

Potential Eucalyptus species and the required silvicultural system for biomass production in the ecological regions of the Southeastern United States

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**2012 Woody Crops Conference
Oak Ridge TN – November 8th**



Motivation

- *Productivity*
- *Coppice*
- *Clonal Forests*
- *Wood Quality*
- *Biomass Market*

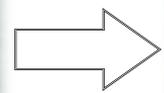
Productivity: 32 ton/ac/yr (40 Mg/ha/yr)



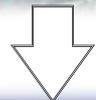
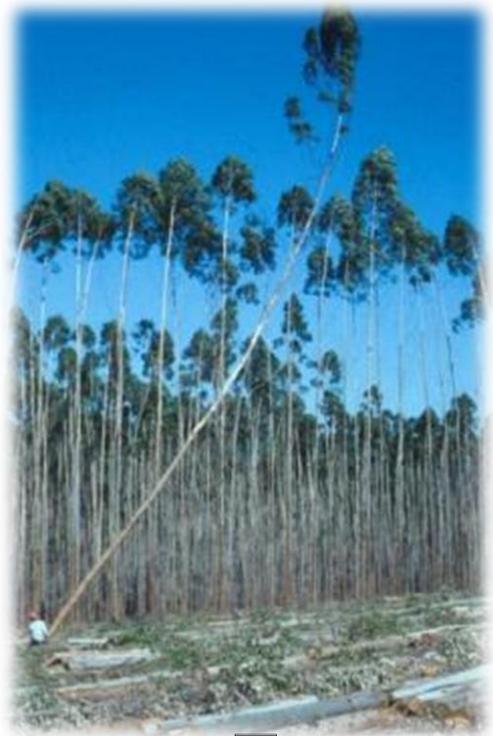
4 years-old

Coppice

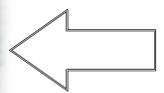
1 year-old



6 to 8 years



2 months



3 months



6 years-old



Clonal Propagation
Good Genetics & Silviculture



Wood Quality
Mulch, Biomass, Pulp,
Panels, Sawtimber...



Limitations

- *Cold Hardness Tolerance*
- *Silviculture Requirements*

Concerns:

- . *Pests & Diseases*
- . *Environmental Impacts*

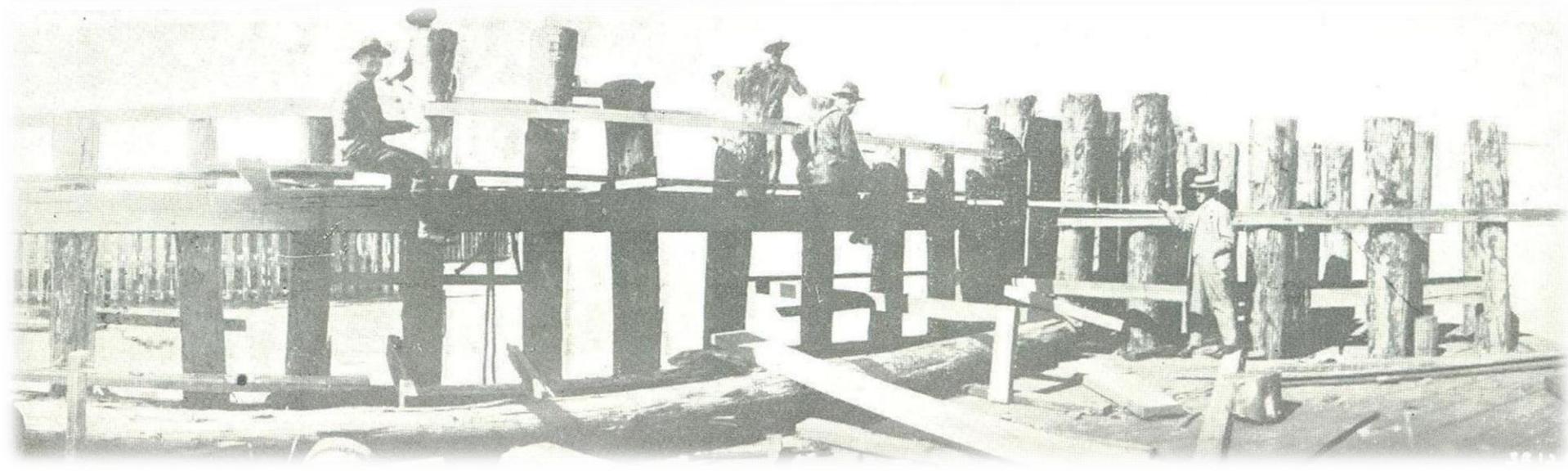


Edmundo Navarro Andrade (1925)

Navarro's Book 1910: "Eucalyptus in the United States" (Portuguese)

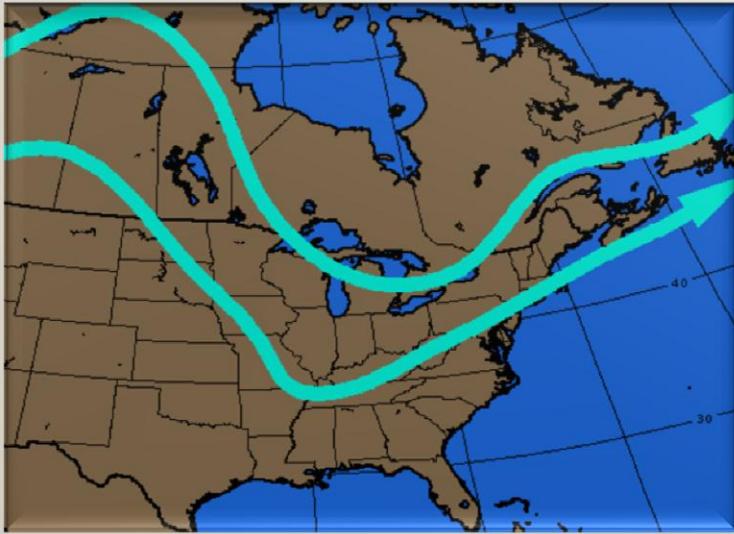
- H. S. Betts e C. Stowell Smith — Utilization of California Eucalypts — Washington, 1910.
- Norman D. Ingham — Eucalyptus in California — Sacramento, Cal. 1908.
- G. B. Lull — A Handbook for Eucalyptus Planters — Sacramento, Cal. 1908.
- Louis Margolin — Yield from Eucalyptus Plantations in California — Sacramento, Cal., 1910.
- Forestry Society of California — Uses for Eucalyptus Lumber and Timber — Los Angeles, Cal., 1908.
- Forest Service — U. S. America — Bulletin 3 Circular — Washington, 1907.
- Paul Combes — L'Eucalyptus et ses dérivés — Paris.
- J. Beauverie — Le Bois — Paris, 1905.
- A. J. McClatchie — Eucalypts Cultivated in the United States — Washington, 1902.

Eucalyptus in California – 1909



Jet Stream

SE US 1983



The Eucalyptus Story in SE US

McClatchie*, Zobel, Meskimen, Kellison, Ledig, Rockwood, Whitesell...

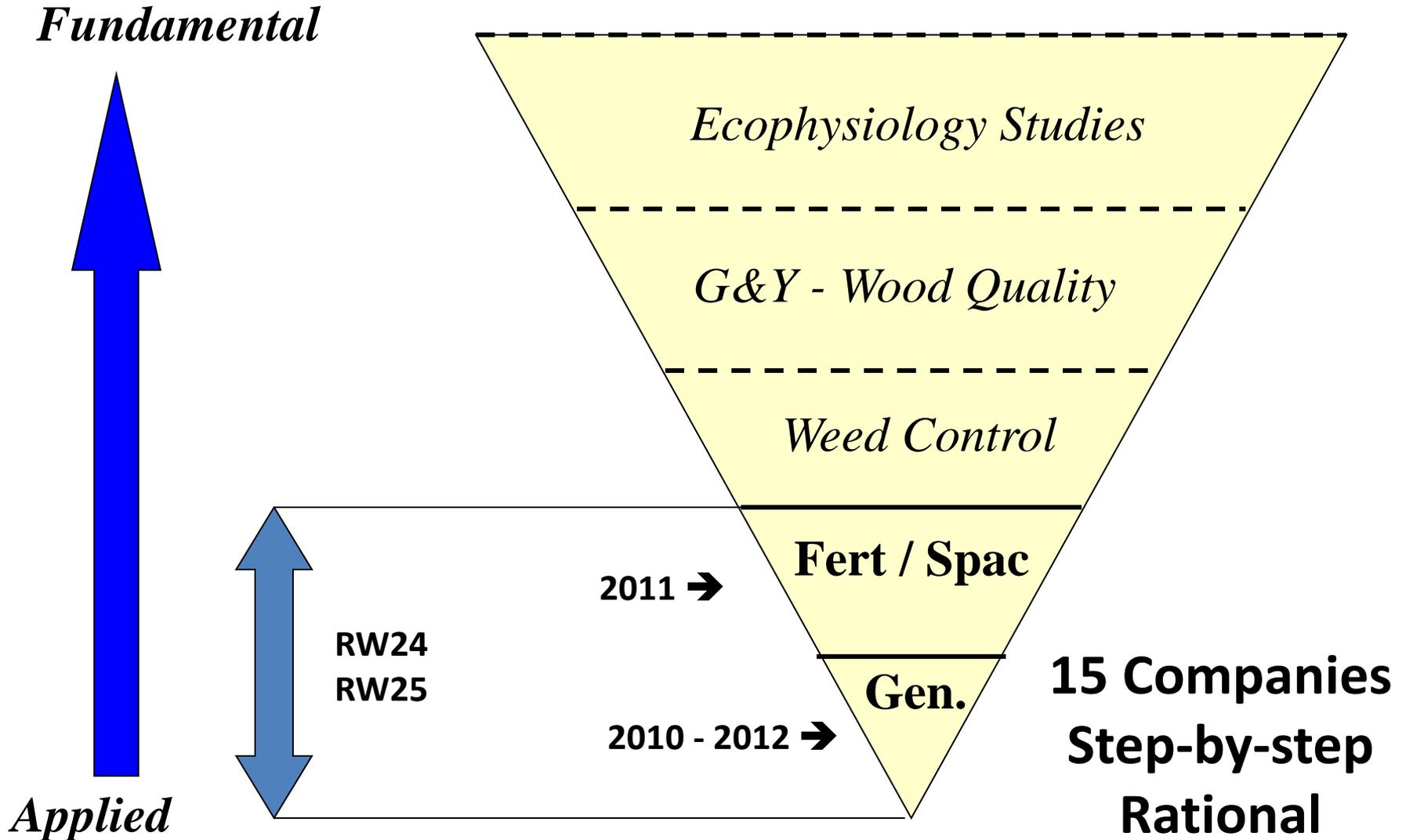
- *First wave*
 - 1957-58
- *Second wave*
 - 1964-65
- *Third wave*
 - 1971-72
- *Fourth wave*
 - 1982-1983-1985
- *Fifth wave*
 - FPC 2010...



Florida, California, Hawaii

* Eucalyptus cultivated in the United States, 1902

The Triangle of Research – RW24

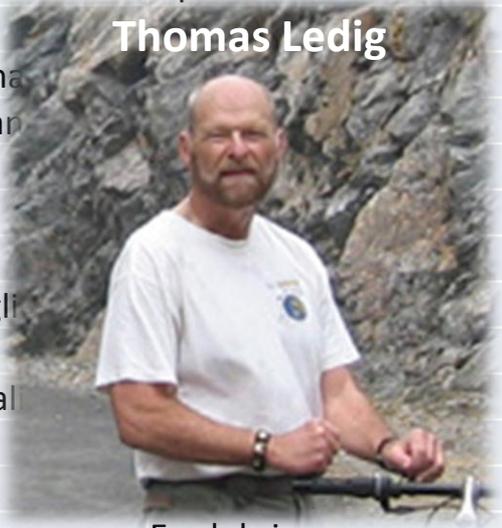


Regionwide Study Objectives

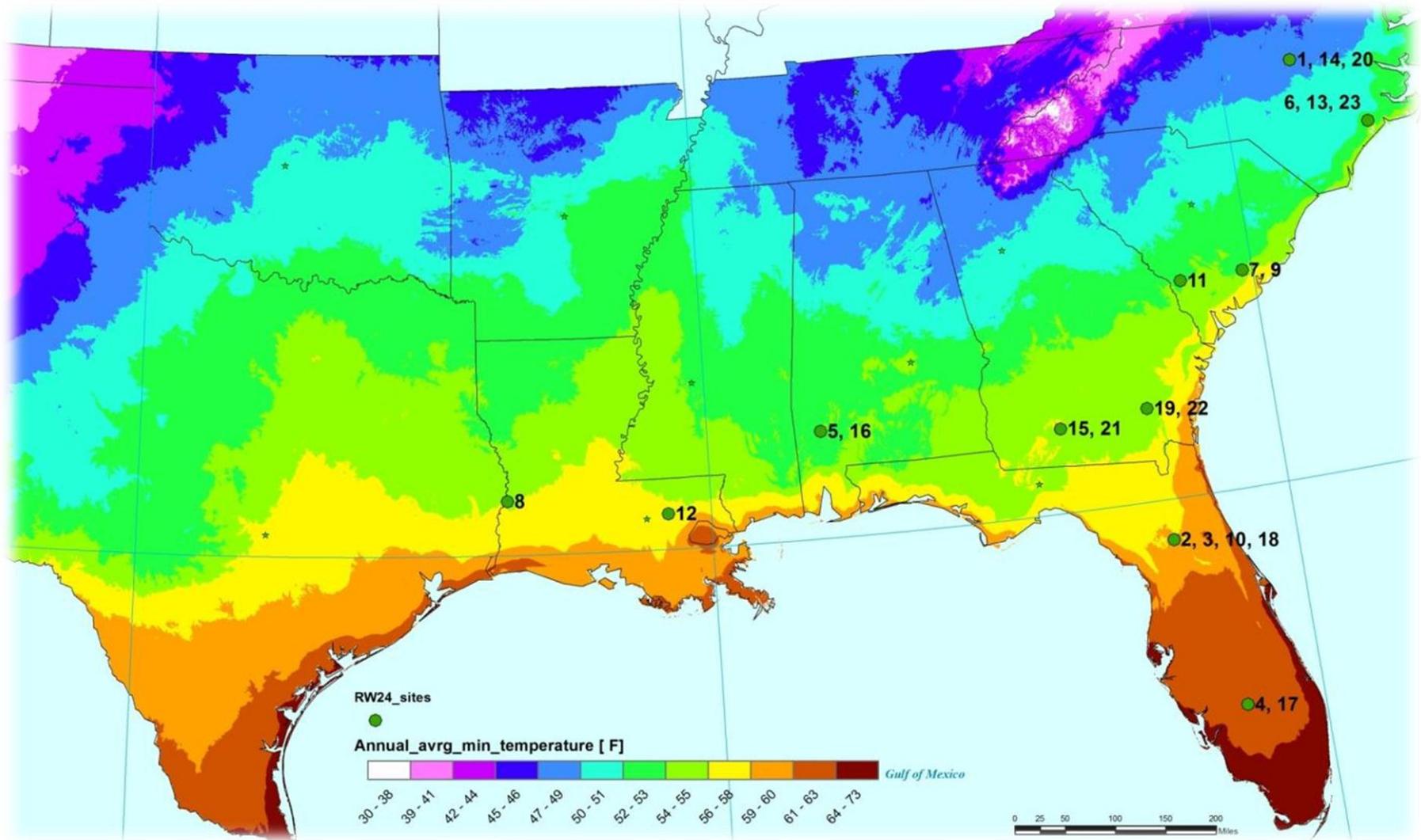
- Identify *Eucalyptus* species/entries that are cold tolerant enough to survive and grow in different sites across the Southeastern US (***screening***)
- Quantify and model the ***biomass*** growth and yield of these species in a 5-year rotation
- Investigate the **environmental** factors and **physiological** controls related with *Eucalyptus* cold-tolerance and elaborate cold-risk zoning and productivity maps for *Eucalyptus* species in the SEUS

150 Species (333 Entries) Planted 2010, 2011, 2012

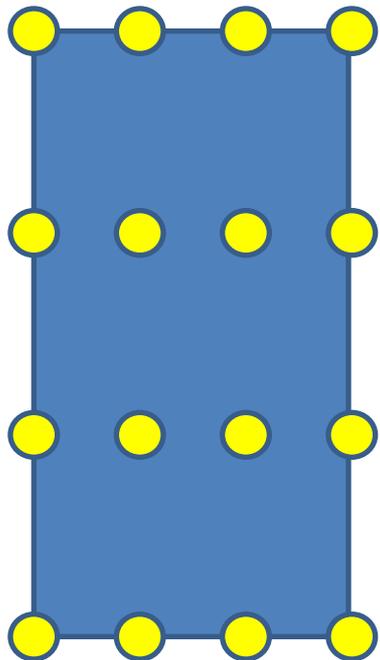
Seeds from 8 Countries

| | | | | |
|--------------------|-----------------|-----------------|----------------|--|
| C.calophylla | E.caesia | E.falcata | E.microtheca | E.punctata |
| C.citriodora | E.caleyi | E.fastigata | E.miniata | Thomas Ledig |
| C.eximia | E.caliginosa | E.flocktoniae | E.moluccana |  |
| C.gummifera | E.camaldulensis | E.forrestiana | E.muelleriana | |
| C.maculata | E.campaspe | E.fraxinoides | E.nicholii | |
| C.papuana | E.camphora | E.gardneri | E.nitens | |
| C.terminalis | E.carnea | E.glaucescens | E.nobilis | |
| C.tessellaris | E.cinerea | E.globulus | E.nova-angliae | |
| C.trachyphloia | E.cladocalyx | E.gomphocephala | E.obliqua | |
| E.accedens | E.cloeziana | E.goniocalyx | E.occidentalis | |
| E.acmenoides | E.cneorifolia | E.gracilis | E.odorata | |
| E.aggregata | E.coccifera | E.grandis | E.oleosa | |
| E.albens | E.conica | E.haemastoma | E.oreades | E.salubris |
| E.amplifolia | E.consideniana | E.incrassata | E.ovata | E.scabra |
| E.amygdalina | E.cosmophylla | E.jacksonii | E.paniculata | E.scoparia |
| E.andrewsii | E.crebra | E.johnstonii | E.parvula | E.siderophloia |
| E.angophoroides | E.dalrympleana | E.laevopinea | E.patens | E.sideroxyton |
| E.astringens | E.dealbata | E.largiflorens | E.pauciflora | E.sieberi |
| E.badjensis | E.deanei | E.lehmannii | E.pellita | E.smithii |
| E.baueriana | E.decipiens | E.lesouefii | E.perriniana | E.stellulata |
| E.baxteri | E.deglupta | E.leucoxyton | E.pilularis | E.stricklandii |
| E.behriana | E.delegatensis | E.longifolia | E.piperita | E.tereticornis |
| E.benthamii | E.diversicolor | E.loxophleba | E.platypus | E.tetraptera |
| E.blakelyi | E.diversifolia | E.macrocarpa | E.polyanthemos | E.tetrodonta |
| E.blaxlandii | E dives | E.marginata | E.populnea | E.torquata |
| E.bosistoana | E.dumosa | E.melanophloia | E.porosa | E.transcontinentalis |
| E.botryoides | E.dundasii | E.melanoxyton | E.preissiana | E.viminalis |
| E.bridgesiana | E.dwyeri | E.melliodora | E.propinqua | E.viridis |
| E.brockwayi | E.elata | E.microcarpa | E.pulchella | <i>.....and more!</i> |
| E.burracoppinensis | E.eremophila | E.microcorys | E.pulverulenta | |

THE DESIGN: Sites across the region and no reps inside each site



Cold hardness zones



4 x 4 = 16

Species C

Plot Size:

Biomass: 16, 32 or 64 trees

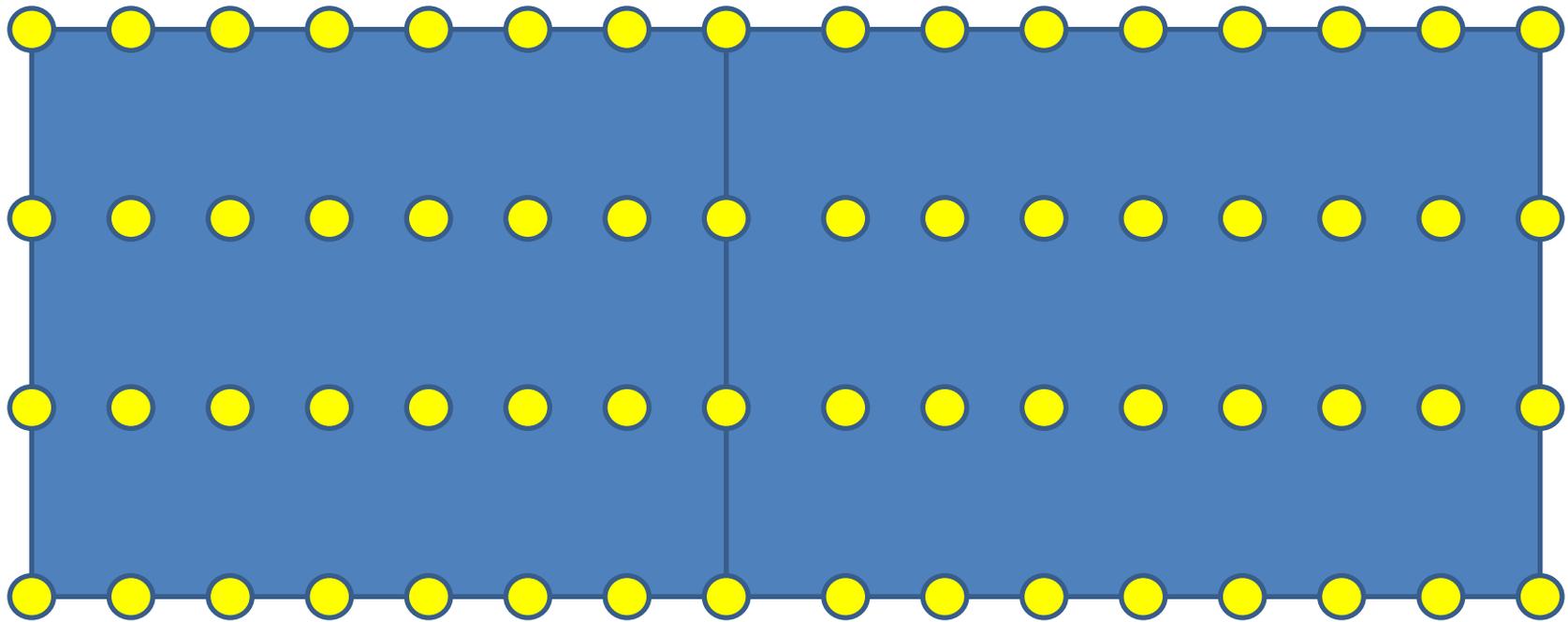
Screening: 3 or 4

4 x 8 = 32

Species B

4 x 16 = 64

Species A

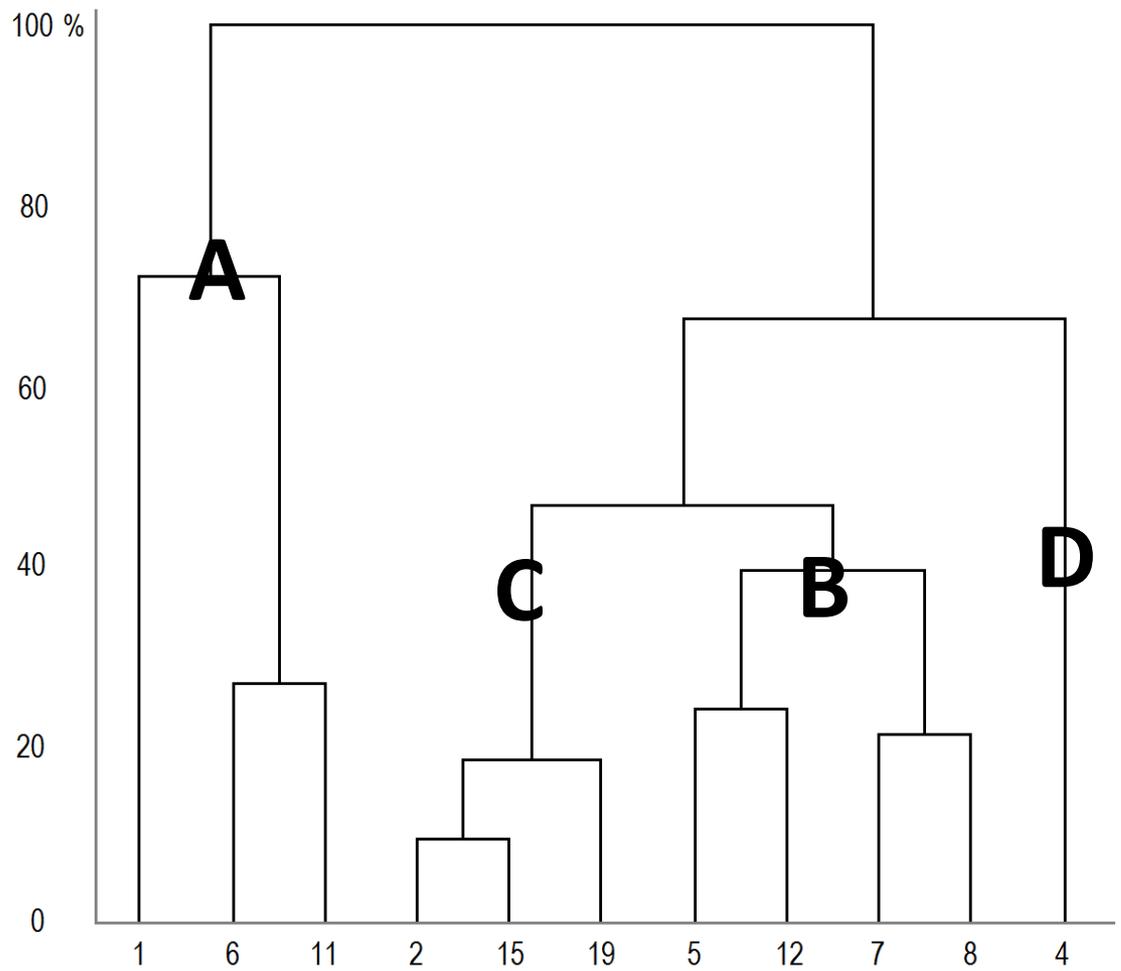


Silviculture



P fertilization

- 1 Raleigh NC
- 2 Citra FL
- 4 Palmdale FL
- 5 Leroy AL
- 6 Jacksonville NC
- 7 Ravenel SC
- 8 Merryville LA
- 11 Allendale SC
- 12 Livingston LA
- 15 Moultrie GA
- 19 Blackshear GA



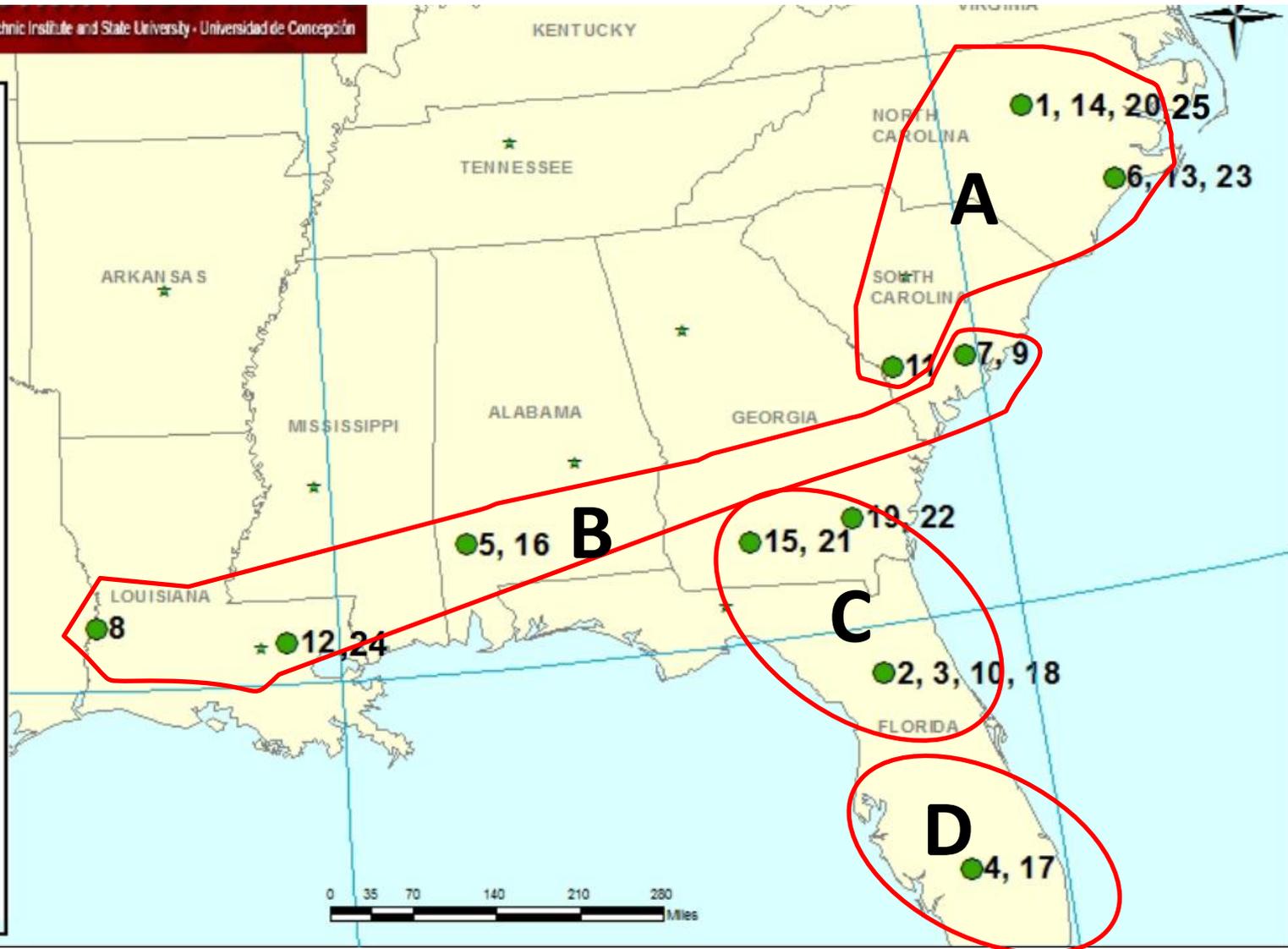
**Dendrogram based on Tmx, Tmin, PPT
(April 2010 to May 2012)**

Method
Ward (minimal variance)
Distancia euclidiana

RW24 – Regions (2010-2012)

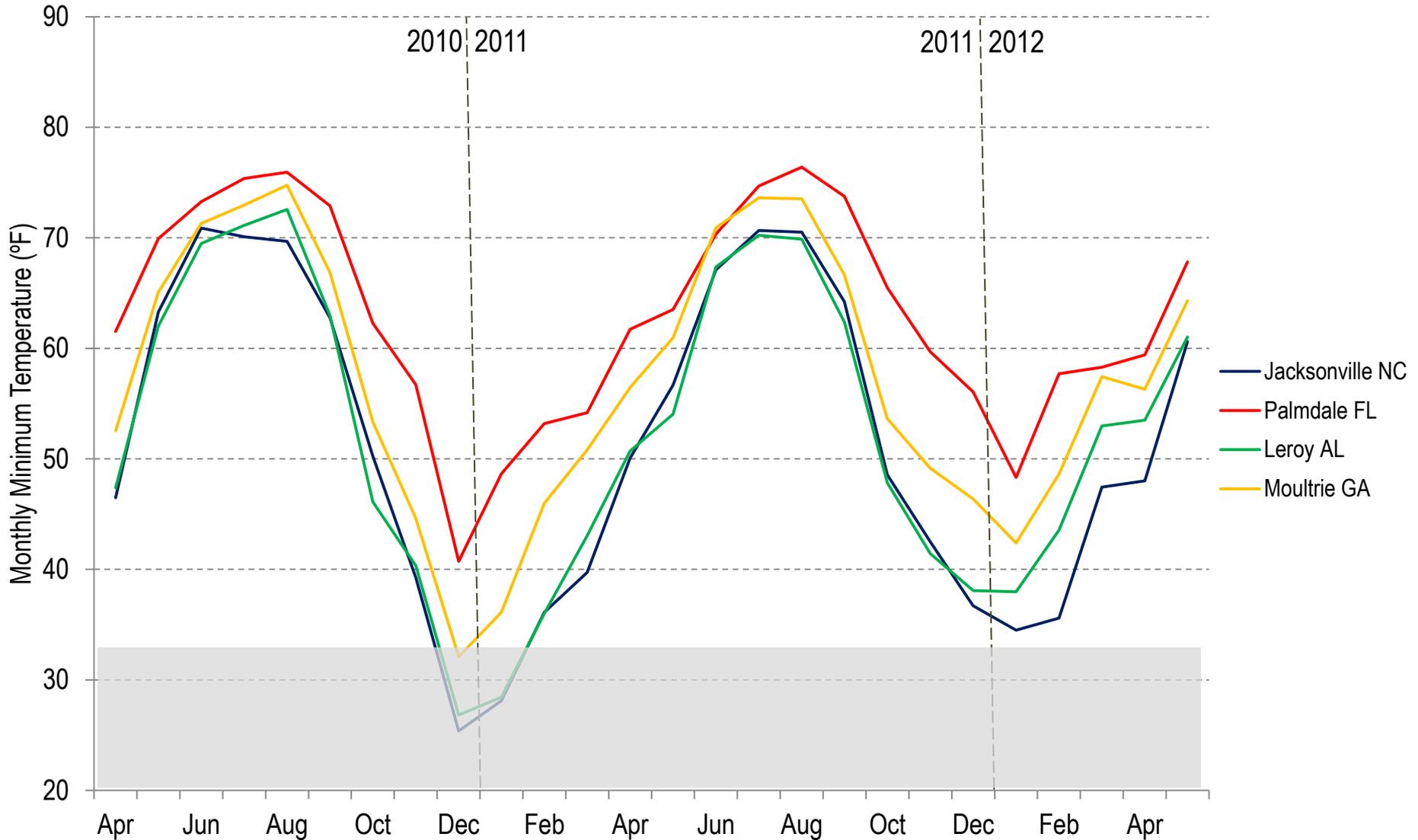
North Carolina State University - Virginia Polytechnic Institute and State University - Universidad de Concepción

| | |
|----|------------|
| 1 | RW24.13.01 |
| 2 | RW24.58.01 |
| 3 | RW24.58.02 |
| 4 | RW24.61.01 |
| 5 | RW24.62.01 |
| 6 | RW24.13.02 |
| 7 | RW24.11.01 |
| 8 | RW24.11.03 |
| 9 | RW24.11.02 |
| 10 | RW24.58.03 |
| 11 | RW24.07.01 |
| 12 | RW24.08.01 |
| 13 | RW24.13.04 |
| 14 | RW24.13.03 |
| 15 | RW24.63.01 |
| 16 | RW24.62.02 |
| 17 | RW24.61.02 |
| 18 | RW24.58.04 |
| 19 | RW24.42.01 |
| 20 | RW24.13.05 |
| 21 | RW24.63.02 |
| 22 | RW24.42.02 |
| 23 | RW24.13.06 |



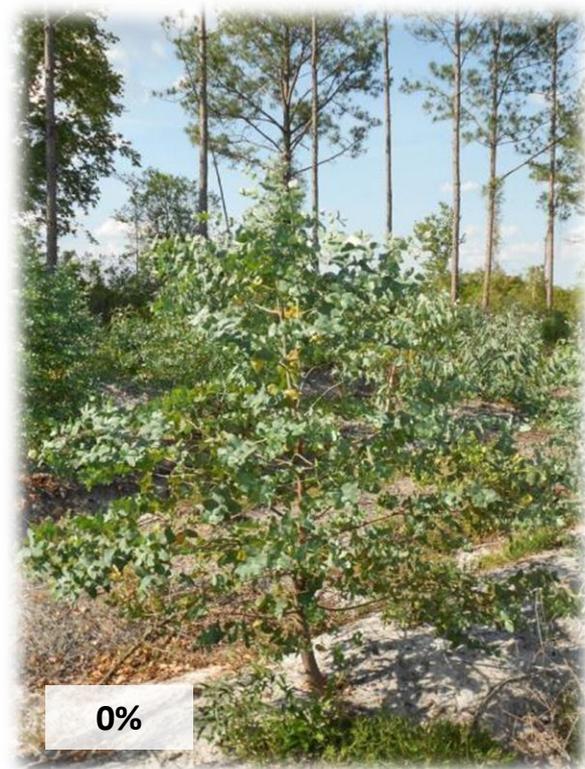
Divisão dos sites em função do mapa PHZ e nosso dendrograma. O que achou? Depois faço a média climático das regiões.

Minimum Temp. – 4 Regions



Cold Damage Evaluation

April Evaluation: 2011 and 2012



0%

Almost no damage



25%

Tips and top, outer damages



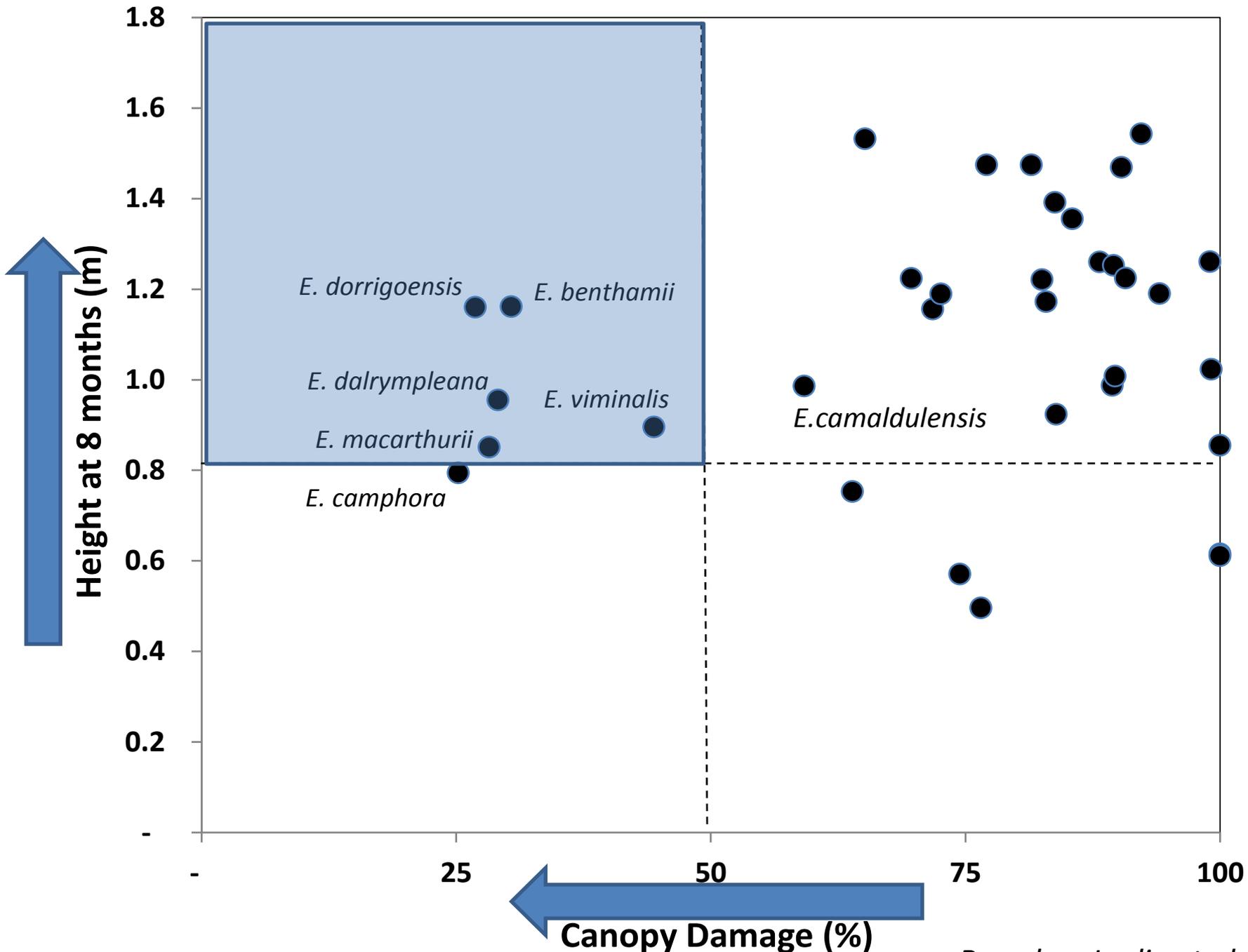
75%

Upper and inner canopy damaged



100%

Full canopy damaged



Based on Leslie et al. 2010



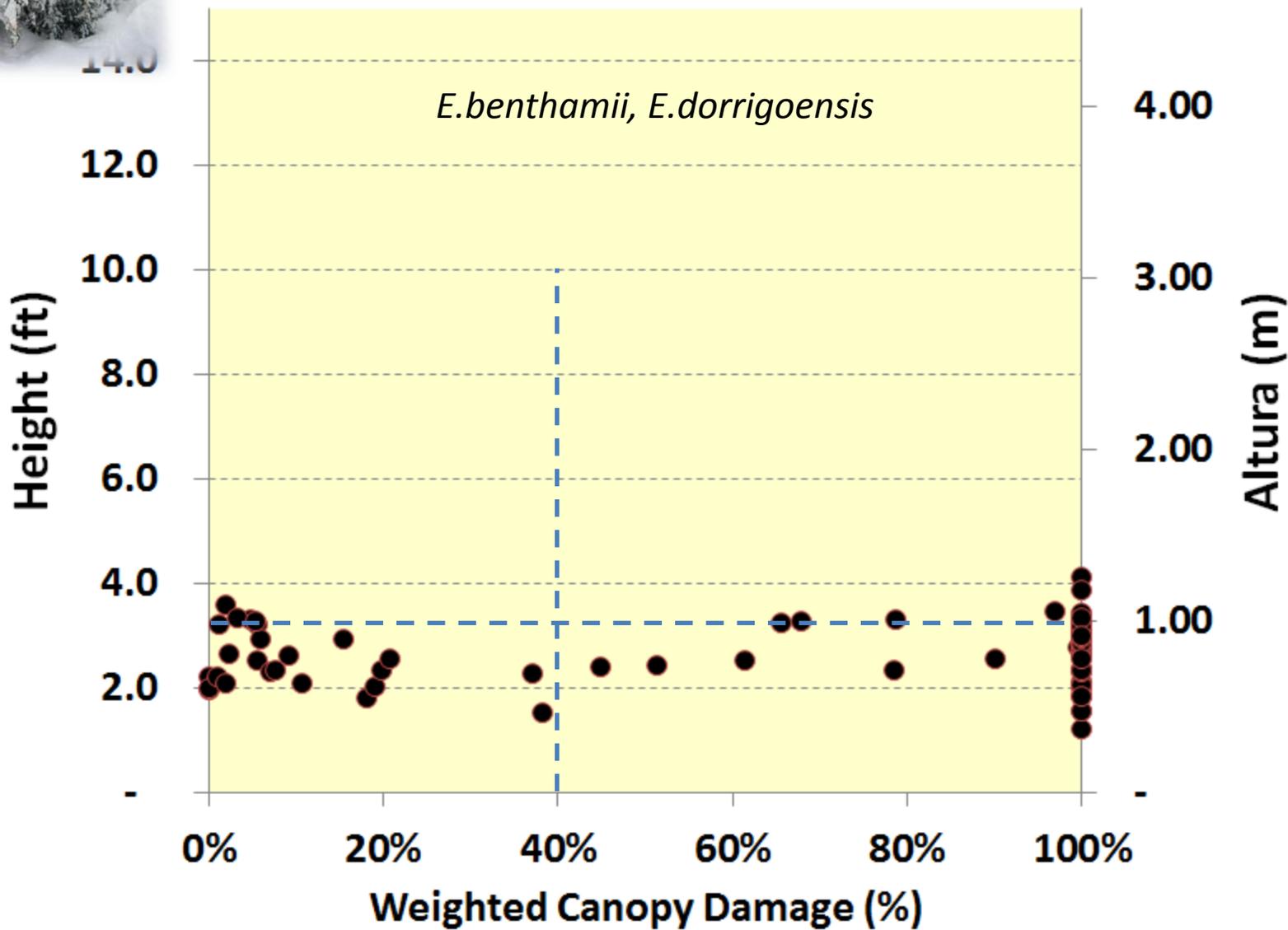
2011 Winter

2012
Winter



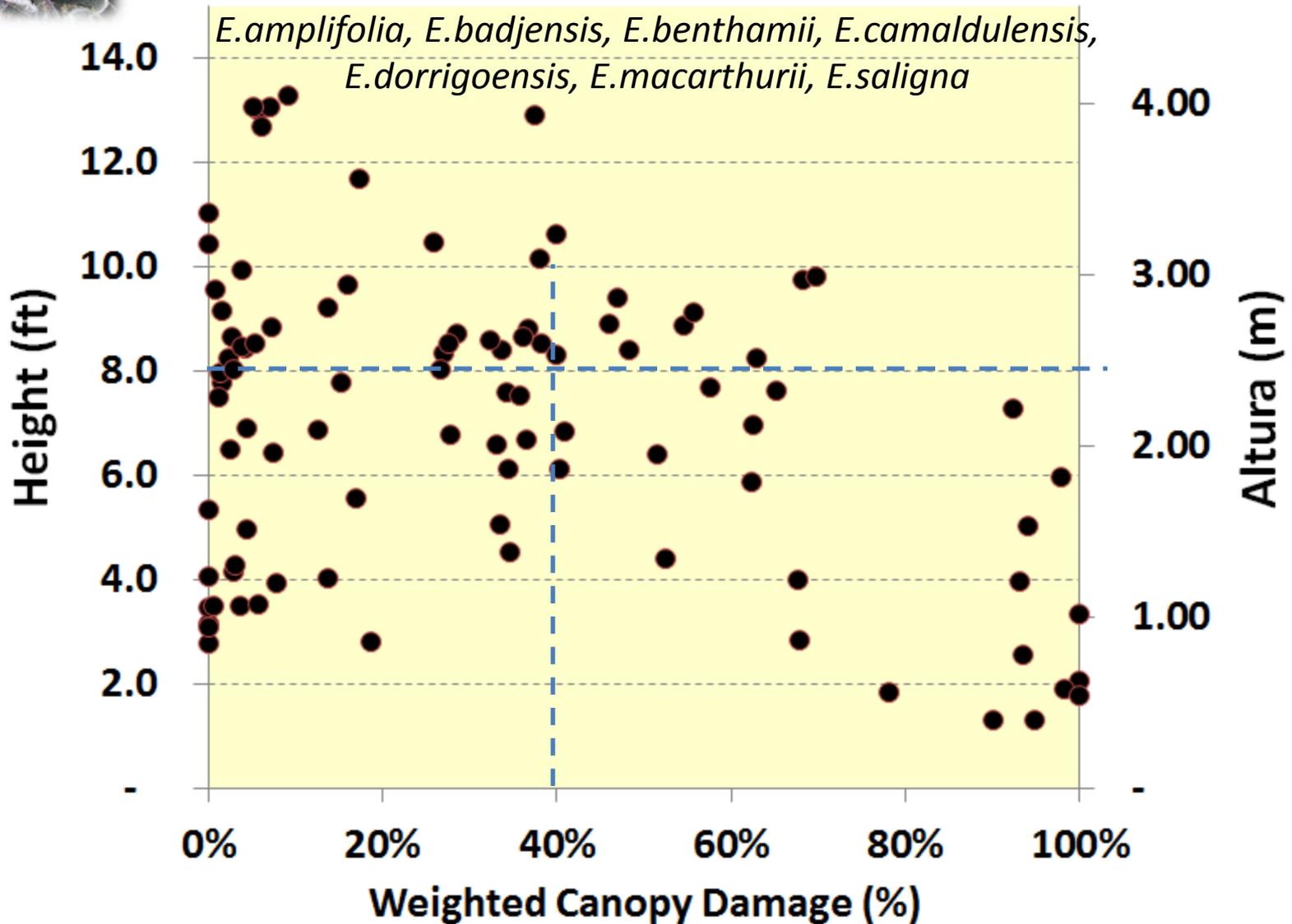


Region B , 2011 Winter , 1 year-old trees





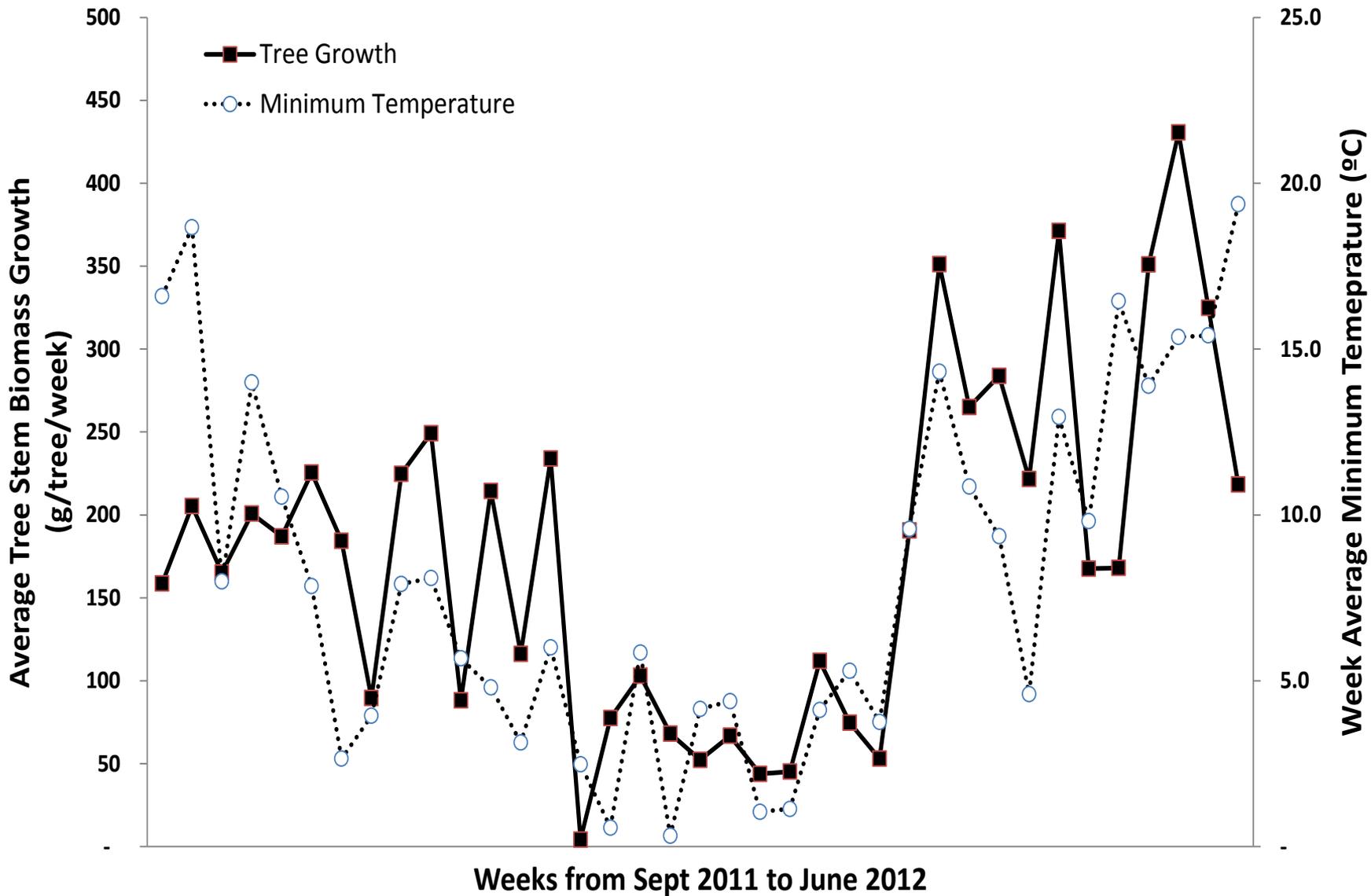
Region B , 2012 Winter , 1 year-old trees



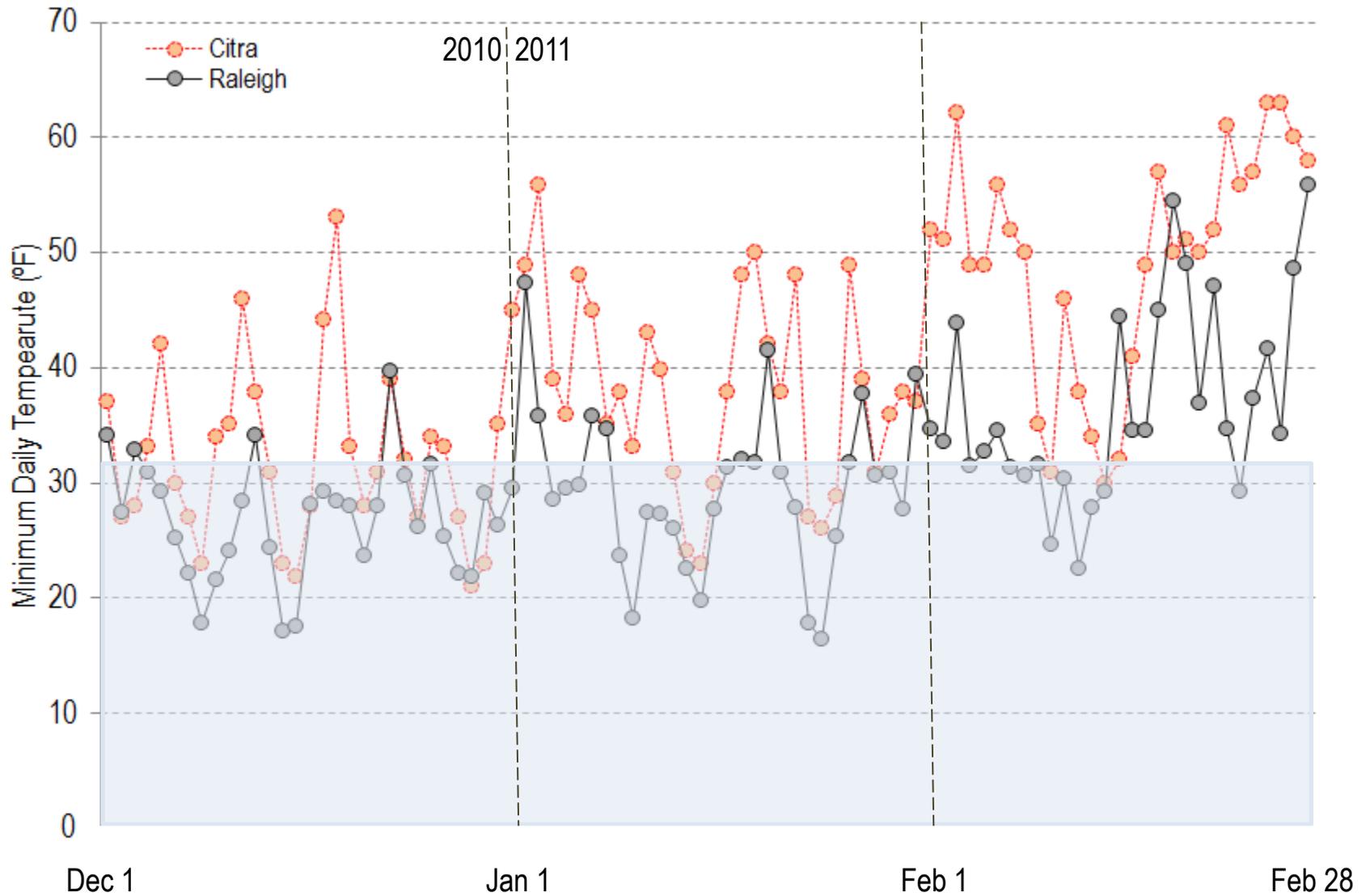


- ***Winter Temperature Effect on Growth***
- ***Risk of Lack of Cold Acclimatization on Mild Winters***





Citra (Region C) and Raleigh (Region A) Dec/2010 a Feb/2011



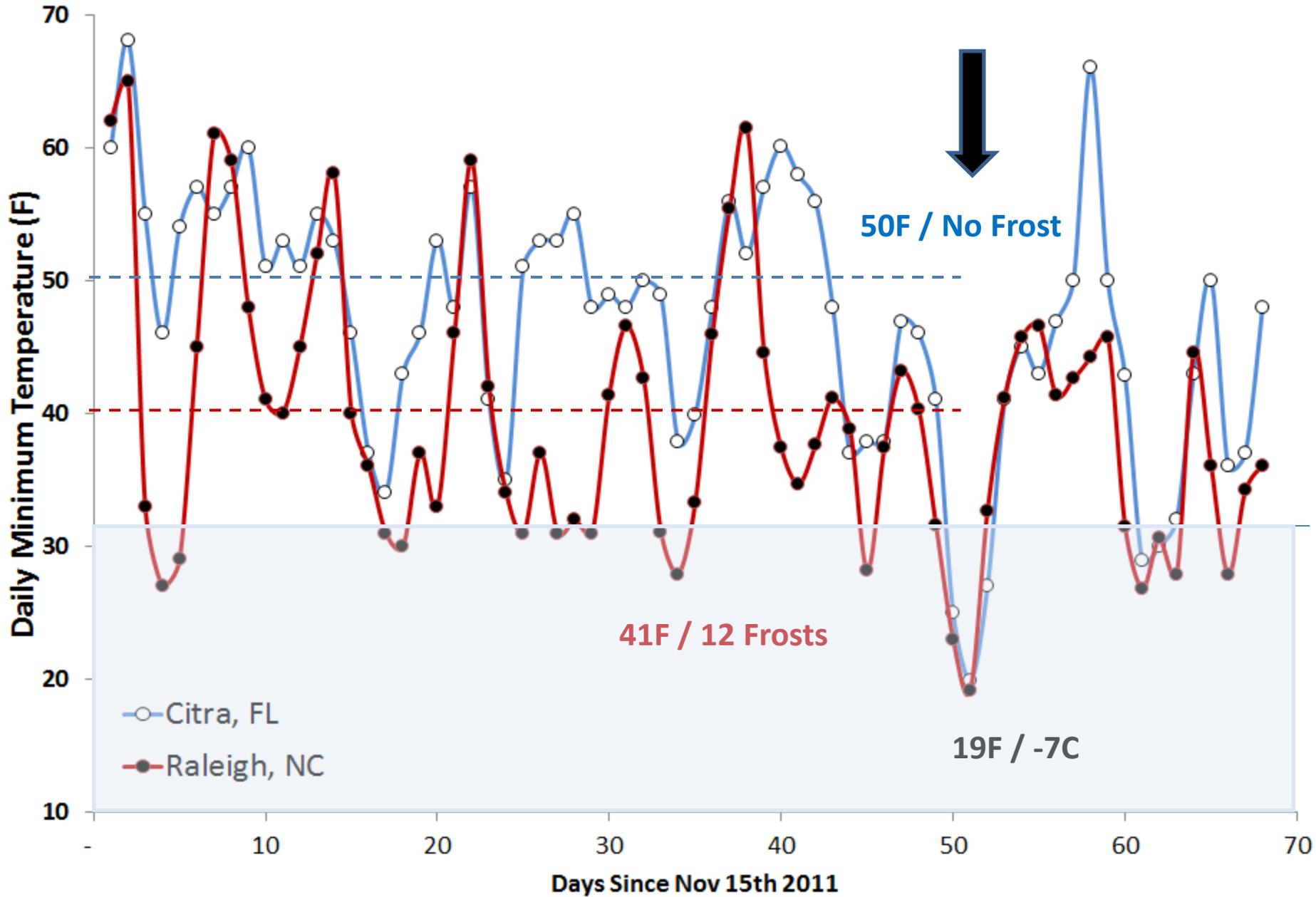
E.grandis



Citra FL – 2011 Winter

E.benthamii





E.viminalis, E.benthamii

E.grandis, E.urophylla



**Raleigh NC – 2012
Winter**



E.grandis

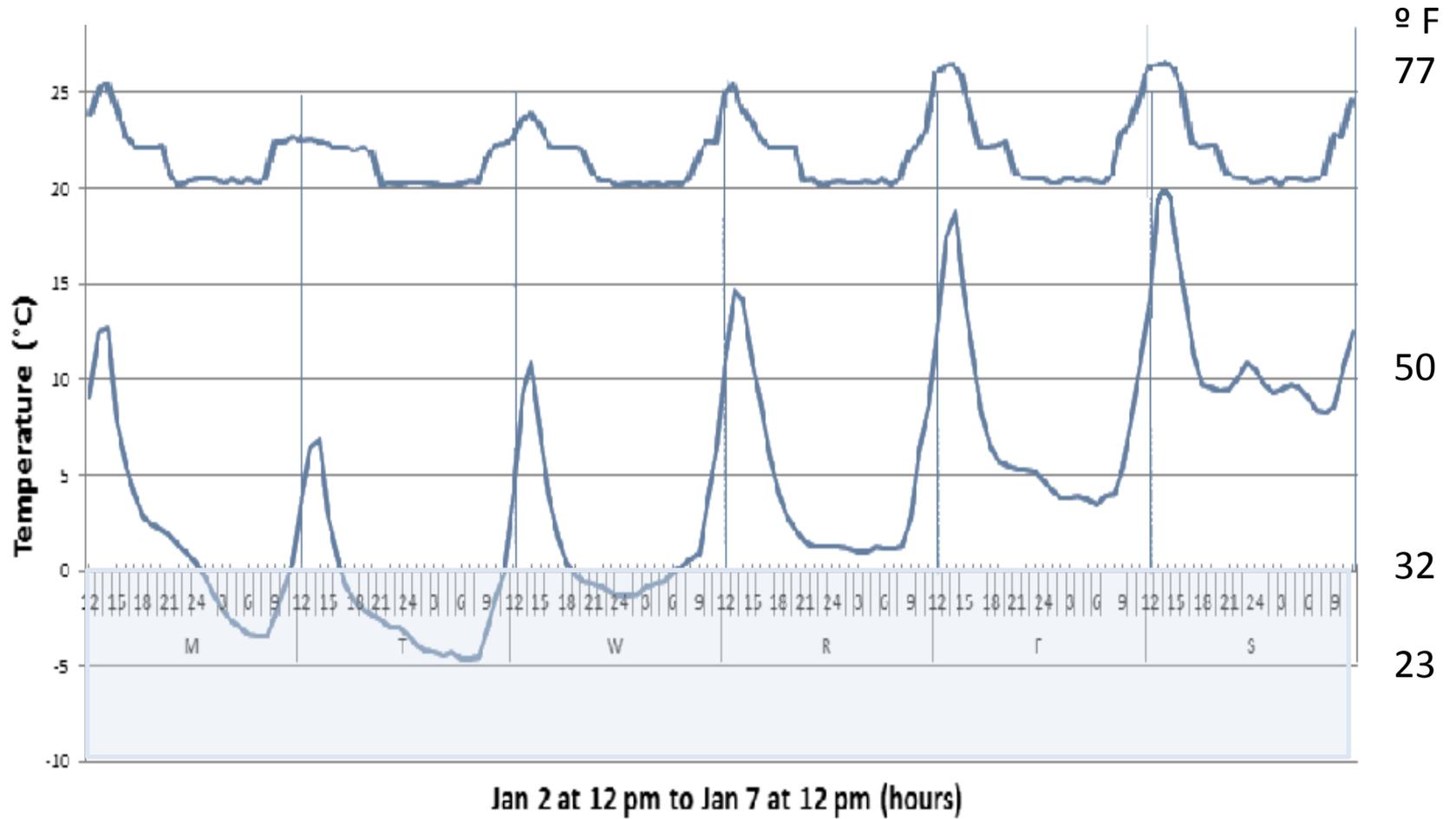
Citra FL – 2012 Winter

E.benthamii





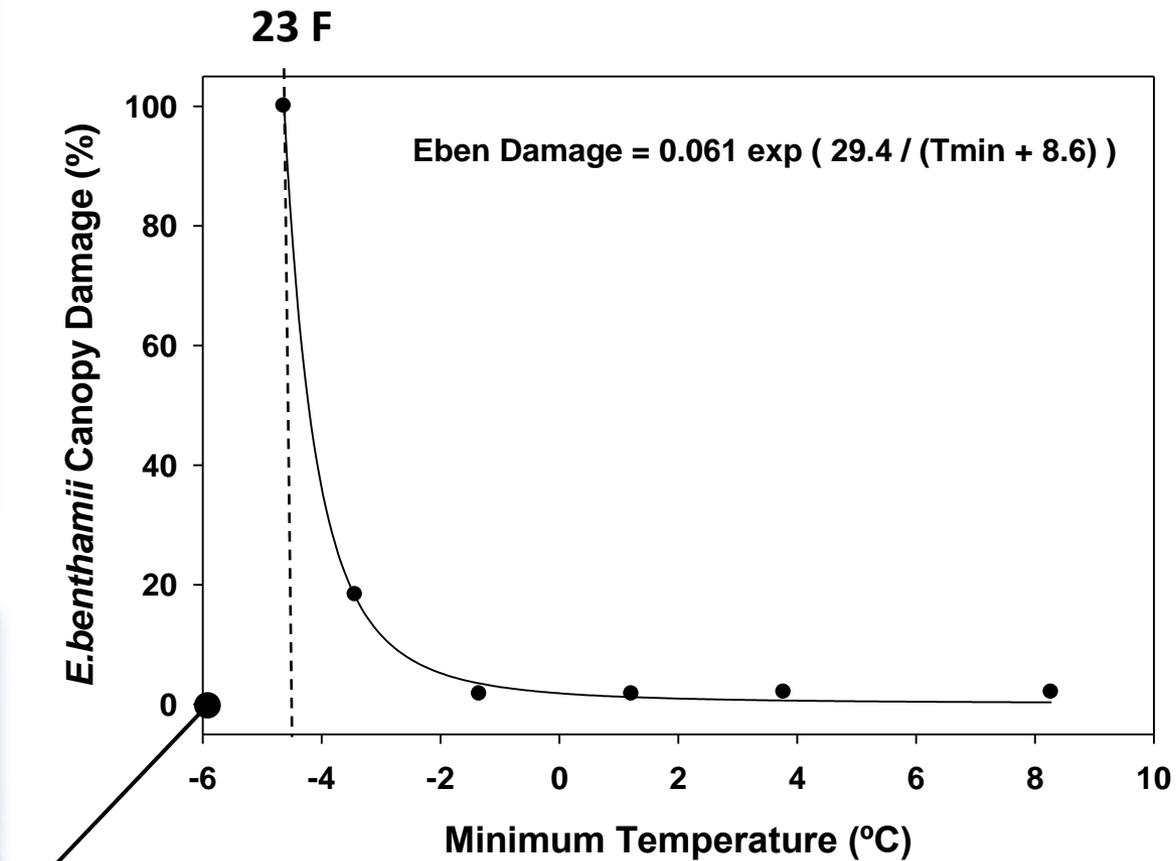
Jet-Stream front – First week of January 2012



Greenhouse



Outside



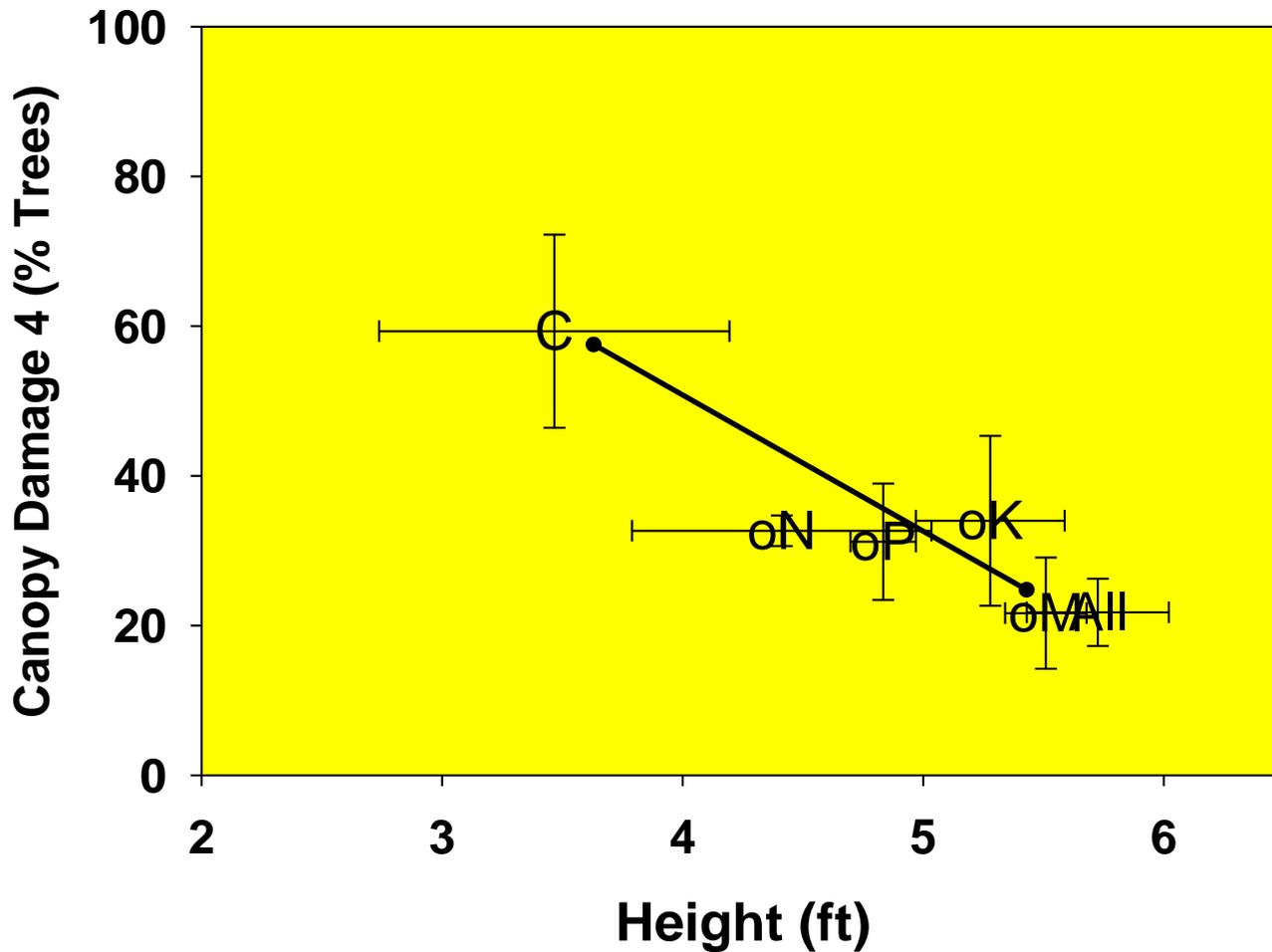
E. benthamii requires acclimatization
by dropping temperatures

Allendale SC (*E. benthamii*) – 1 year-old



Control

All Nutrients



***Eucalyptus* trial in Raleigh NC
December 26th 2010**



E.camaldulensis

E.benthamii

FPC – RW24

Eucalyptus trial in Raleigh NC

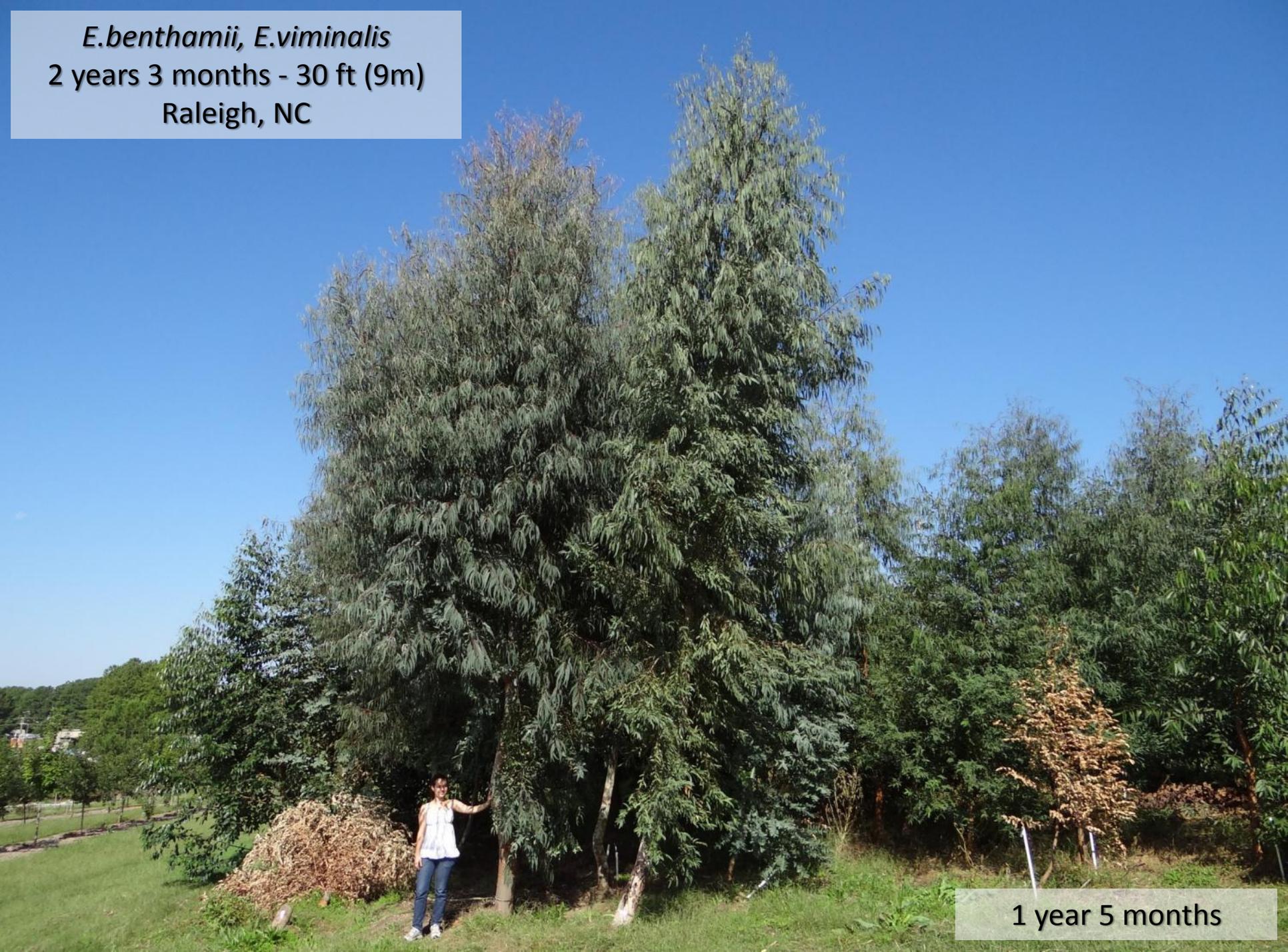
January 3rd 2011



E.camaldulensis

E.benthamii

E.benthamii, *E.viminalis*
2 years 3 months - 30 ft (9m)
Raleigh, NC

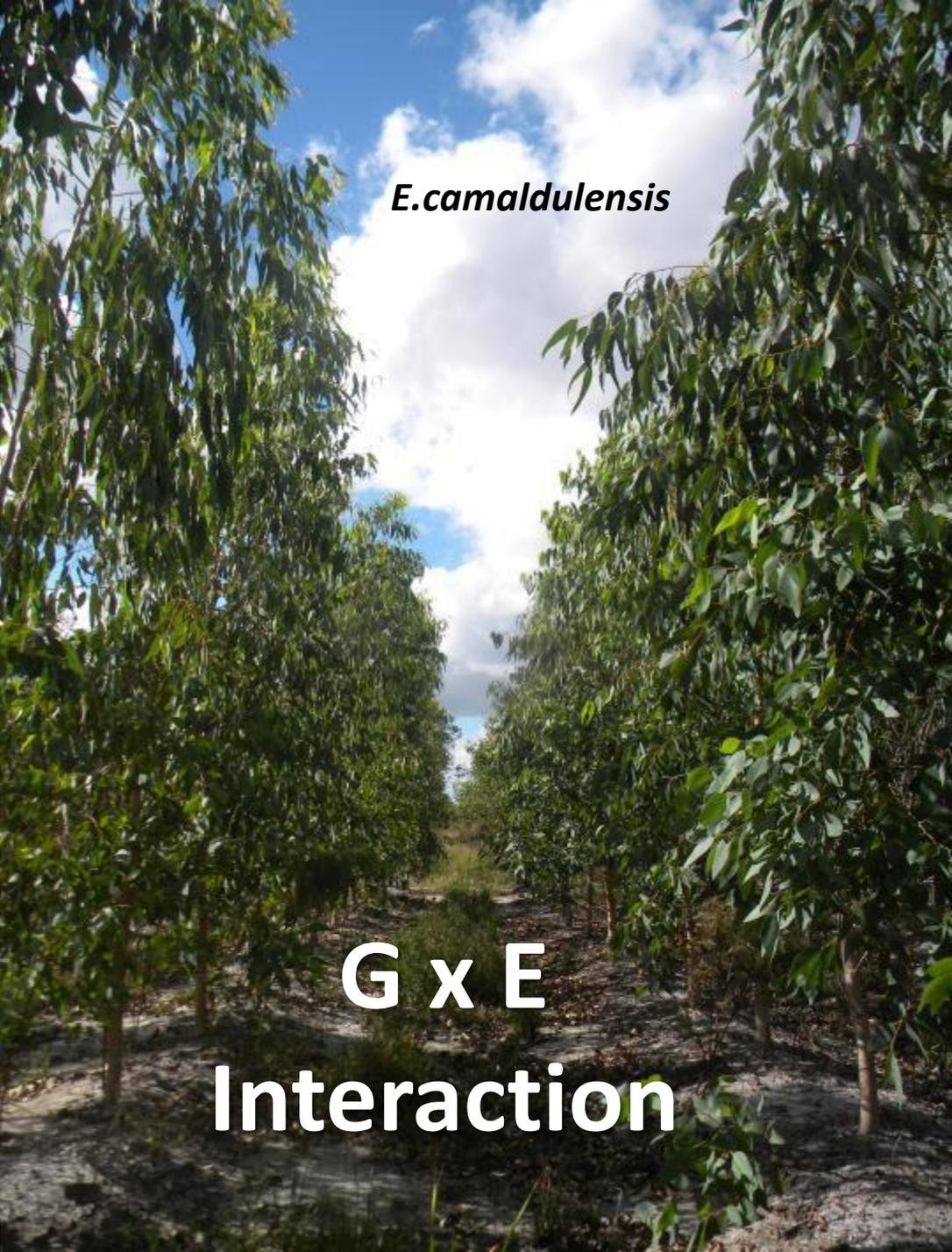


1 year 5 months

E.benthamii
Palmdale, FL

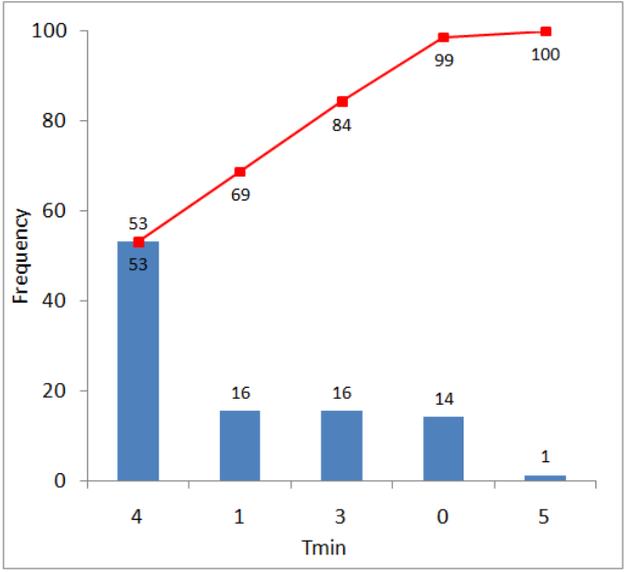
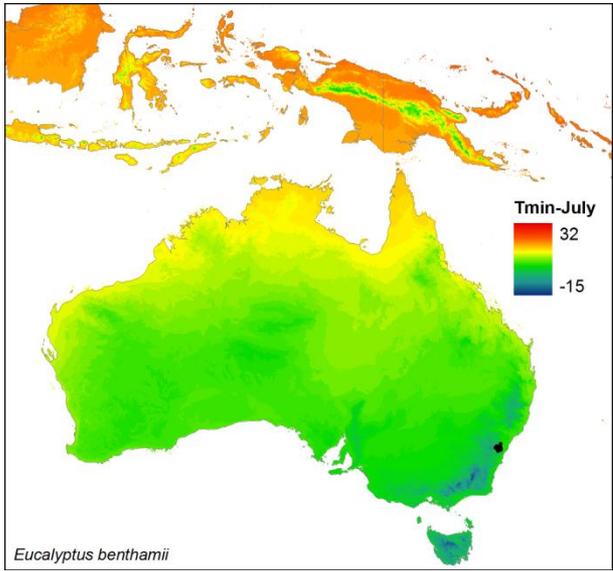


E.camaldulensis



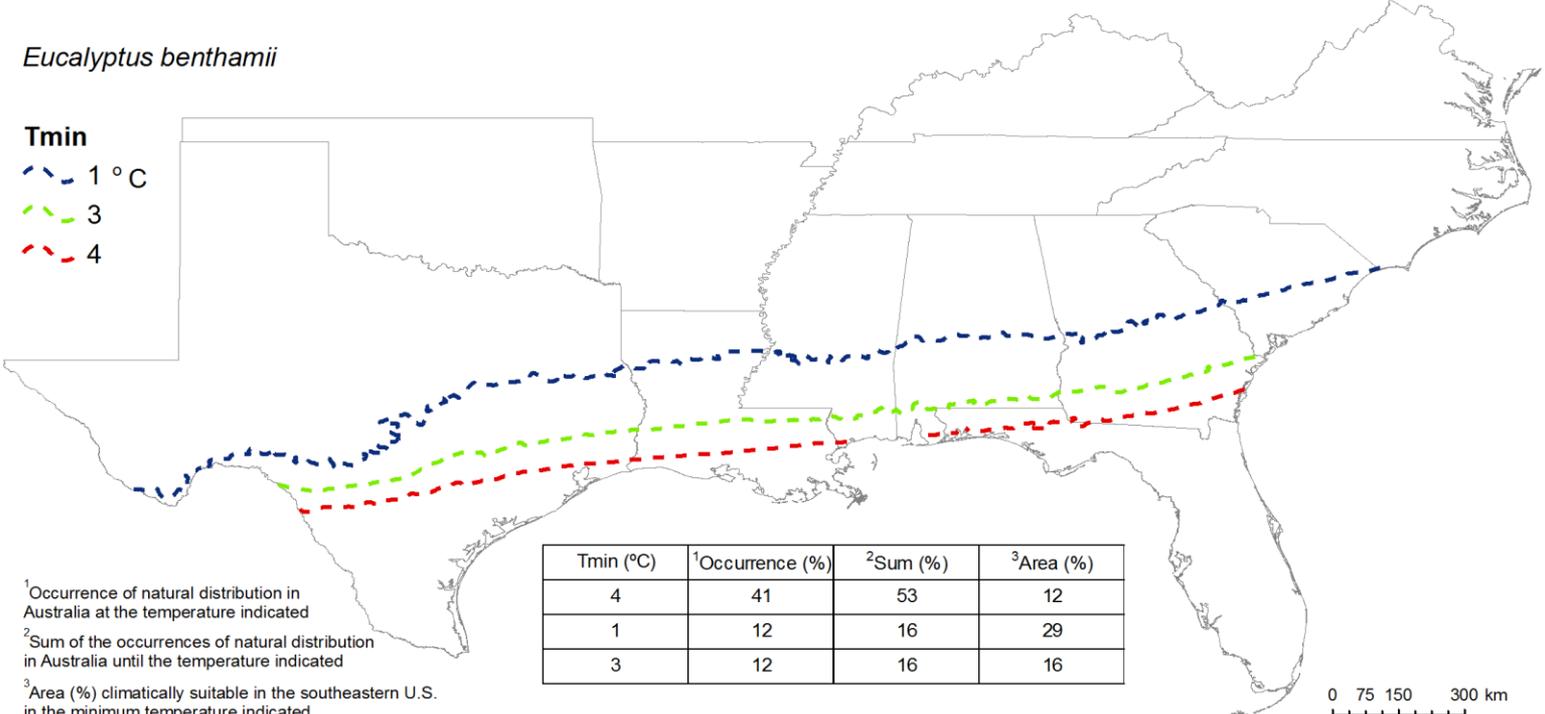
G x E
Interaction

Eucalyptus benthamii



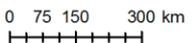
Eucalyptus benthamii

Tmin
 - - 1 °C
 - - 3
 - - 4



¹ Occurrence of natural distribution in Australia at the temperature indicated
² Sum of the occurrences of natural distribution in Australia until the temperature indicated
³ Area (%) climatically suitable in the southeastern U.S. in the minimum temperature indicated

| Tmin (°C) | ¹ Occurrence (%) | ² Sum (%) | ³ Area (%) |
|-----------|-----------------------------|----------------------|-----------------------|
| 4 | 41 | 53 | 12 |
| 1 | 12 | 16 | 29 |
| 3 | 12 | 16 | 16 |







MWV Site – South Carolina
7 years-old
9.4 ton/ac/year



South Carolina



IBSS Project (Biofuels)

USDA FS

Water Use and WUE

of *E.benthamii* x Loblolly Pine



Brasil

Somewhat Known Species – Regions A, B, C

*E.badjensis, E.benthamii, E.dorrigoensis,
E.gunnii, E.macarthurii, E.nitens, E.viminalis*

Somewhat Known Species – Region D

E.grandis, E.camaldulensis

Potential New Species

*E.angophoroides, E.baueriana, E.blakelyi,
E.bridgesiana, E.caleyii, E.camphora, E.elata,
E.glaucescens, E.kartzoffiana, E.leucoxylon,
E.michaeliana, E.quadrangulata, E.scoparia*



Very, very, very preliminary Conclusions

- *The Regionwide Study is capturing the climatic effects*
- *Each winter is a different case (4 more to come...)*
- *There is “probably perhaps” suitable species for the SE US*
- *Strong G x E Interaction: Region Specific*
- *Time for Silviculture and Breeding Actions (?)*

An aerial photograph showing a landscape with a dirt road on the left, a large cleared area in the middle, and a young plantation of trees in the foreground. The background is a dense forest. The text 'Merryville LA 1.5 yr' is overlaid on the dirt road.

Merryville LA 1.5 yr

Thanks!