Preliminary analyses of the influence of cold and climate on American chestnut growth

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Chestnut Blight

- The **primary factor** limiting the health and productivity of American chestnut

- A **variety of approaches** are being pursued by TACF and their cooperators to address this:

TACF's 3BUR approach:

BREEDING (B1)

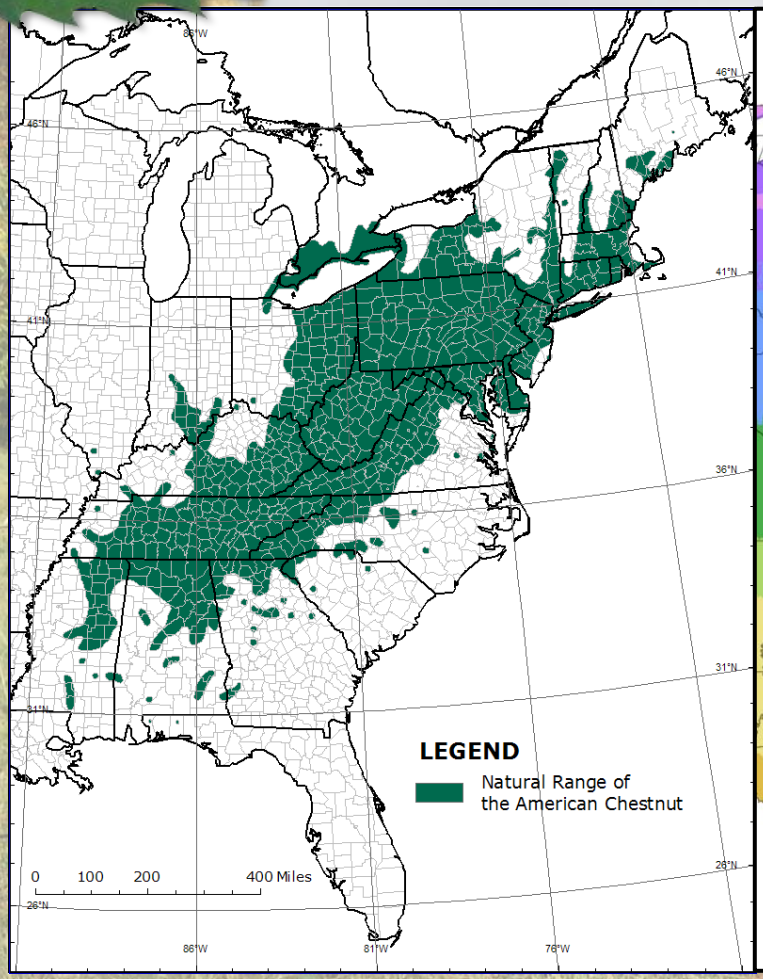
BIOTECHNOLOGY (B2)

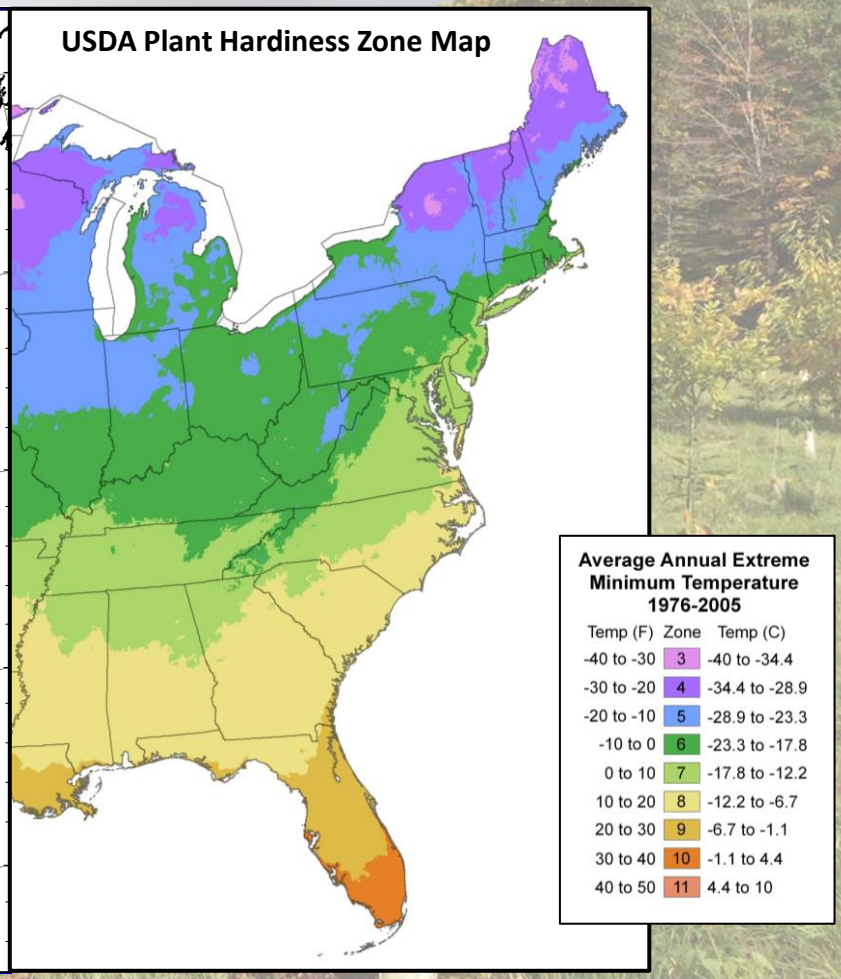
BIOCONTROL (B3)

United for Restoration

Local Adaptation

Zone 8a -12 °C (10.4 °F)
Zone 5a -29 °C (-20.2 °F)
17 °C difference (~30 °F)





Limited cold tolerance and winter injury

Restoration Ecology
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RESEARCH ARTICLE

Inadequate Cold Tolerance as a Possible Limitation to American Chestnut Restoration in the Northeastern United States

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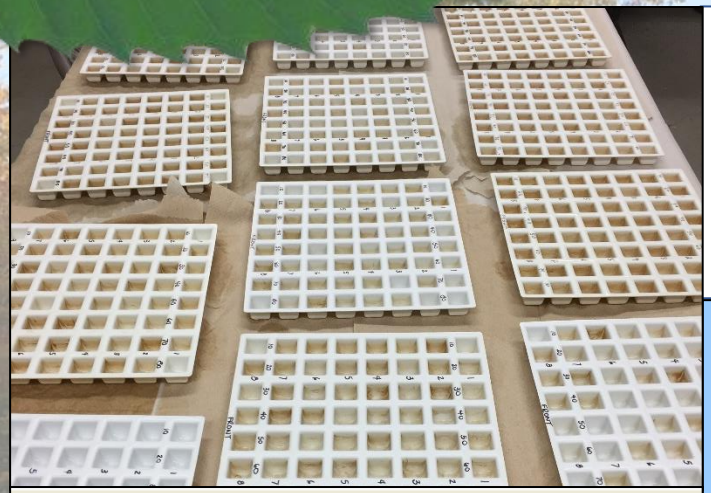
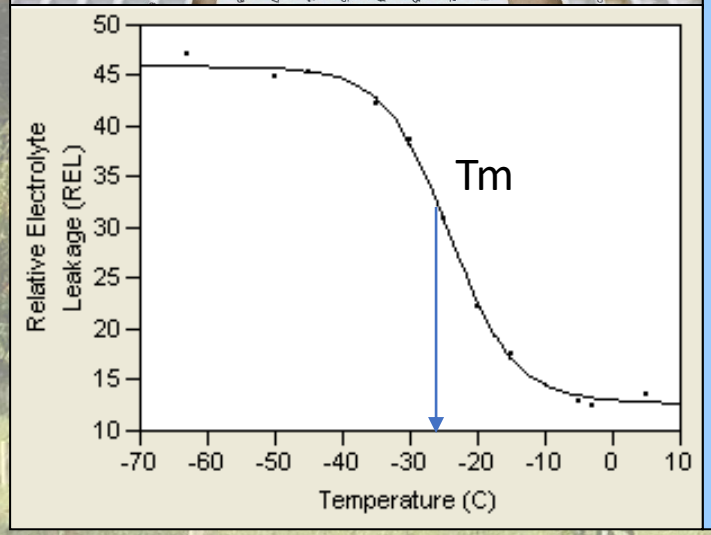
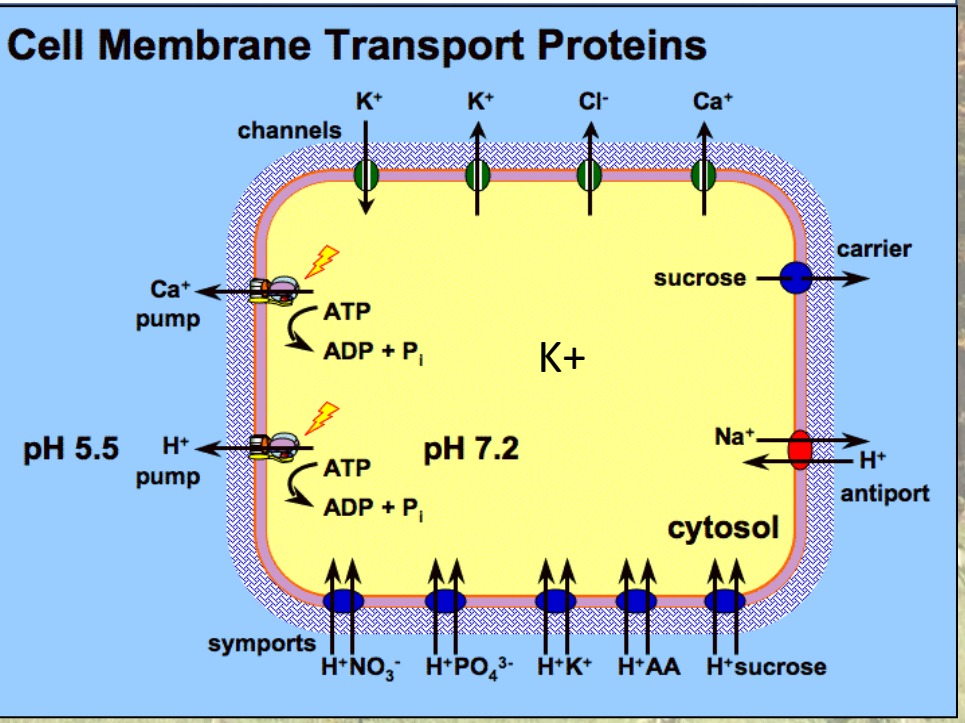
- Woody shoots
- Seasonal measurements
- Controlled laboratory freezing
- Field injury
- Chestnut, sugar maple, red oak

Laboratory cold tolerance

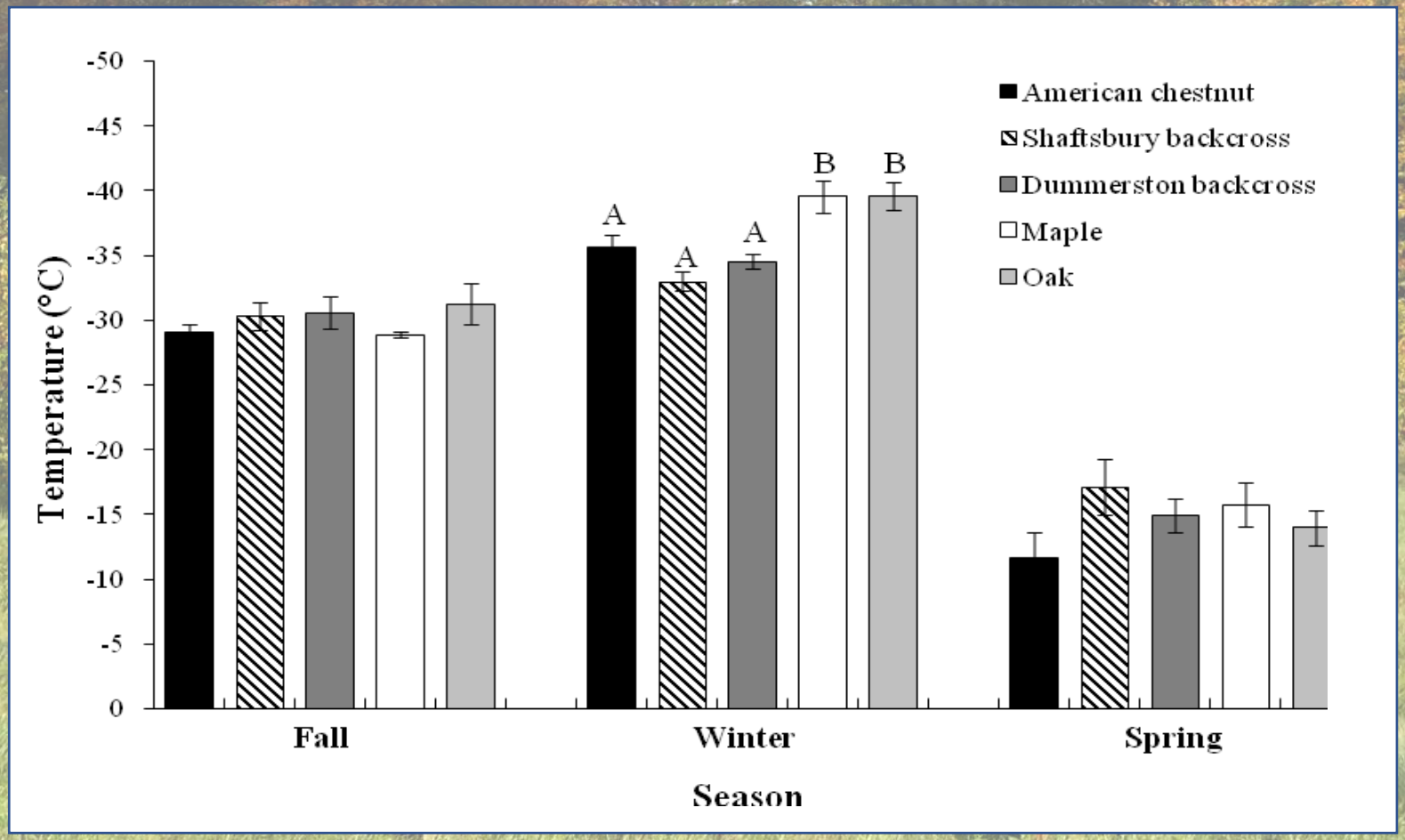


- Shoots chopped into 5-mm segments
- 15-17 test temperatures - from +5°C to –90°C
- Damage = ↑Relative Electrolyte Leakage (REL)





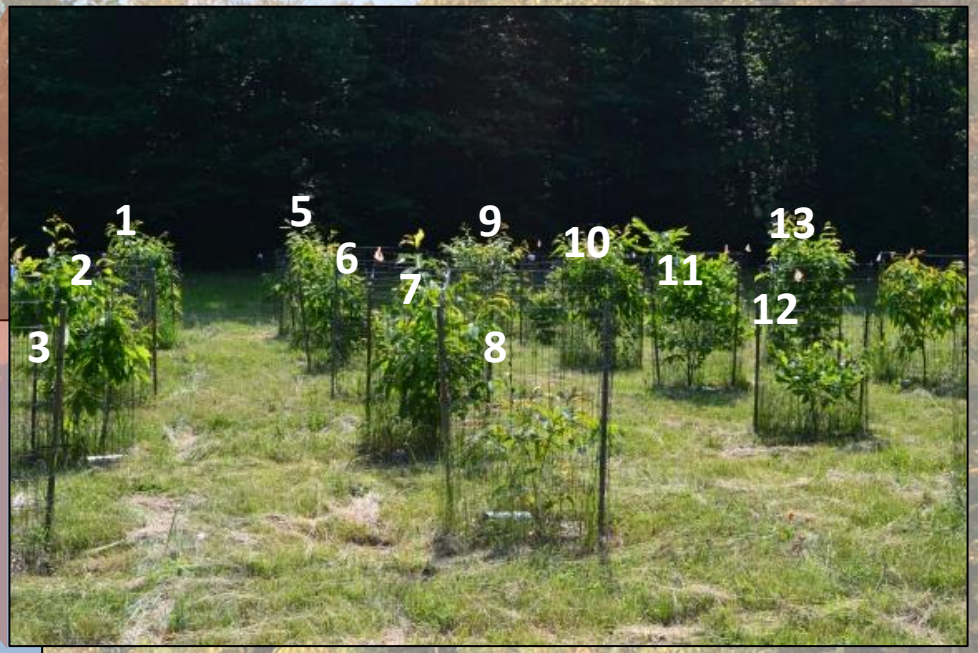
Shoot cold tolerance



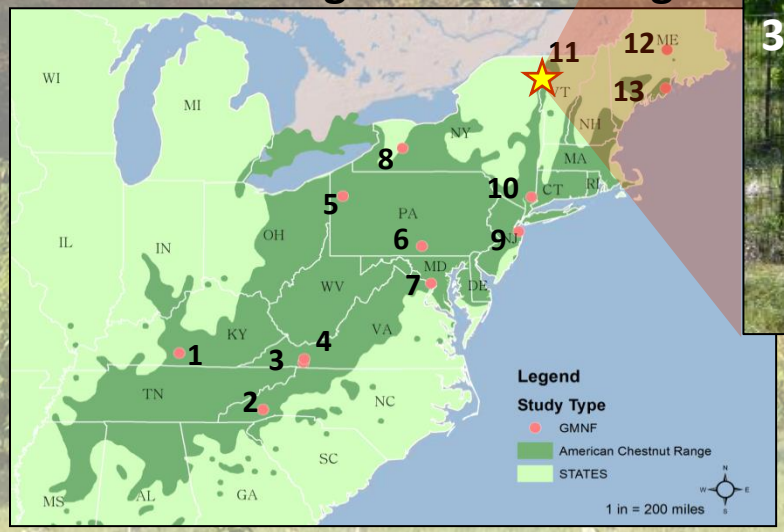
Winter injury

Provenance test

Common garden



Sources throughout native range



First and only for American chestnut

Tom Saielli TACF

Seed source distribution

Code	Location (County, State)	Latitude	Longitude	Elevation (m)	Temperature zone
KY1	Metcalfe County, KY	37°00'16" N	85°37'34" W	269	Warm
MD1	Montgomery County, MD	38°57'53" N	77°05'33" W	100	Warm
NJ1	Monmouth County, NJ	40°24'09" N	74°06'14" W	20	Warm
NC1	Jackson County, NC	35°22'21" N	82°47'29" W	1387	Moderate
NY1	Westchester County, NY	41°19'41" N	73°41'10" W	94	Moderate
NY2	Wyoming County, NY	42°37'44" N	78°03'17" W	417	Moderate
PA1	Franklin County, PA	39°59'38" N	77°23'55" W	600	Moderate
PA2	Mercer County, PA	41°20'58" N	80°04'58" W	384	Moderate
VA1	Smyth County, VA	36°49'40" N	81°25'49" W	1036	Moderate
VA2	Smyth County, VA	36°51'55" N	81°26'10" W	1041	Moderate
ME1	Piscataquis County, ME	45°09'35" N	69°04'58" W	101	Cold
ME2	Knox County, ME	44°10'55" N	69°08'09" W	68	Cold
VT1	Chittenden County, VT	44°31'39" N	73°12'11" W	57	Cold

Green Mountain National Forest, VT

USDA Forest Service, TACF and the University of Vermont - establish on the Green Mountain National Forest, VT in 2009

Monitoring: e.g., winter injury and much more

Spring phenology

CHESTNUT PHENOLOGICAL STAGES

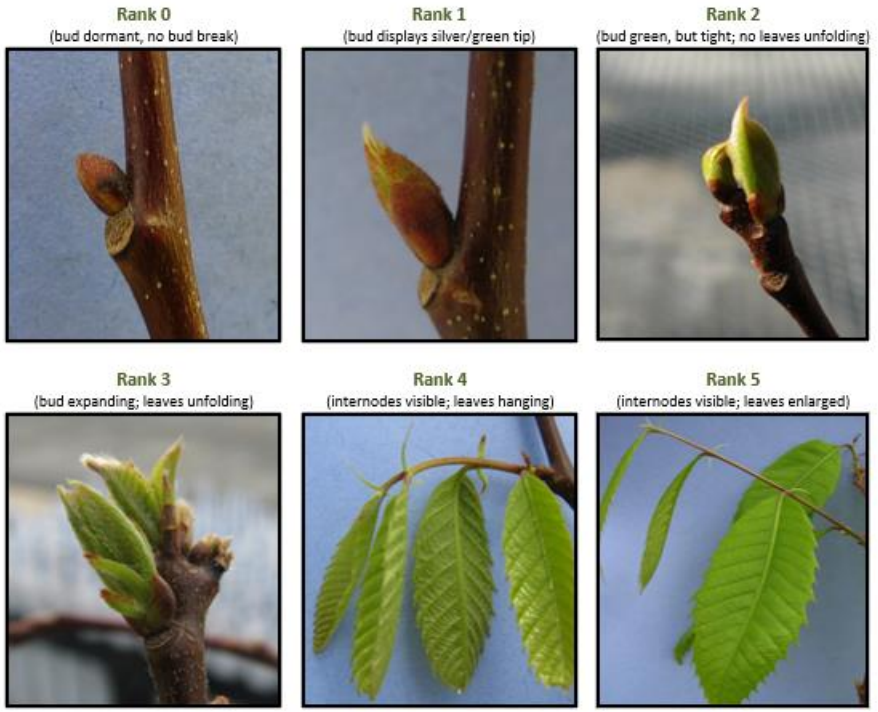
The number to the left of the decimal denotes the most advanced phenological bud break that is occurring on the tree according to these categories:

0-Bud dormant, no sign of breaking
1-Bud displays silver/green tip
2-Bud green, but tight, no leaves unfolding
3-Bud expanding, leaves unfolding from bud
4-Internodes visible, leaves hanging but not enlarged
5-Internodes visible, leaves enlarged

3.5

Example: a seedling with terminal buds at stage 3 with 50% of the buds to this stage would receive ranking of 3.5. The phenological stage of the tree's leader bud should also be noted separately (or in the case of dieback or deer browse, the uppermost bud).

The number to the right of the decimal indicates the percentage of buds on the seedling (to the nearest 10%) that have developed to this stage.



Spring phenology rankings for American chestnut (adapted from West, N.E. and R.W. Wein. 1971. A plant phenological index technique. BioScience 21(3): 116-117).

Winter injury and spring frost

Winter shoot injury – expected
Spring frost injury – not expected

Winter

Spring frost

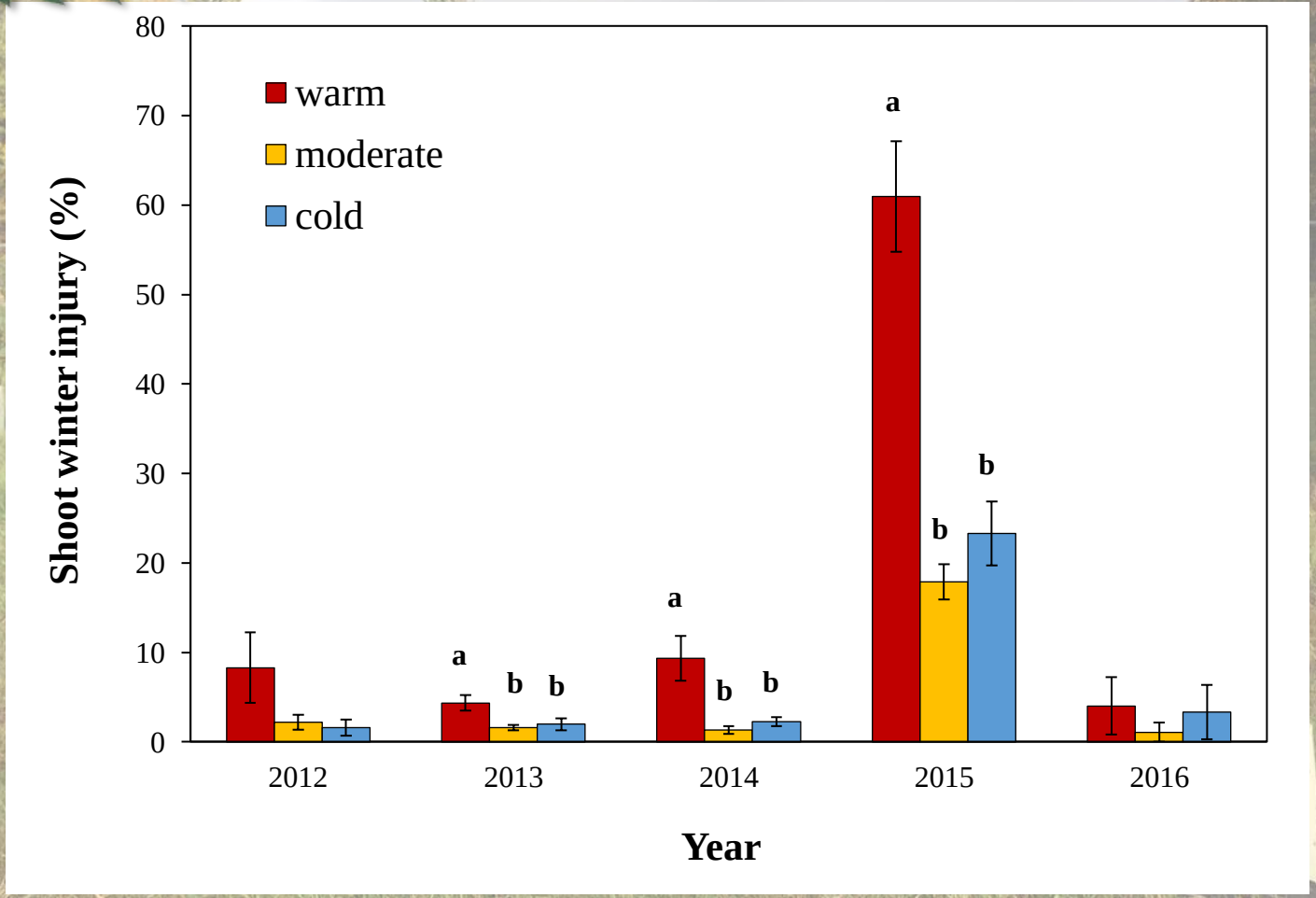
Tree ring analysis

Coring tree with increment borer

Measuring tree ring widths

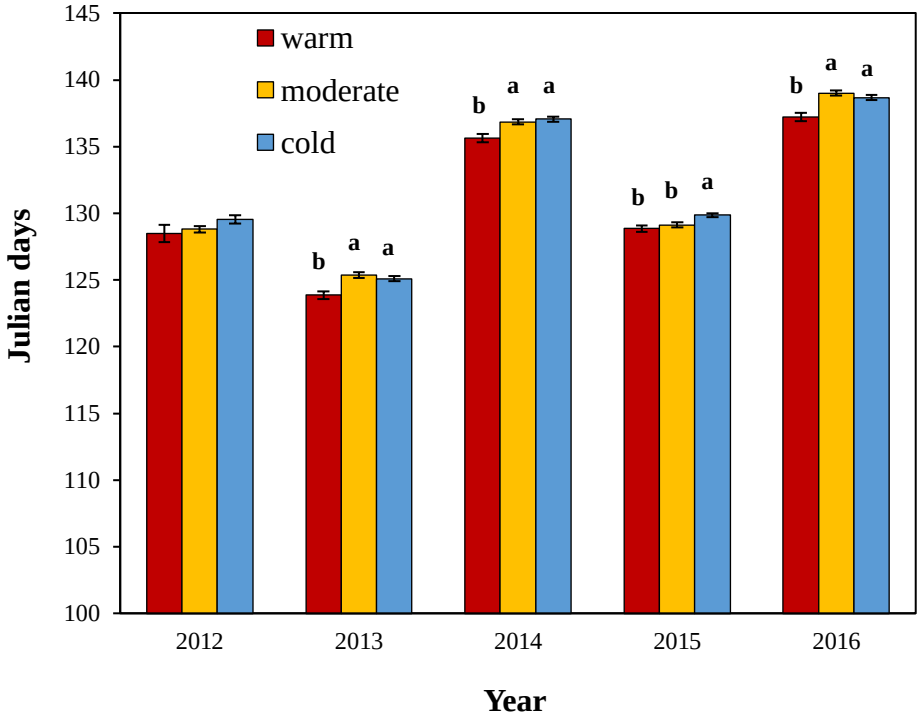
- **Growth levels and trends**
- **Correlations between growth and cold injury / penology**
- **Correlations between growth and climate (temperatures and moisture)**

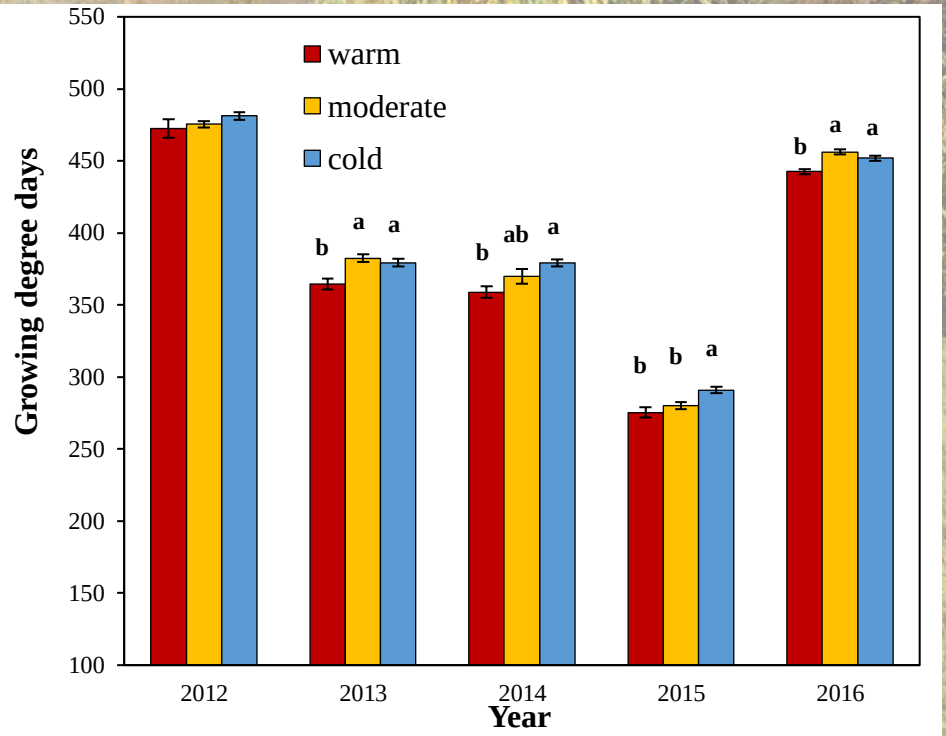
Shoot winter injury



Spring phenology

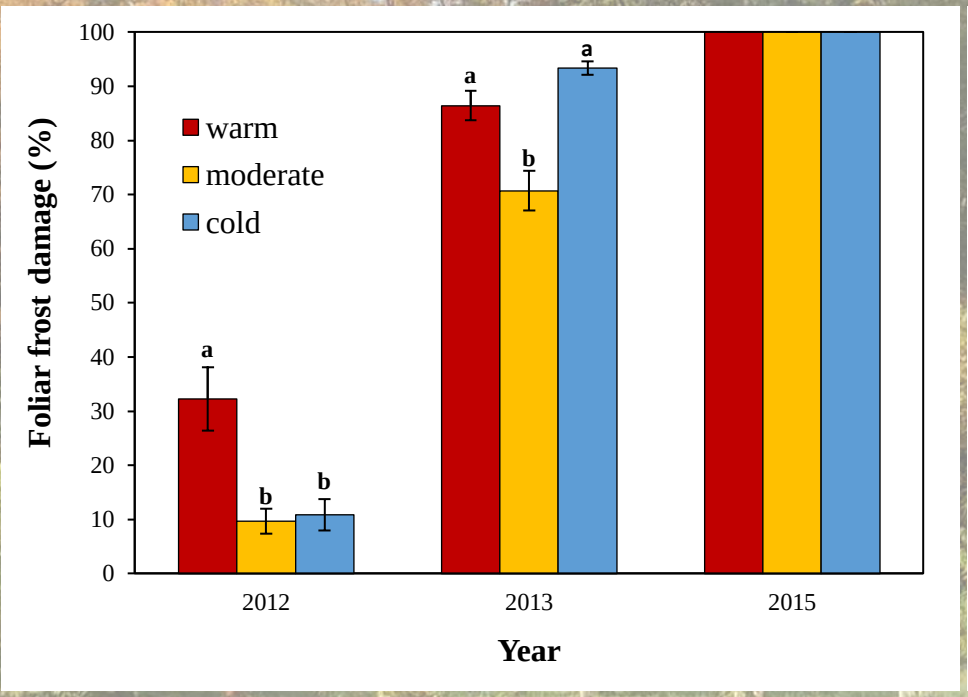
Budbreak = 3.5 or 50% of buds reach stage 3

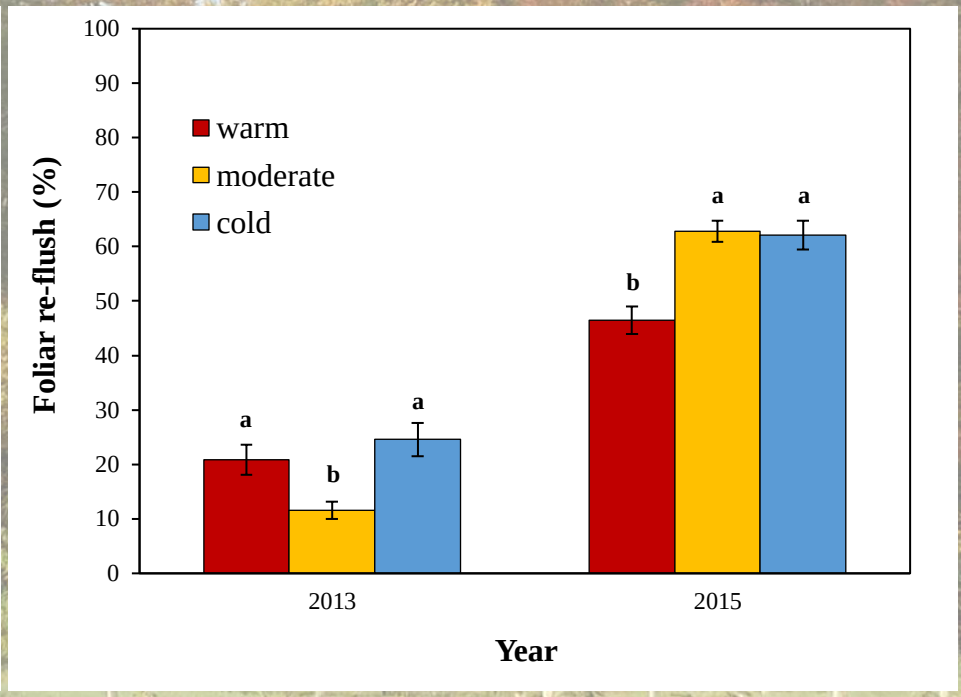




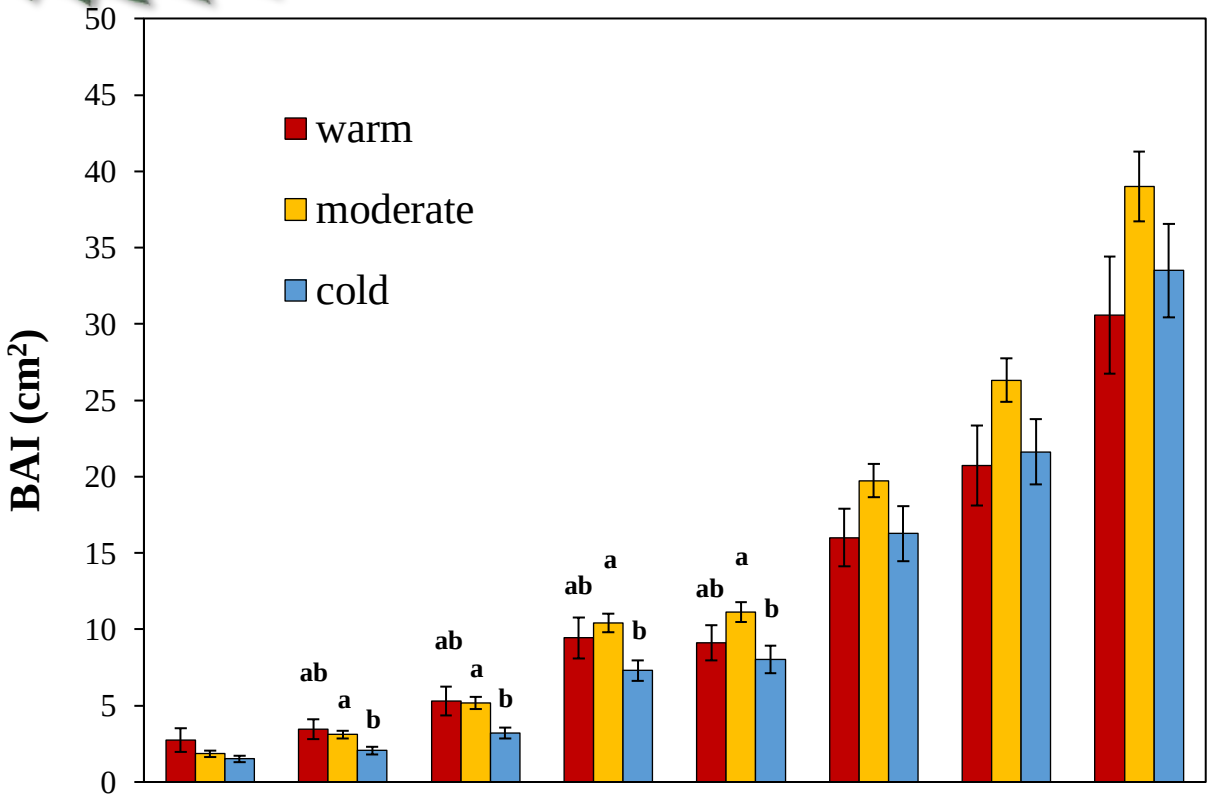
Growing degree days = accumulation of mean daily temperatures above 5 °C from January 1 until budbreak.

Spring frost damage





Basal area increment



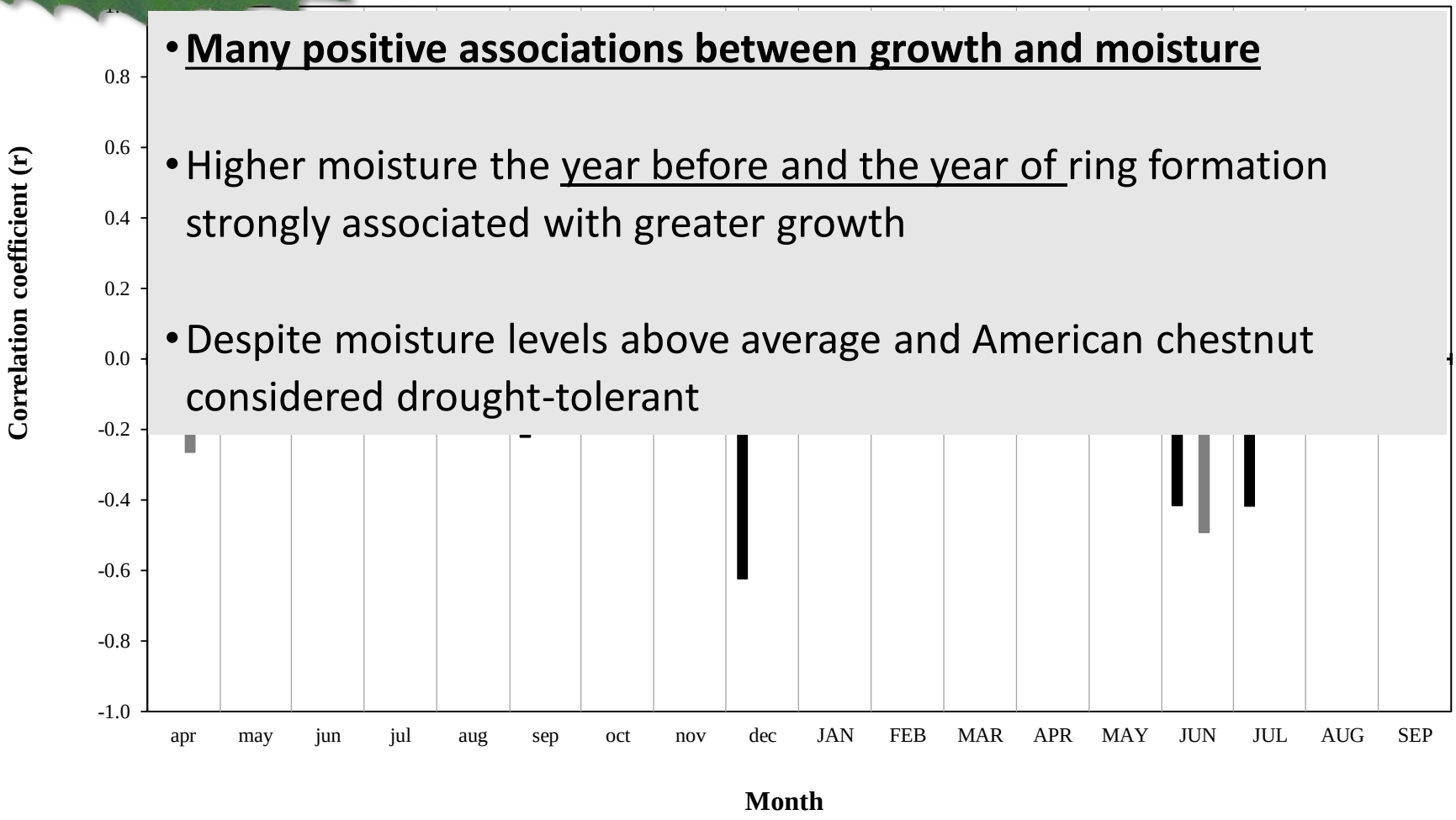
Factors associated with growth

- **↑ Growth with earlier budbreak** – especially in trees from the warm temperature zone
- **Foliar frost injury ≠ altered growth**
- **↓ Growth with winter shoot damage** - especially following significant shoot loss (warm temperature zone)

Precipitation correlations

Correlations with Moisture

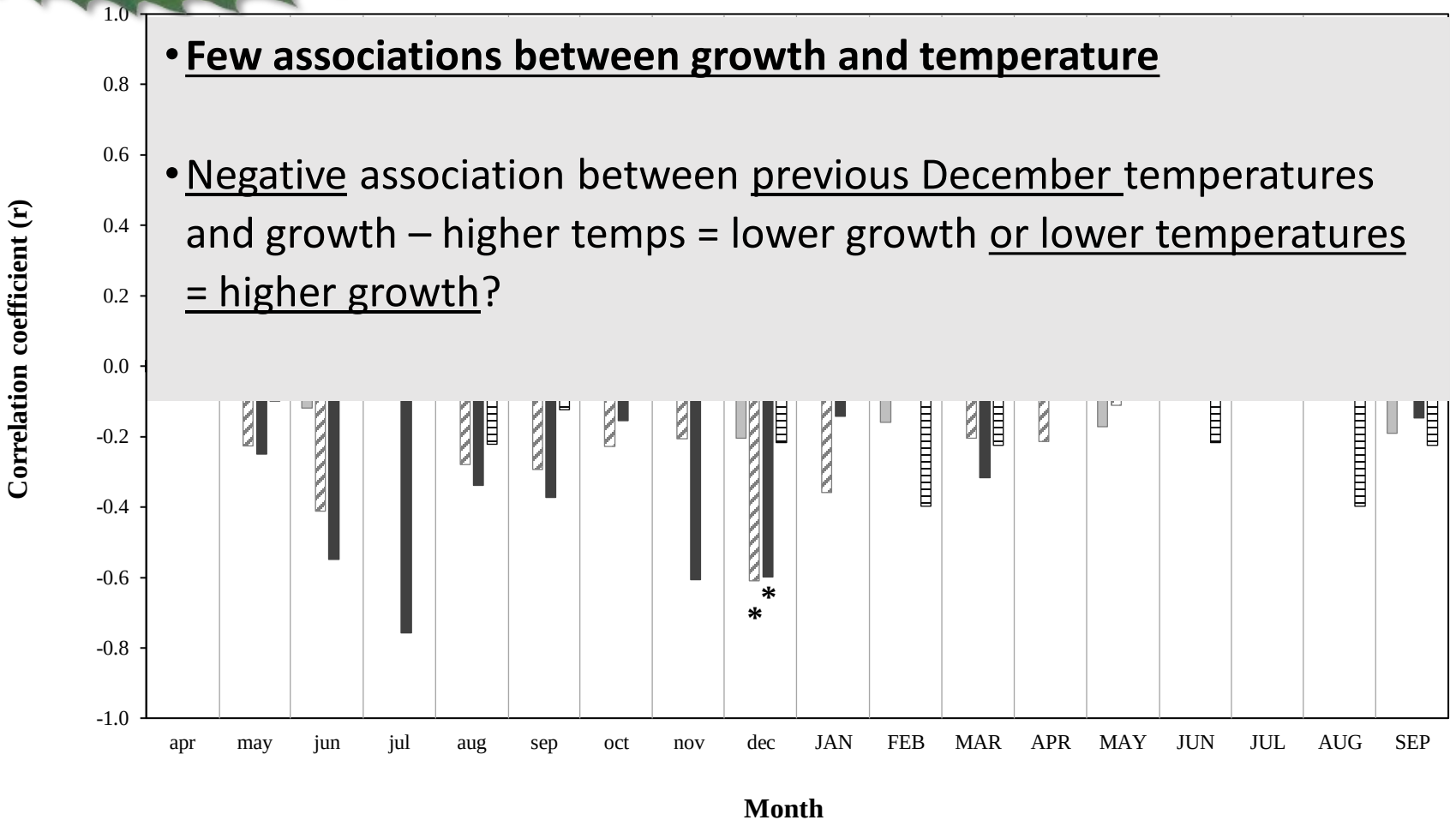
- **<u>Many positive associations between growth and moisture</u>**
- Higher moisture the <u>year before and the year of</u> ring formation strongly associated with greater growth
- Despite moisture levels above average and American chestnut considered drought-tolerant



Temperature correlations

Correlations with Temperature

- **Few associations between growth and temperature**
- Negative association between previous December temperatures and growth – higher temps = lower growth or lower temperatures = higher growth?

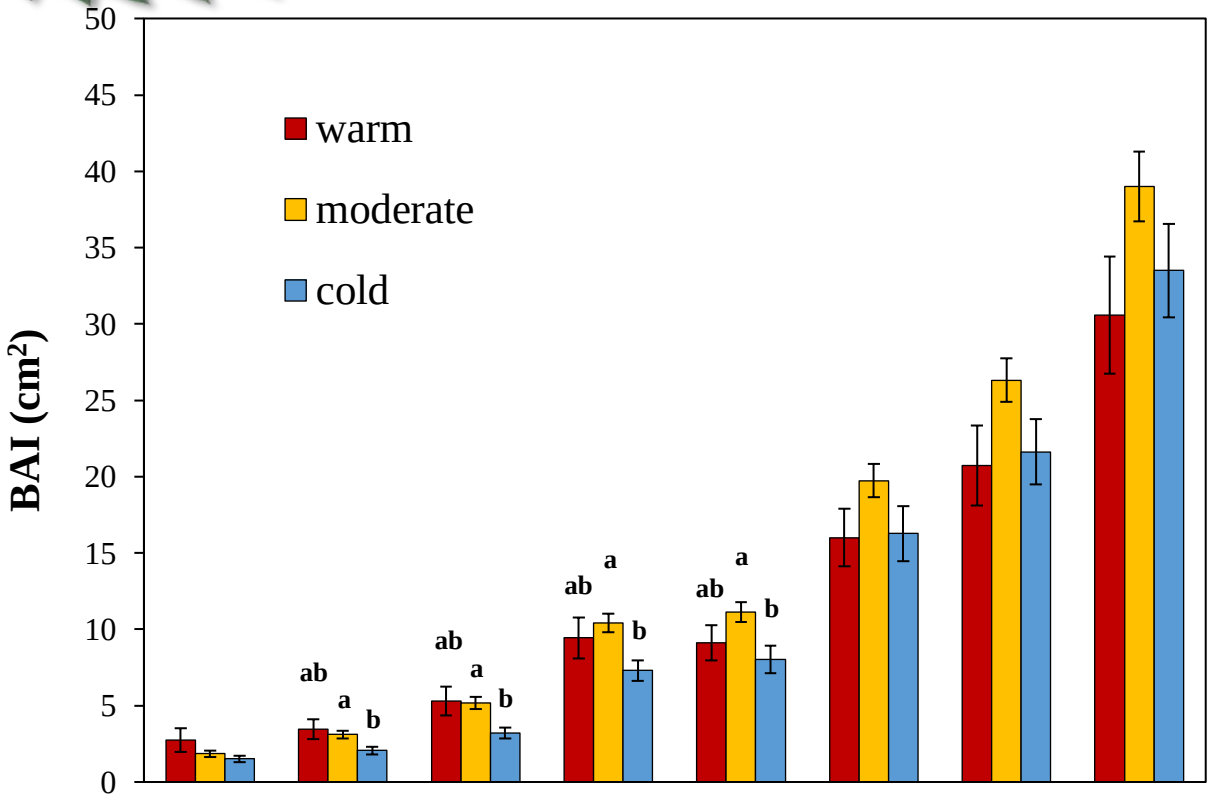


Growth of other Vermont tree species

Overall productivity of trees was exceptional – even at this northern edge of the species' range and with winter shoot and spring frost injury

Species	BAI (cm^2)
American chestnut	**34.0**
Sugar maple	17.7
Red maple	18.5
Yellow birch	17.3
American beech	16.2
Red oak	26.2
Eastern hemlock	26.2
Eastern white pine	40.7

Basal area increment



Conclusions

- Regardless of genetic source, American chestnut is vulnerable to both winter shoot freezing injury and spring leaf frost damage

- Level of vulnerability varied among genetic sources - warm temperature zones generally having the greatest risk of damage

Conclusions

- Genetic sources sometimes differed in growth, but differences modest compared to the high overall growth potential

- Growth was generally higher with a lengthened growing season (earlier budbreak/leaf out), but was depressed following elevated shoot winter injury

Conclusions

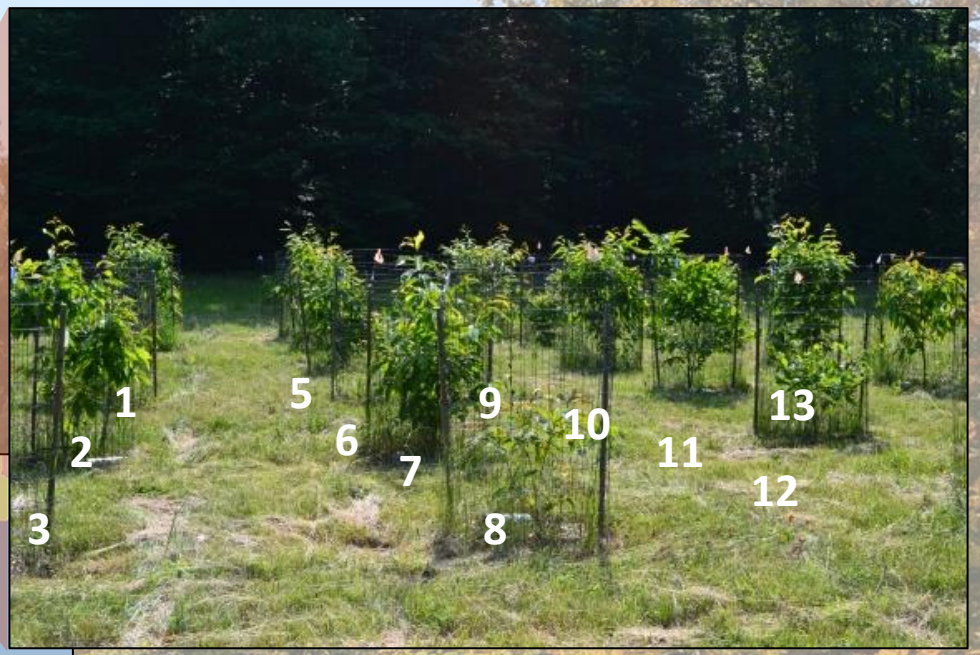
- **Climate influences**- highlight the vulnerability to cold damage and the positive influence of adequate moisture availability on American chestnut growth

- **Genetic influences** – e.g., warm temperature zone trees more cold sensitive, broke bud earlier and tended to have high growth, cold zone trees grew less but had lower winter injury

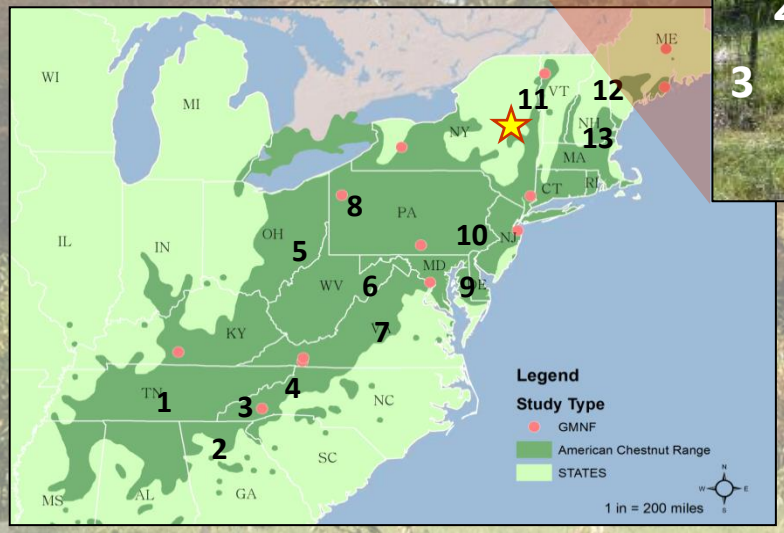
- Moderate temperature zone tended to have low foliar frost and shoot winter injury while also exhibiting exemplary growth

Provenance test

Common garden



Source sites throughout native range



Provenance tests with other species:
best growth for populations from 200+ miles south of planting site without significant increase in freezing injury Wright 1976

Why? Tradeoff in using resources for growth versus protection?

Perspective

- Many interesting associations regarding the climate sensitivity of American chestnut
- However, our data has a limiter time scale (8 years for tree cores) and is based on climatic stresses and cues at only one location
- More informative to conduct the tree ring and climate analyses for older trees (more years of climate exposure) and over a broader geographic scales to better characterize the breadth of climate sensitivity and response for American chestnut

Questions?