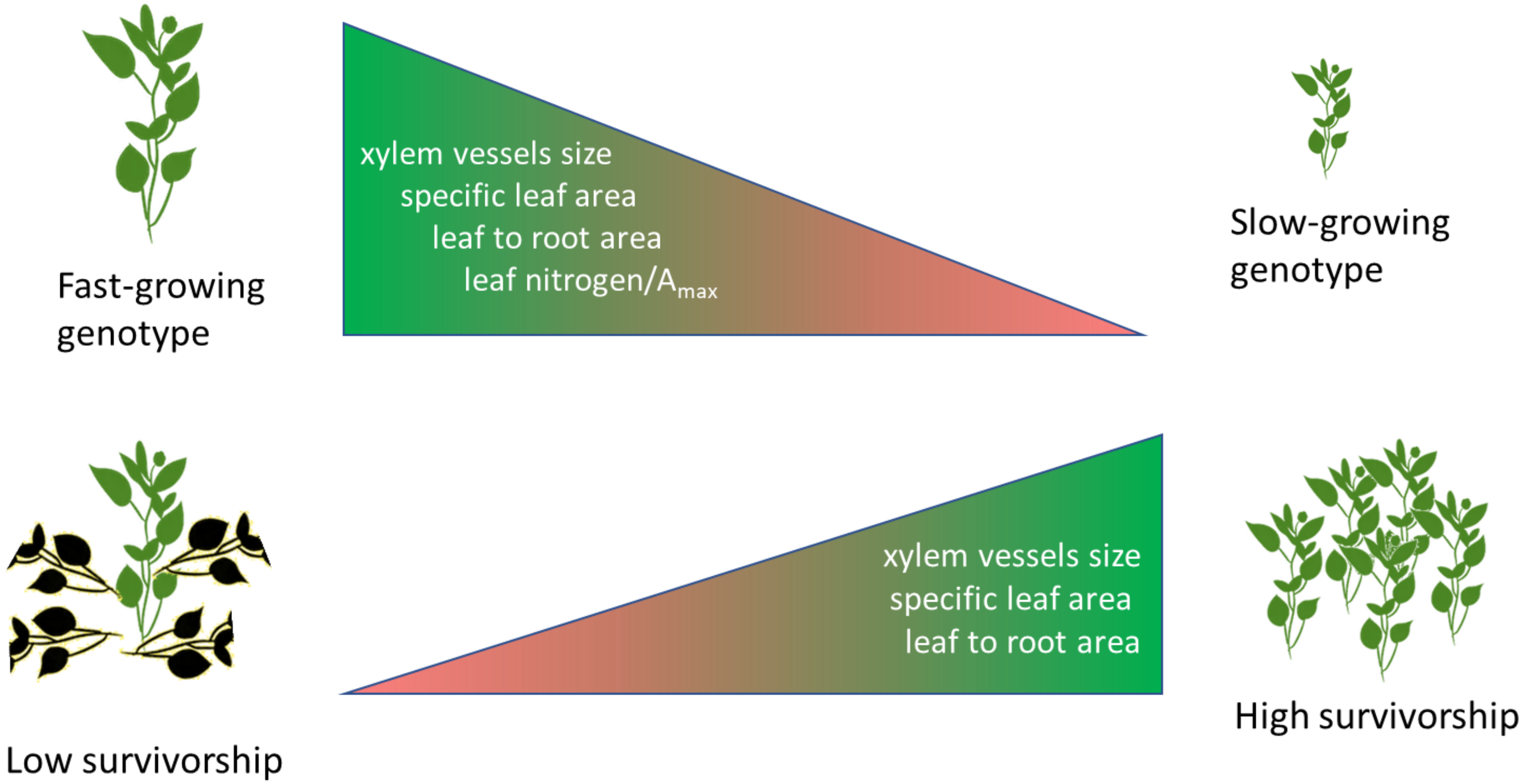
- stem diameter (measure of growth)

Approach to analysis

- We did not expect all fitness components (growth, reproduction, survivorship) to be simultaneously maximized by populations closest to home

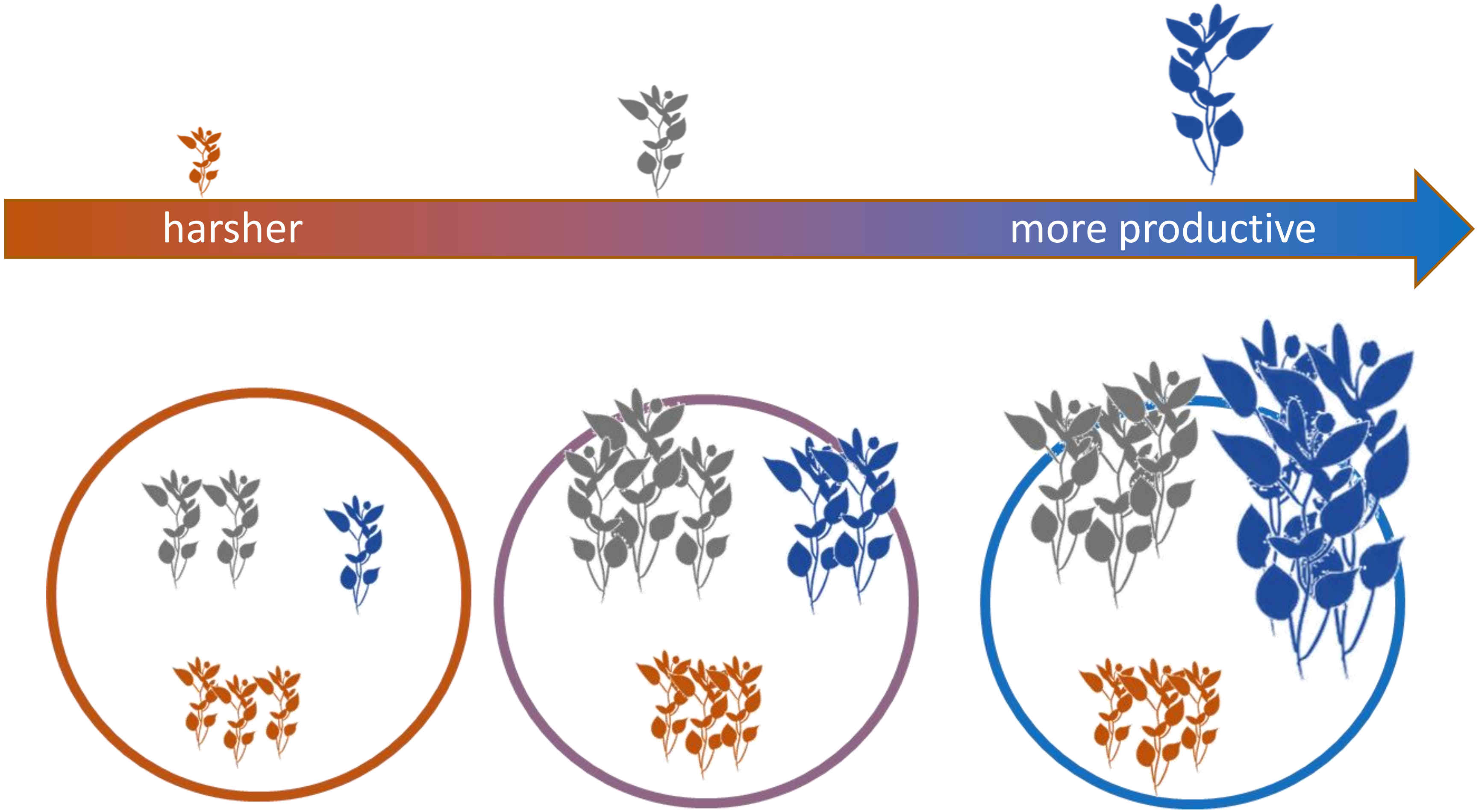
- Instead, we expected growth-survivorship tradeoffs

Growth-survivorship tradeoff



Reich, P.B. (2014) Journal of Ecology 102, 275-301

Expectation for common-gardens



Hypotheses

1. Populations of individuals that grow faster under good conditions have higher mortality under stressful conditions
2. Populations with faster-growing individuals come from more productive regions and vice versa
3. Certain leaf traits should be correlated with this tradeoff

Results

Overall growth and survivorship

For *A. dumosa:*

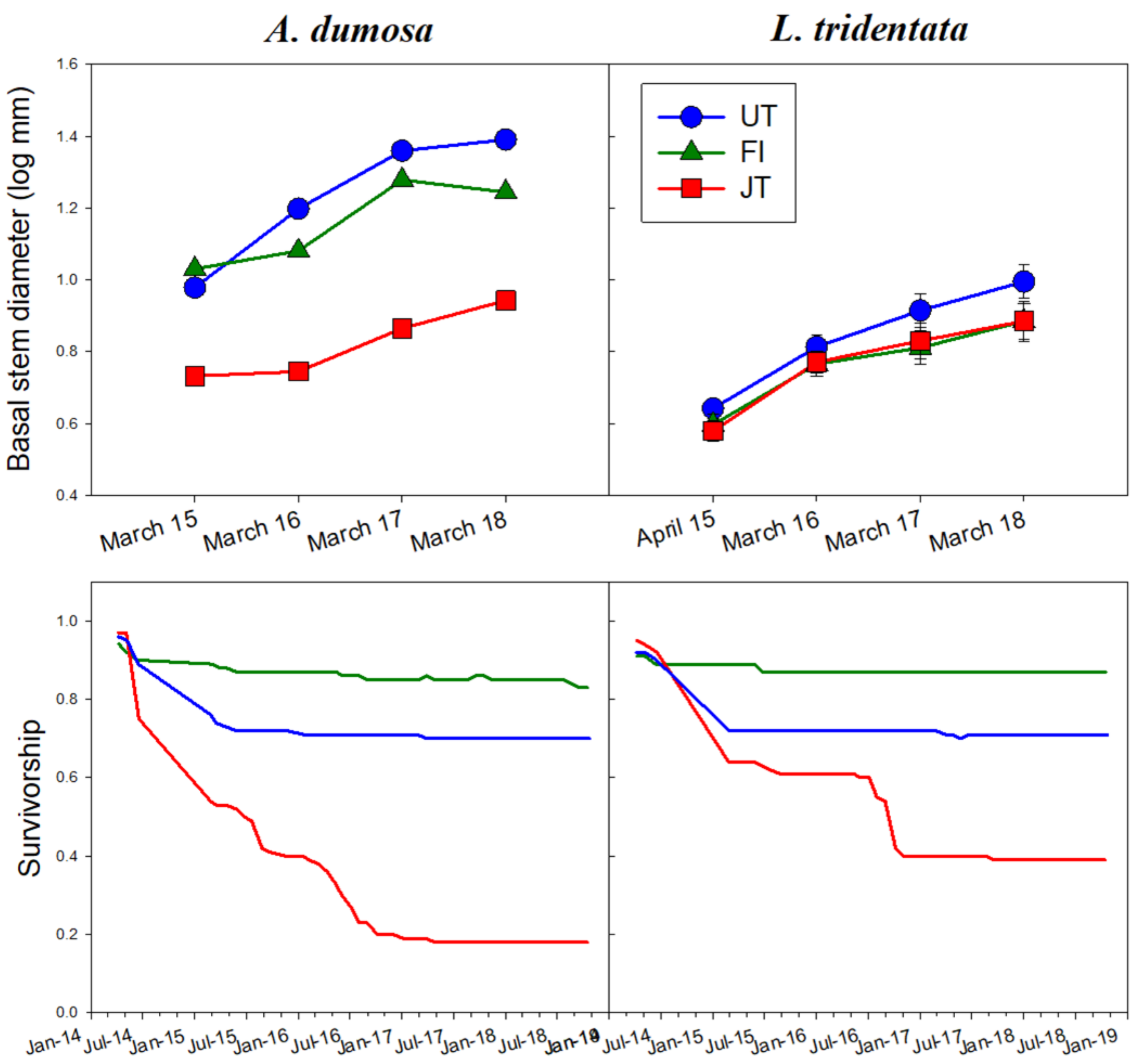
growth: UT > FI > JT

survival: FI > UT > JT

For *L. tridentata growth*:

growth: no difference

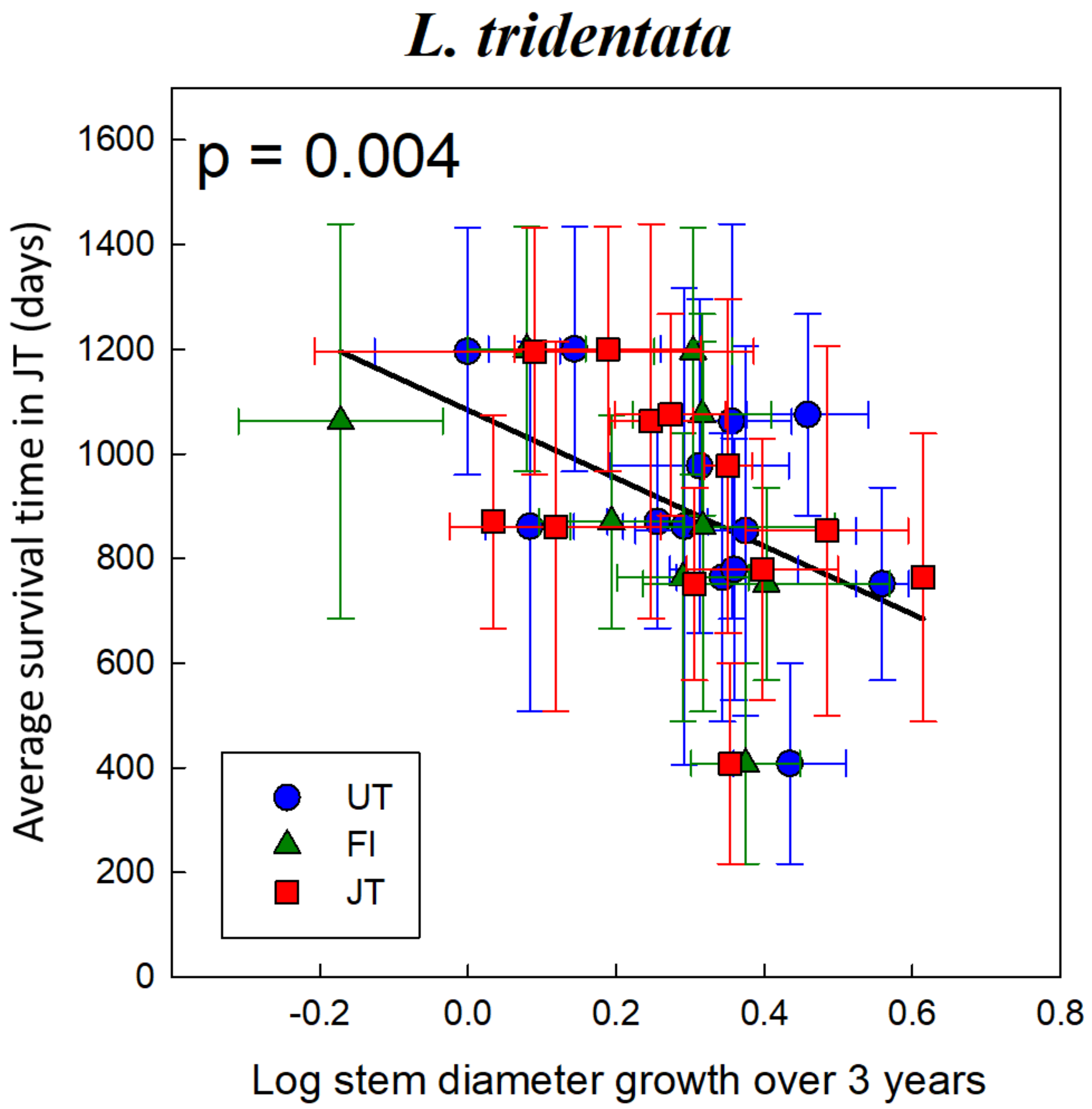
survival: FI > UT > JT



Larrea tridentata

Tradeoffs

Populations with higher growth rates in any garden, tended to have lower survivorship in JT Garden



Homesite - climate effects

Populations from sites with more winter precipitation had

- higher stem growth rates
- lower survivorship in JT

Populations from sites with more variability in summer precipitation had

- lower stem growth rates
- Higher survivorship in JT

	Stem growth (all gardens)		Survival (JT)	
Factor	**Effect sign**	**p**	**Effect sign**	**p**
Winter precipitation	**+**	0.003	**-**	0.037
Coeff. Var. of summer precipitation	**-**	0.036	**+**	0.01
Avg. difference in max. and min. temperature	**+**	0.003	**-**	0.02

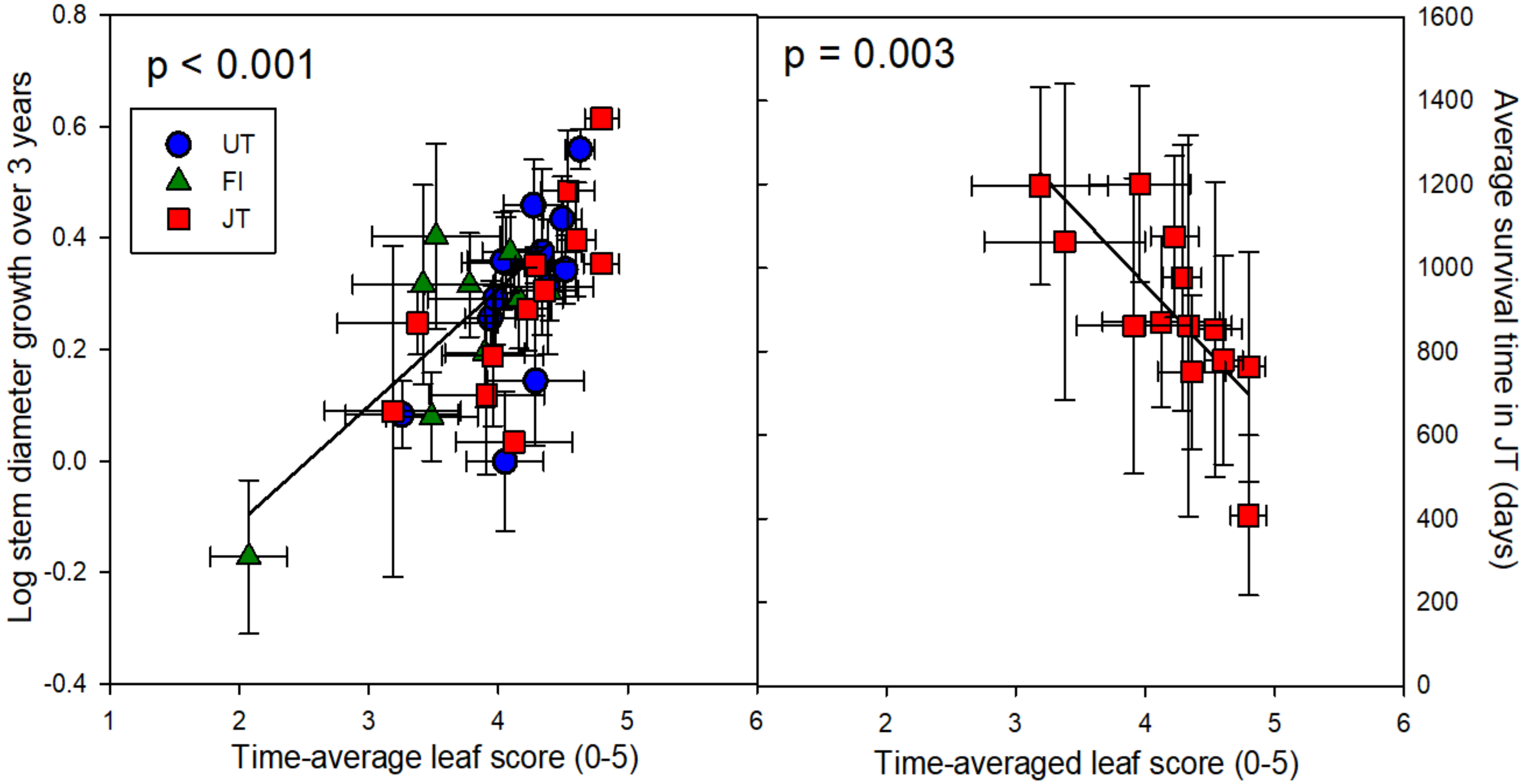
Condensed results of model selection analysis

Traits:

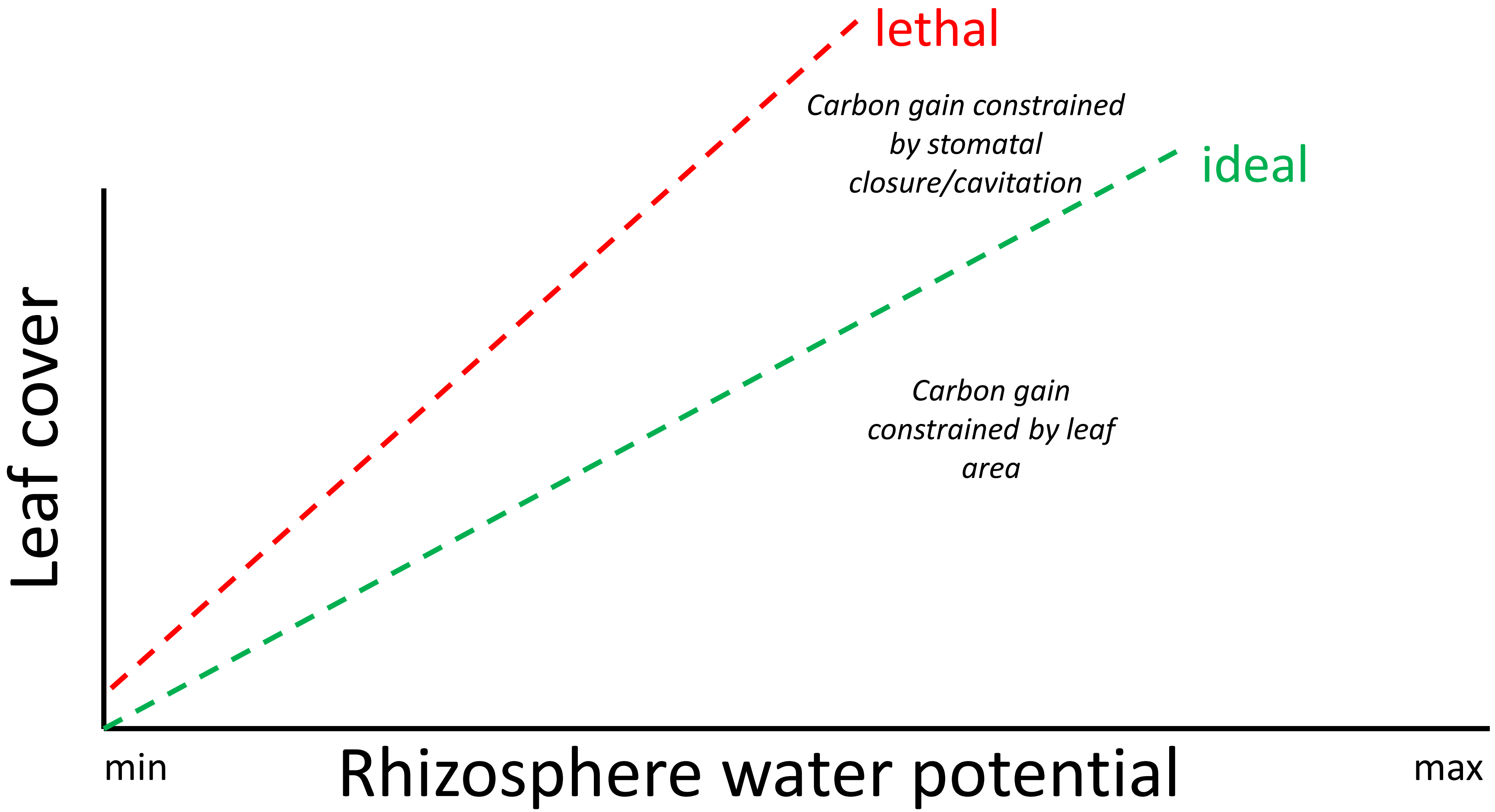
Populations with higher leaf cover grew faster and were less tolerant to harsh conditions (in JT)

Other leaf trait were highly plastic between gardens but not different between populations

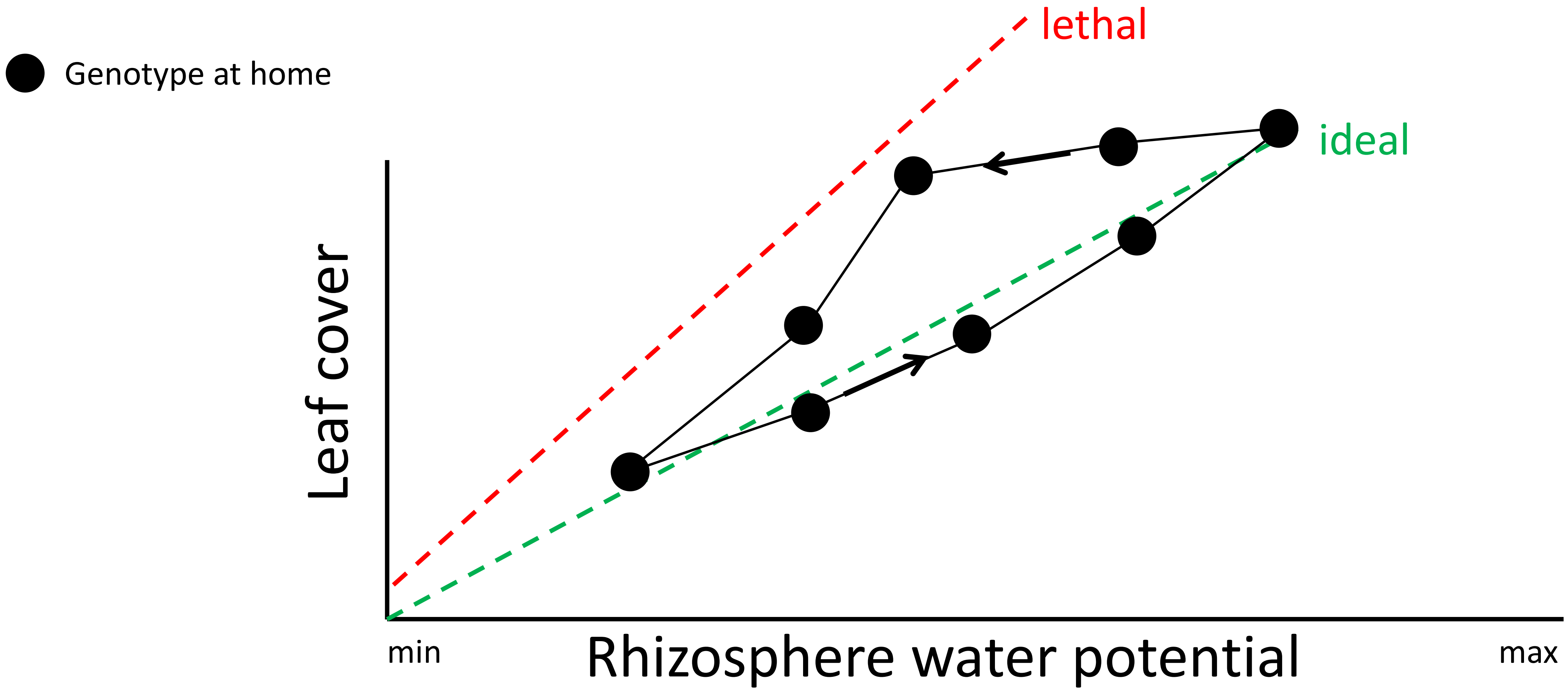
LEAF COVER SCORE



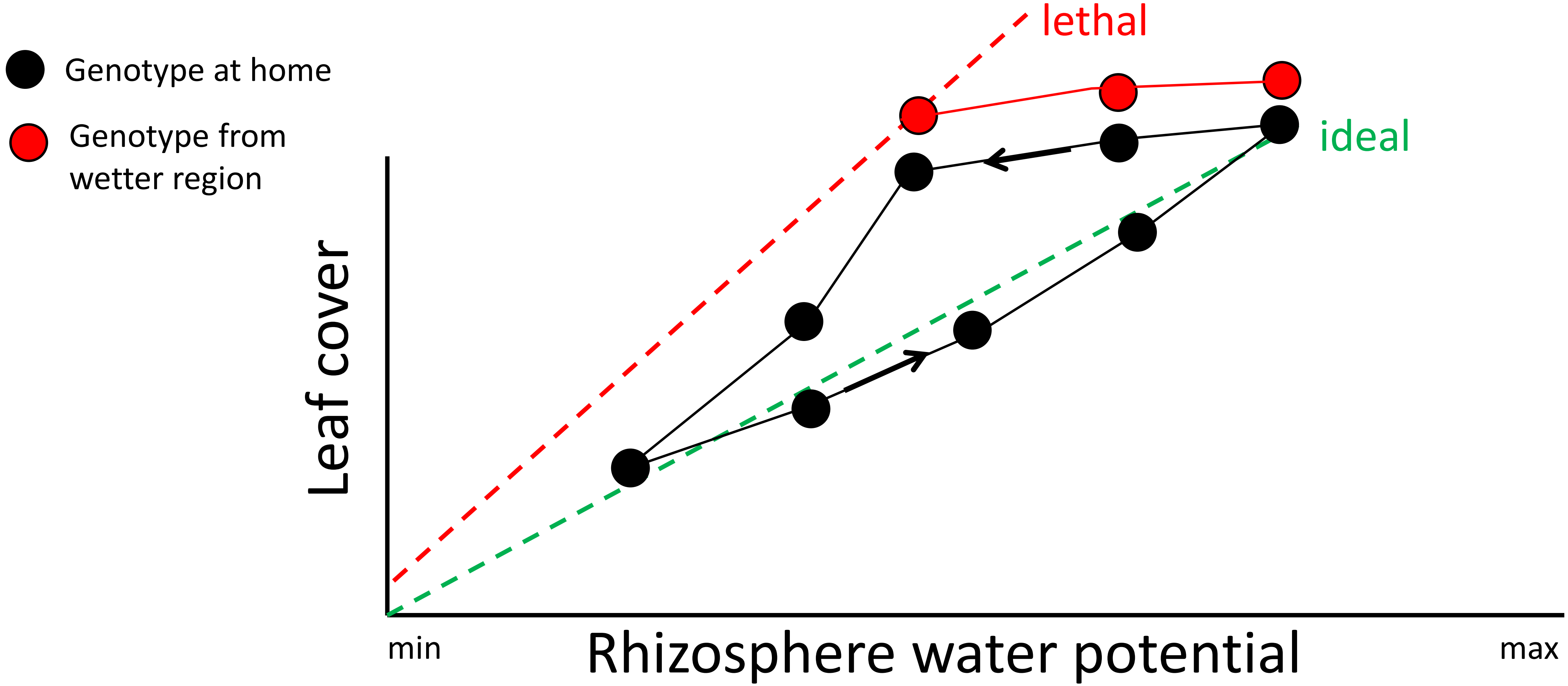
Hydraulic safety margins



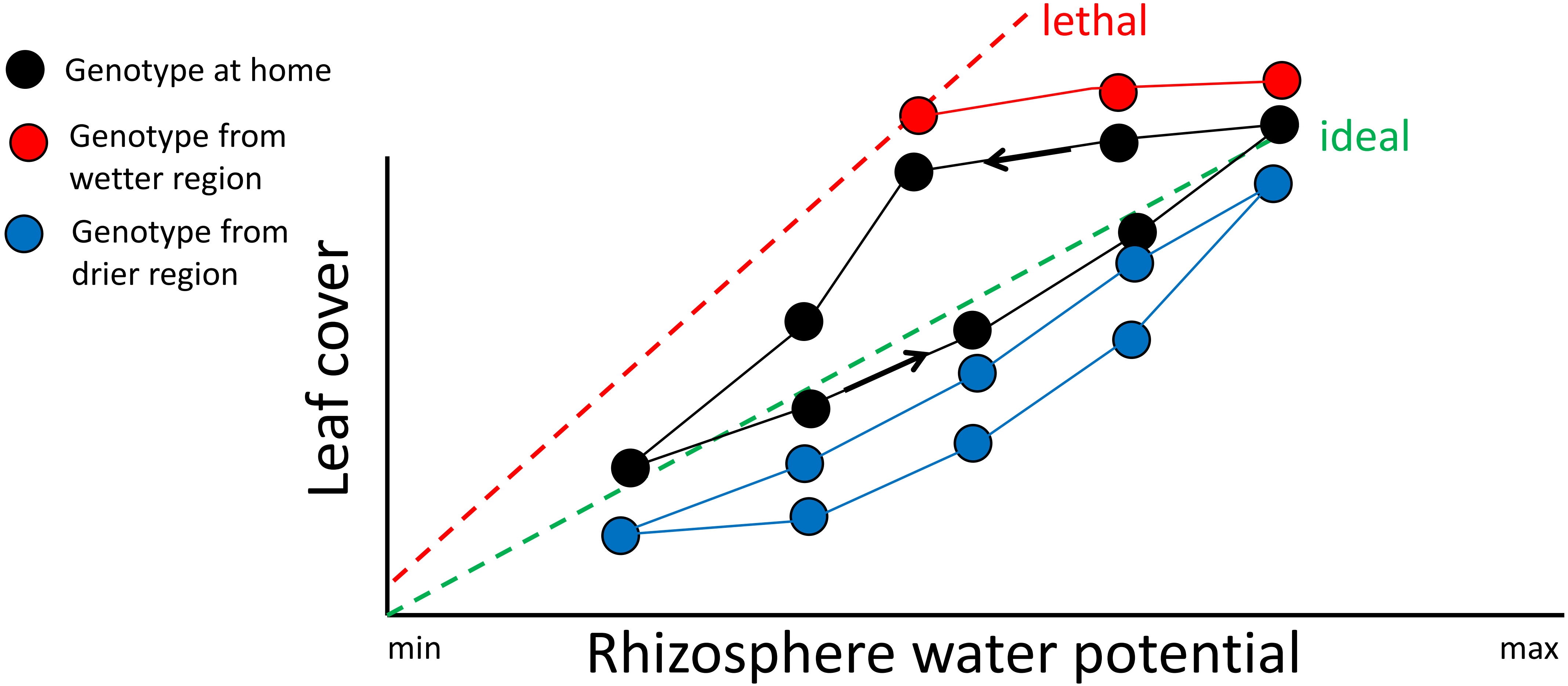
Hydraulic safety margins



Hydraulic safety margins



Hydraulic safety margins



L. tridentata summary:

1. Growth was insensitive to garden conditions, survivorship was not

2. Among populations, there was a growth-survivorship tradeoff

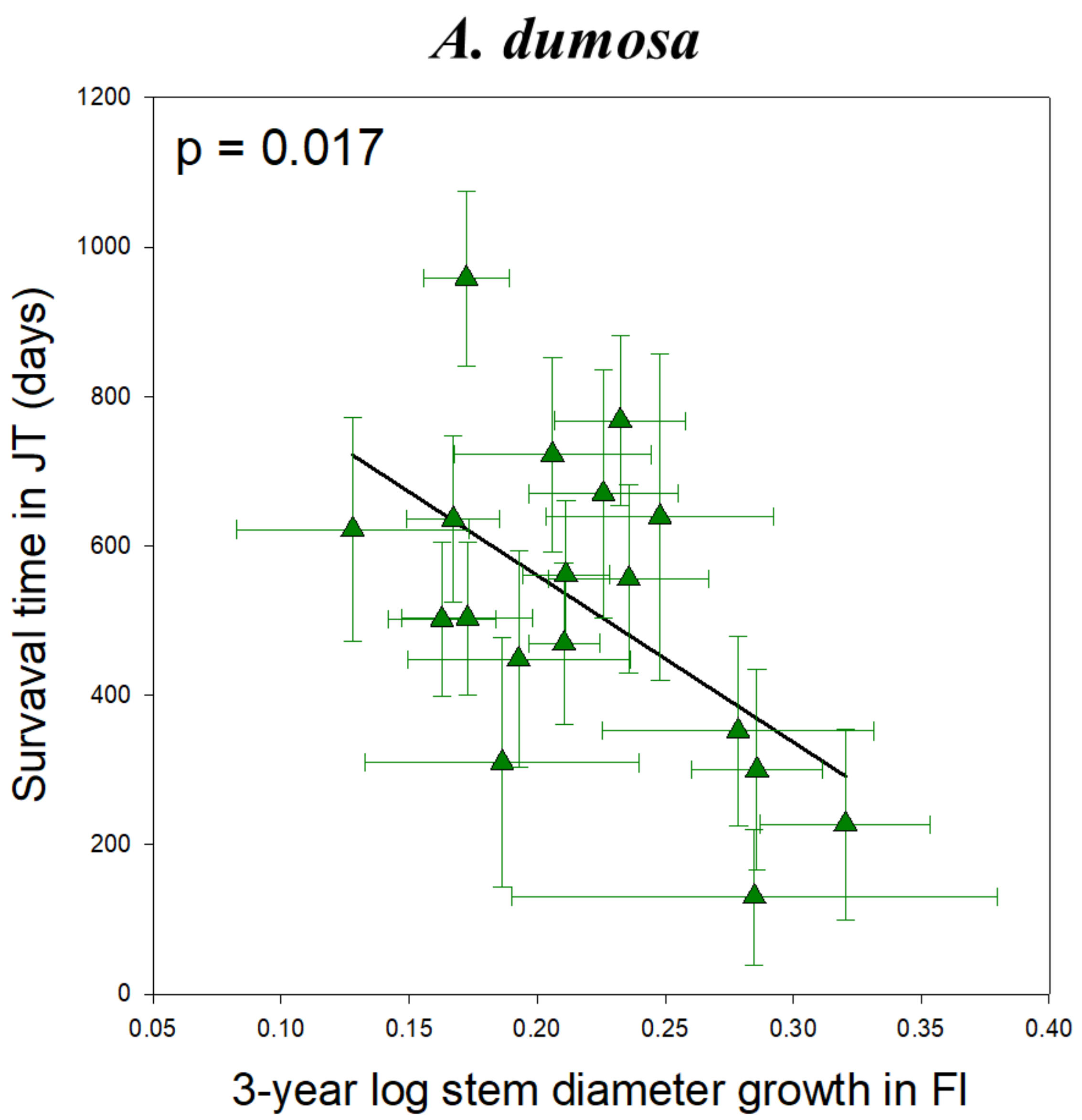
3. Faster growth was associated with more mesic homesites and greater leaf cover.

Ambrosia dumosa

Tradeoffs

Negative correlation between survival time in JT and growth in FI ….

… but not with growth in UT or JT

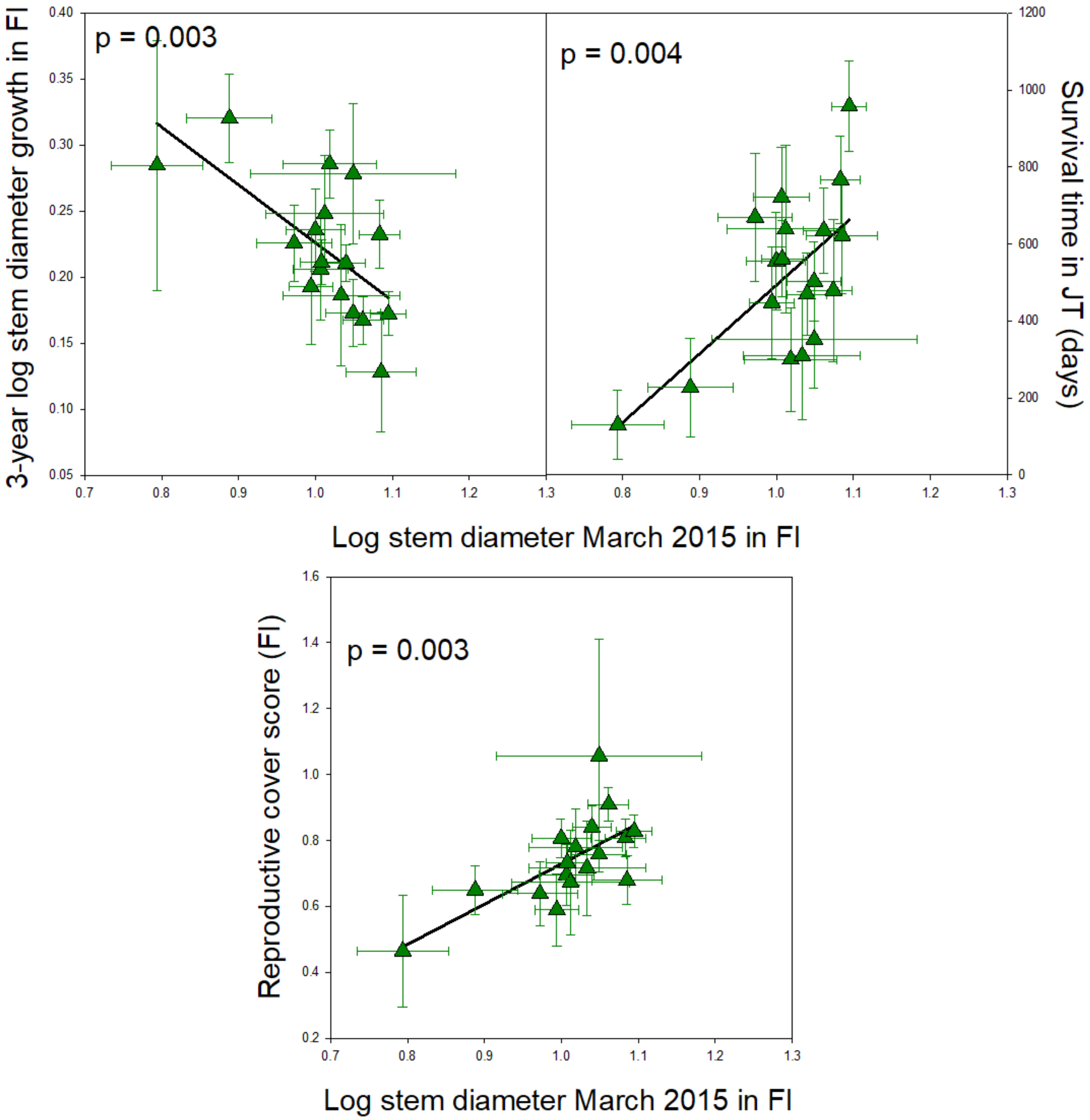


Size effects

Populations with initially larger plants had

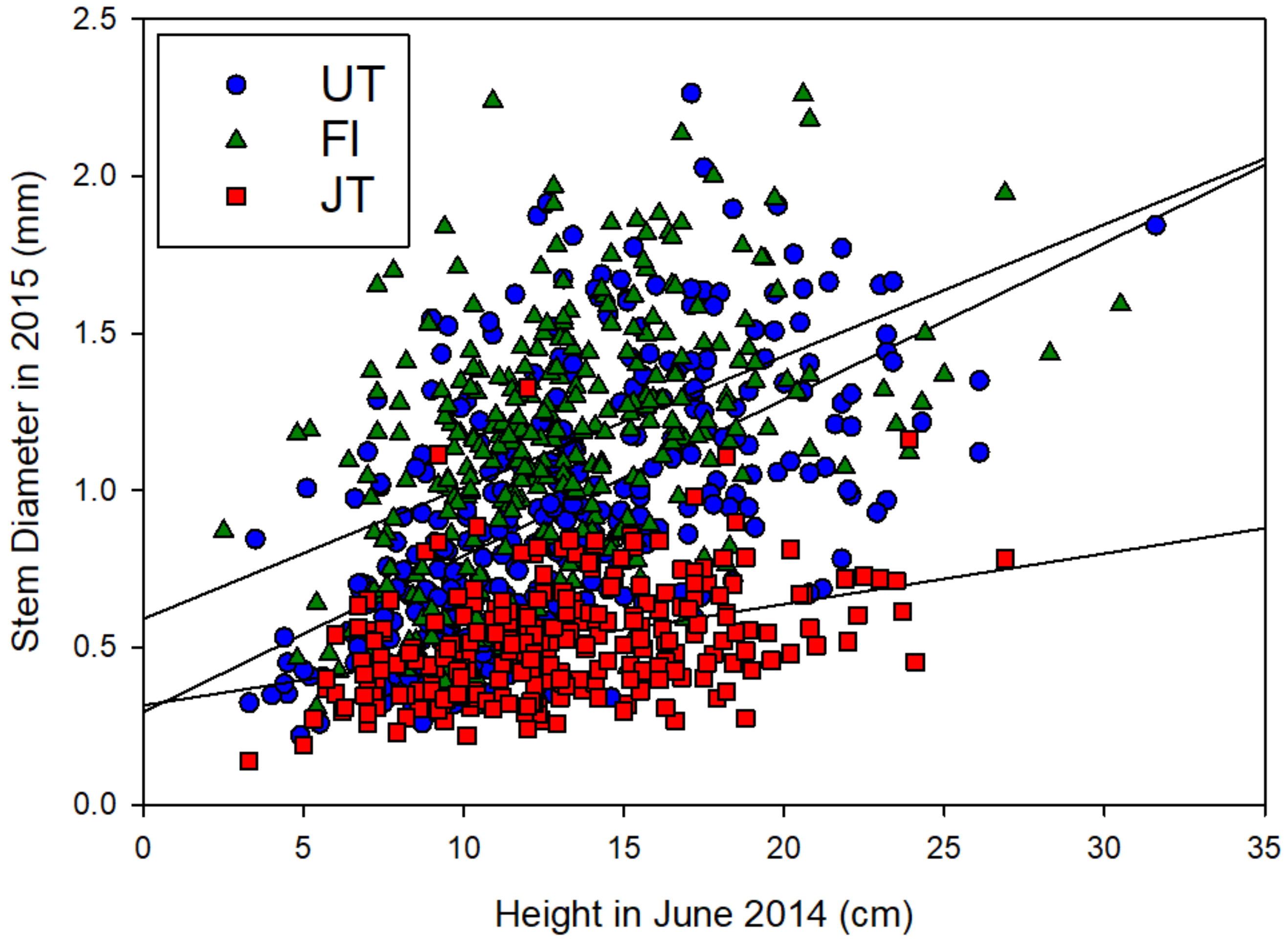
- subsequently, lower relative growth rates
- longer survival times
- greater reproductive cover

NO TRADEOFF!



Bigger is better

Size after the shock of transplanting correlated with future success



Traits

- plastic between gardens
- different between populations
- interactions
- size dependence
- none consistently related to growth

	Leaf cover score	Leaf %N	Leaf $d^{13}C$	SLA
Height in 2014	< 0.01(*)	0.01*	< 0.01**	< 0.01
Garden	0.18**	0.25**	0.25**	0.71**
Population	0.03*	0.01	0.01*	0.03**
G x P	0.05(*)	0.03	0.03**	0.03(*)

**	$p < 0.005$
*	$0.005 \leq p < 0.05$
(*)	$0.05 \leq p < 0.1$

Homesite climate effects

Populations from regions with wetter or colder winters had:

- Higher reproductive cover
- Higher survivorship in JT

	Repr. Cover (UT,FI)		Survival (JT)	
Factor	Effect sign	p	Effect sign	p
Height in June 2014	+	< 0.001	+	< 0.001
Winter precipitation			-	0.005
Minimal temperature	-	< 0.001	+	0.002

Condensed results of model selection analysis

A. dumosa summary:

1. Initial transplant size mattered for growth, survivorship and reproduction more than anything else
   - Y-model: "positive phenotypic correlations occur where negative correlations are expected" (van Noordwijk & de Jong 1986)

2. What happened between seedling germination in the greenhouse and transplant establishment affected subsequent performance

3. Although traits varied among populations, clear trait v. fitness correlations were not found

4) Restoration Implications

Seed transfer zones

Validated: Shrub performance was correlated with homesite climate indices:

- performance was most consistently correlated with precipitation and temperature norms at the homesites

The transplanting protocol is potentially problematic:

- it skips the germination and establishment phase
- potential for transplanting artefacts (plants respond to greenhouse, transplanting and watering before they respond to local climate)

Beyond climate

- Different populations have different “strengths” on the spectrum between hardiness and productivity

- Understanding the strengths and weaknesses of source populations, restoration managers could consider selection criteria beyond climate, e.g.:

  - Future disturbance frequency
  - The need to resist invasive species
  - …

THANK YOU FOR ATTENDING!