Differences in ecophysiology and climate responses among subspecies and seed provenances of big sagebrush: Implications for seed selection

Matt Germino

Supervisory Research Ecologist, Great Basin LCC Scientist

-and-

Jess Vanderveen, Lar Svenson

USGS Forest and Rangeland Ecosystem Science Center, Boise

Bryce Richardson *USFS, Rocky Mountain Research Station, Provo*

Krista Shellie *USDA ARS, Parma ID*

Nancy Shaw *USFS, Boise*

Funding: GBNPSIP, USGS

PROGRESS AND PROSPECTS FROM AUG 2011 to PRESENT

FINDINGS SHOWN HERE ARE PRELIMINARY; ANALYSES UNDERWAY

- Rationale-justification
- The ecophysiological approach, how we are using it
- Variation among/within subspecies:
    - Climate of origin
    - Performance in the cold winter
    - Performance in the hot summer
- Correspondence of ecophysiology to taxonomic and genomic identity

Main questions, linking basic and applied

1. What are the principle changes in ecophysiological performance, and the main underlying processes (ie. limitation)?
2. How does within-subspecies variation (ie. population level) variation compare with among-subspecies variation?
3. Does the population variation relate to climate-of-origin? Do local seed sources perform better? (Wyo&Tri w/ ID= 1 or 2)
4. How do ecophysiological differences relate to establishment success, considering performance, stress response, & growth strategies?
5. Does ecophysiological variation compare well with taxonomic and genomic variation?

Approach: High-throughput (450 to 1300 plants), field-based ecophys.
Big sagebrush (*Artemisia tridentata)* subspecies:

*wyomingensis (*Wyoming)	stress, water
tridentata (basin)	growth
vaseyana (mountain)	competition, cold

Physiological performance, balance points, tradeoffs, efficiencies, thresholds, strategies:

- Survival (80% Vas, 6.5% for Tri,Wyo)
- Growth
- Growth allometrics:
  - Root:Shoot, N
  - Repro:Vegetative shoot
  - Sun-interception efficiency
    Crown: STAR (m^2 sunlit/m^2 total)
    Leaf: SLA (cm^2/g)
  - Leaf type and retention
- Water status (uptake-efflux)
- Photochemical efficiency (FvFm)
- Photosynthesis, transpiration: Water-use efficiency
- Freezing point (supercooling temp)
- Response to drought
- Response to freezing

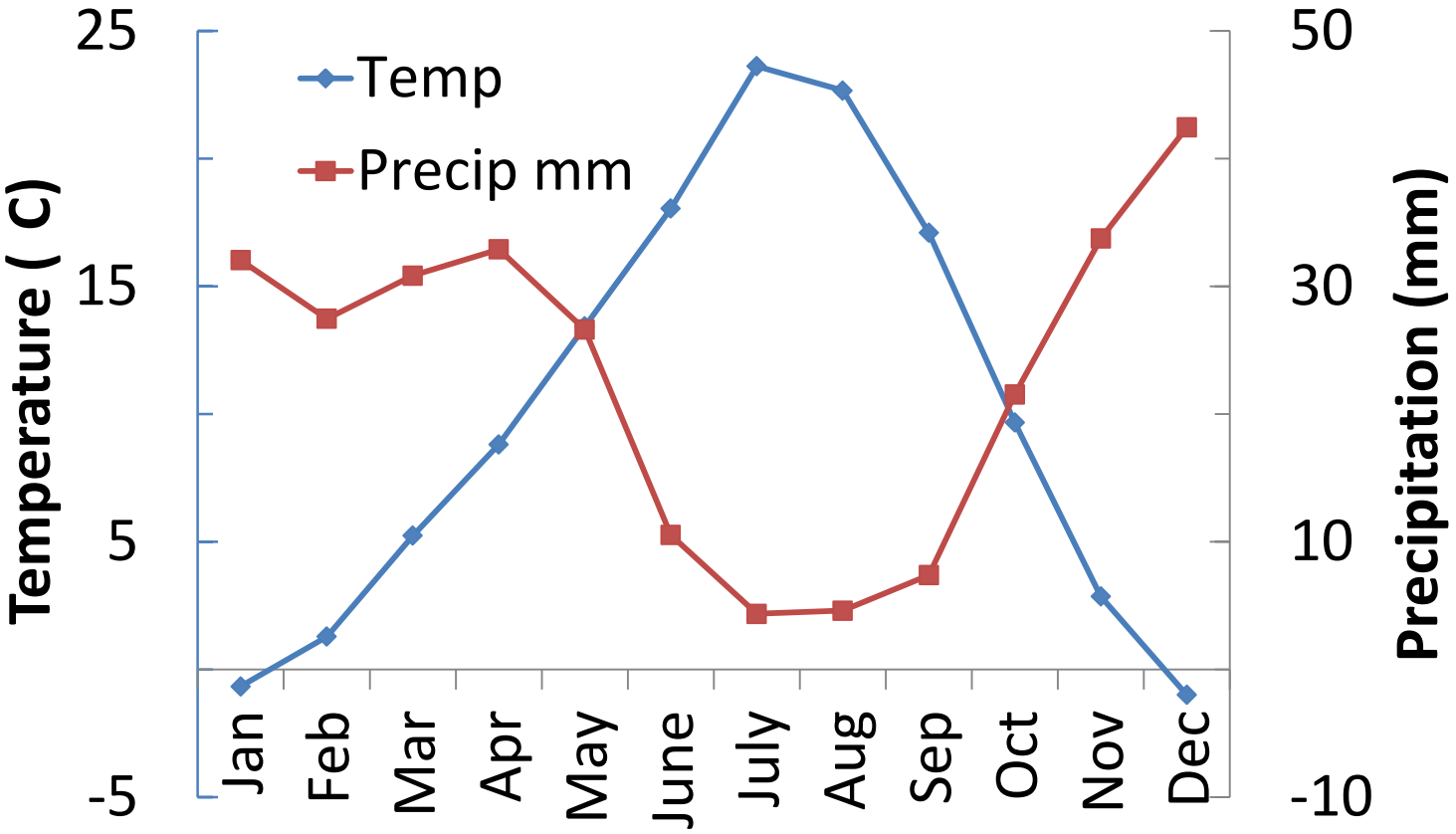
Climate diagram for Orchard ID common-garden site (from NRCS Snowtel): *Cold desert!*

Soils: 50 cm of loess/silt over a gradient of sand to pebble @ 50-180 cm

(Wet soils at 130 cm depth in late August)

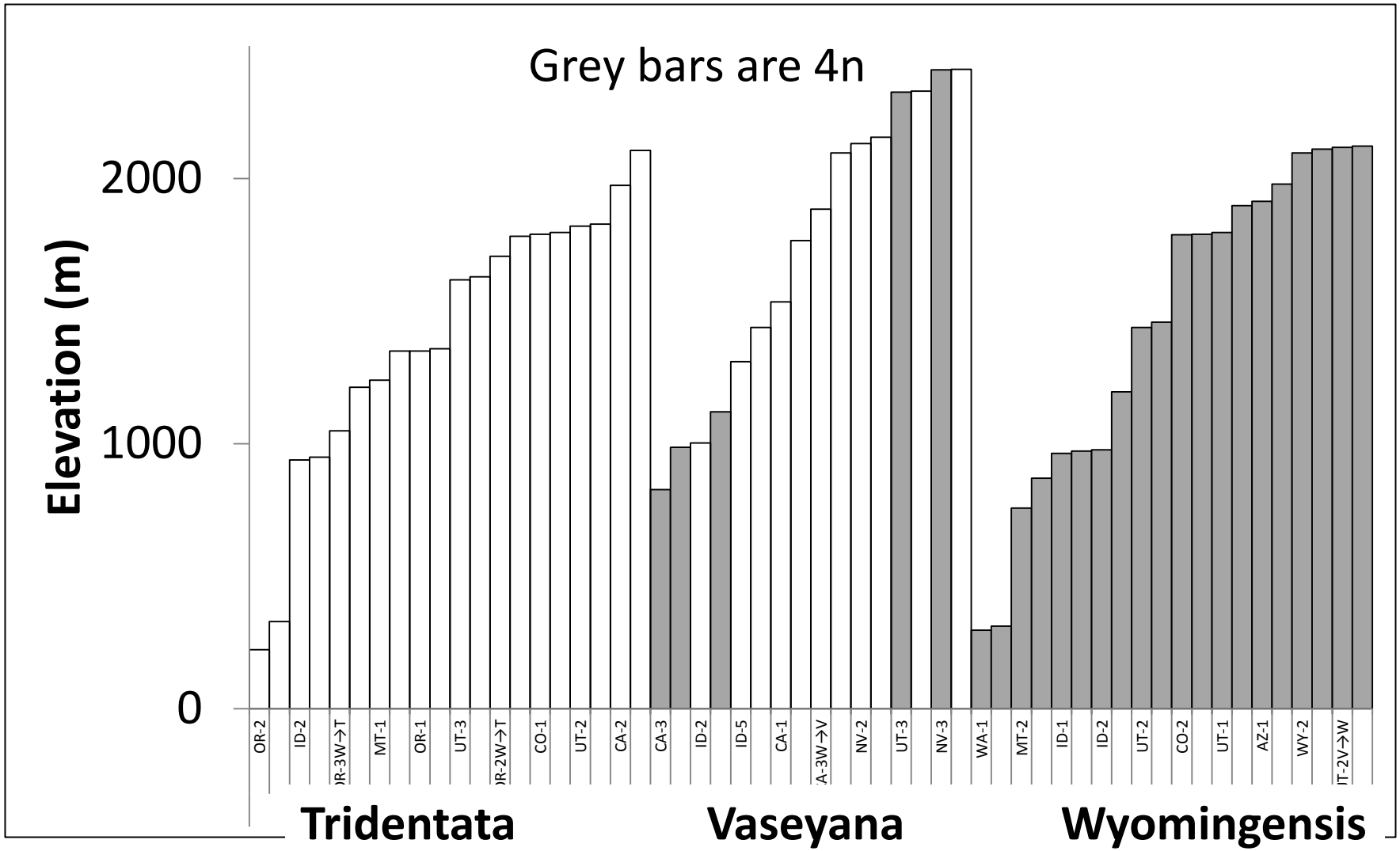
Mean annual temperature = 10.3

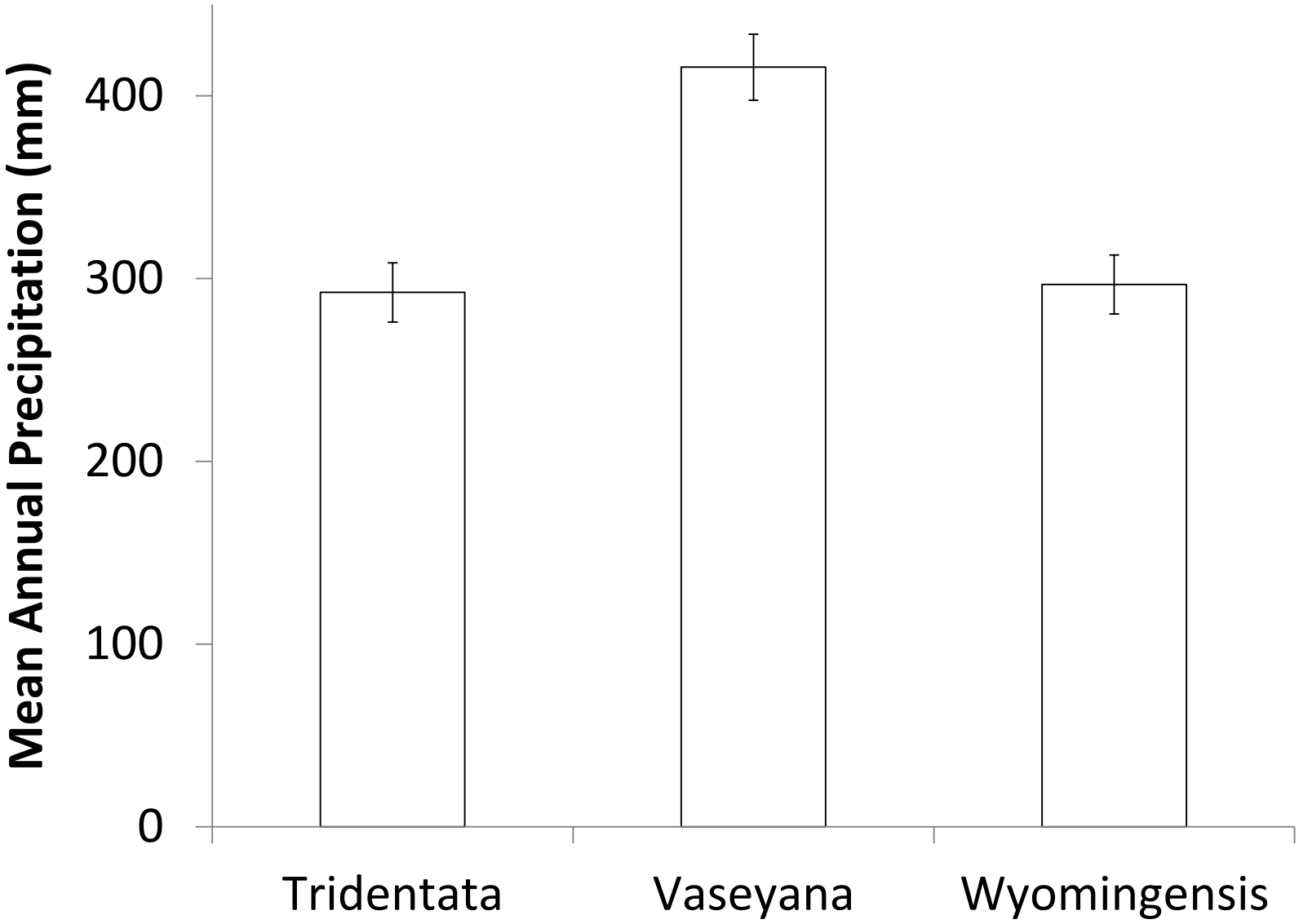
Mean annual precipitation = 333 (Rehfeldt's) or 278 mm/y (Snowtel)

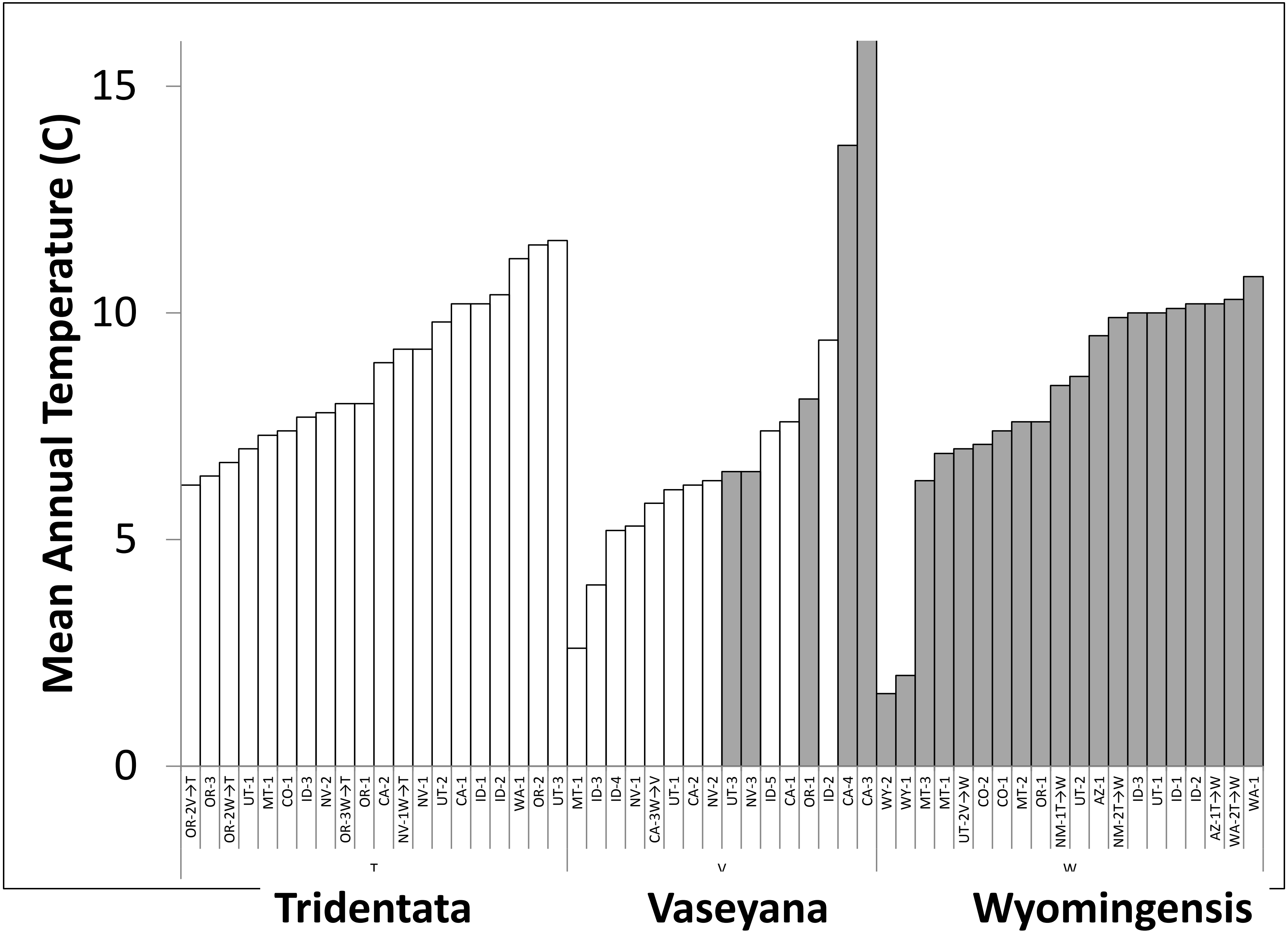


Sampling all conditions of hot/cold and wet/dry

Can differences in home-climate explain the results? First, a glimpse at climate-of-origin shows a high similarity for subspecies:




Mean Annual Precipitation (mm)
400
300
200
100
0
Tridentata
Vaseyana
Wyomingensis



Mean Annual Temperature (C)
0
5
10
15
OR-2V→T
OR-3
OR-2W→T
UT-1
MT-1
CO-1
ID-3
NV-2
OR-3W→T
OR-1
CA-2
NV-1W→T
NV-1
UT-2
CA-1
ID-1
ID-2
WA-1
OR-2
UT-3
MT-1
ID-3
ID-4
NV-1
CA-3W→V
UT-1
CA-2
NV-2
UT-3
NV-3
ID-5
CA-1
OR-1
ID-2
CA-4
CA-3
WY-2
WY-1
MT-3
MT-1
UT-2V→W
CO-2
CO-1
MT-2
OR-1
NM-1T→W
UT-2
AZ-1
NM-2T→W
ID-3
UT-1
ID-1
ID-2
AZ-1T→W
WA-2T→W
WA-1
T
V
W
Tridentata
Vaseyana
Wyomingensis

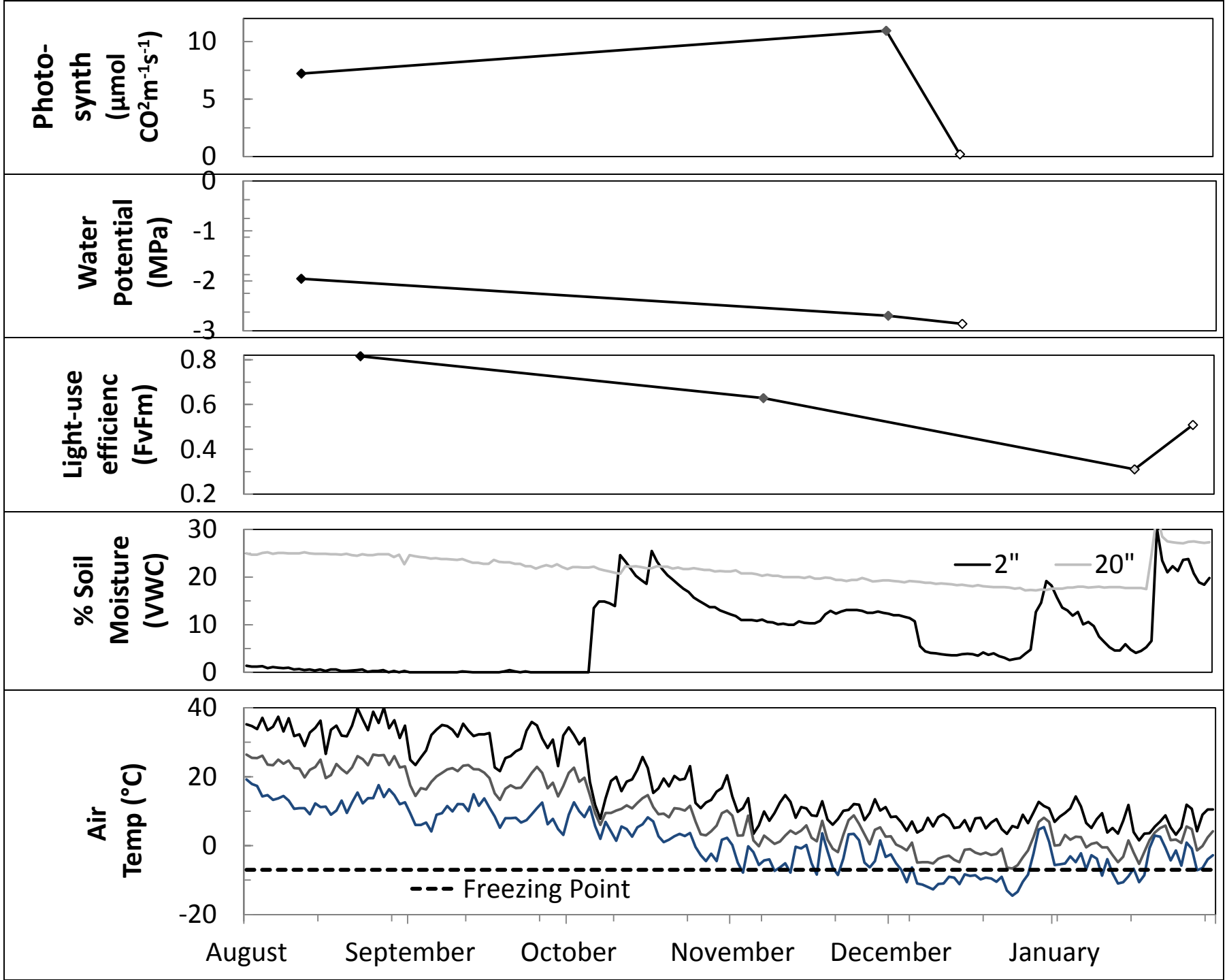
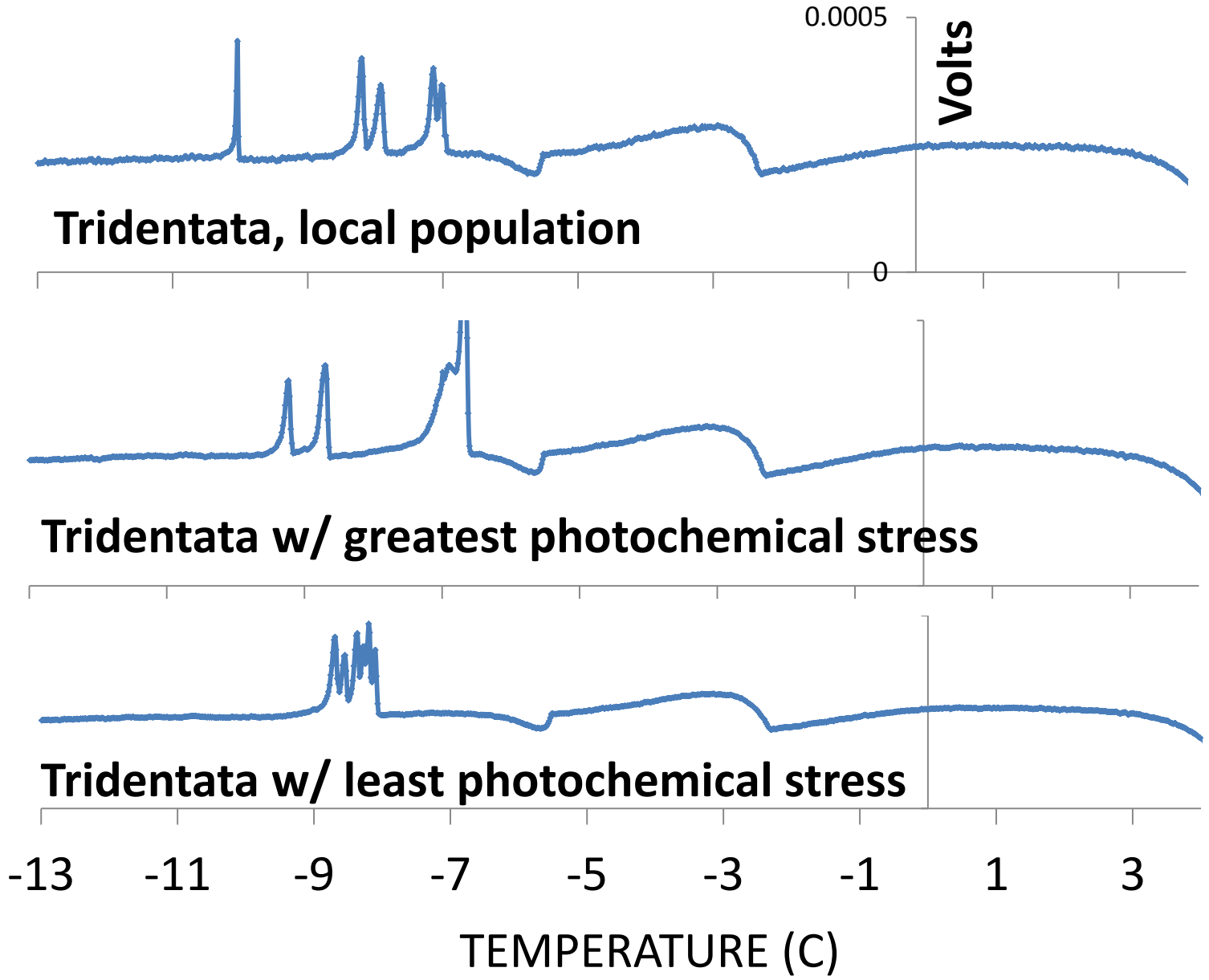
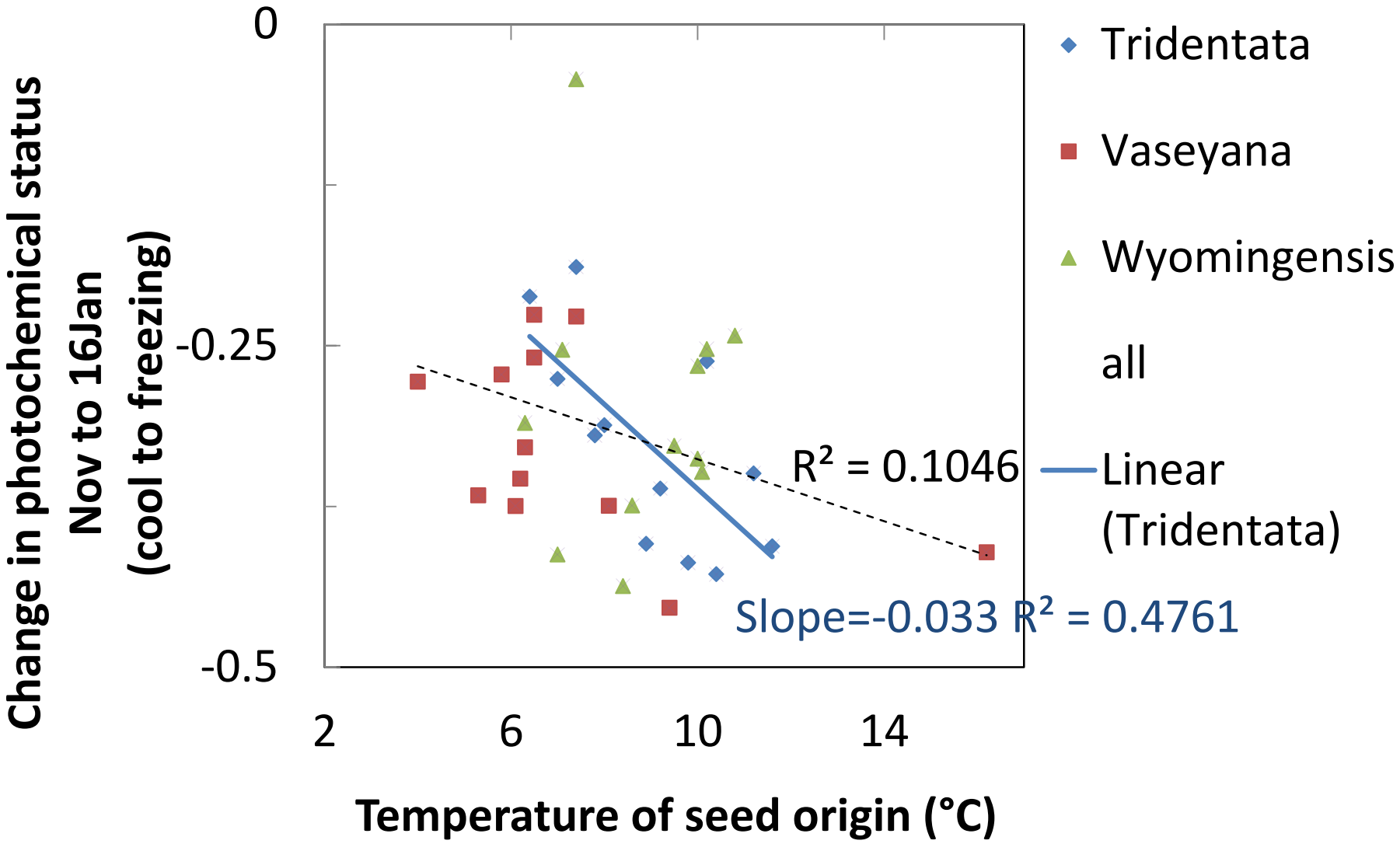


Photo-synth (µmol CO2m-1s-1)
10
5
0
Water Potential (MPa)
0
-1
-2
-3
Light-use efficienc (FvFm)
0.8
0.6
0.4
0.2
% Soil Moisture (VWC)
30
20
10
0
2"
20"
Air Temp (°C)
40
20
0
-20
Freezing Point
August
September
October
November
December
January

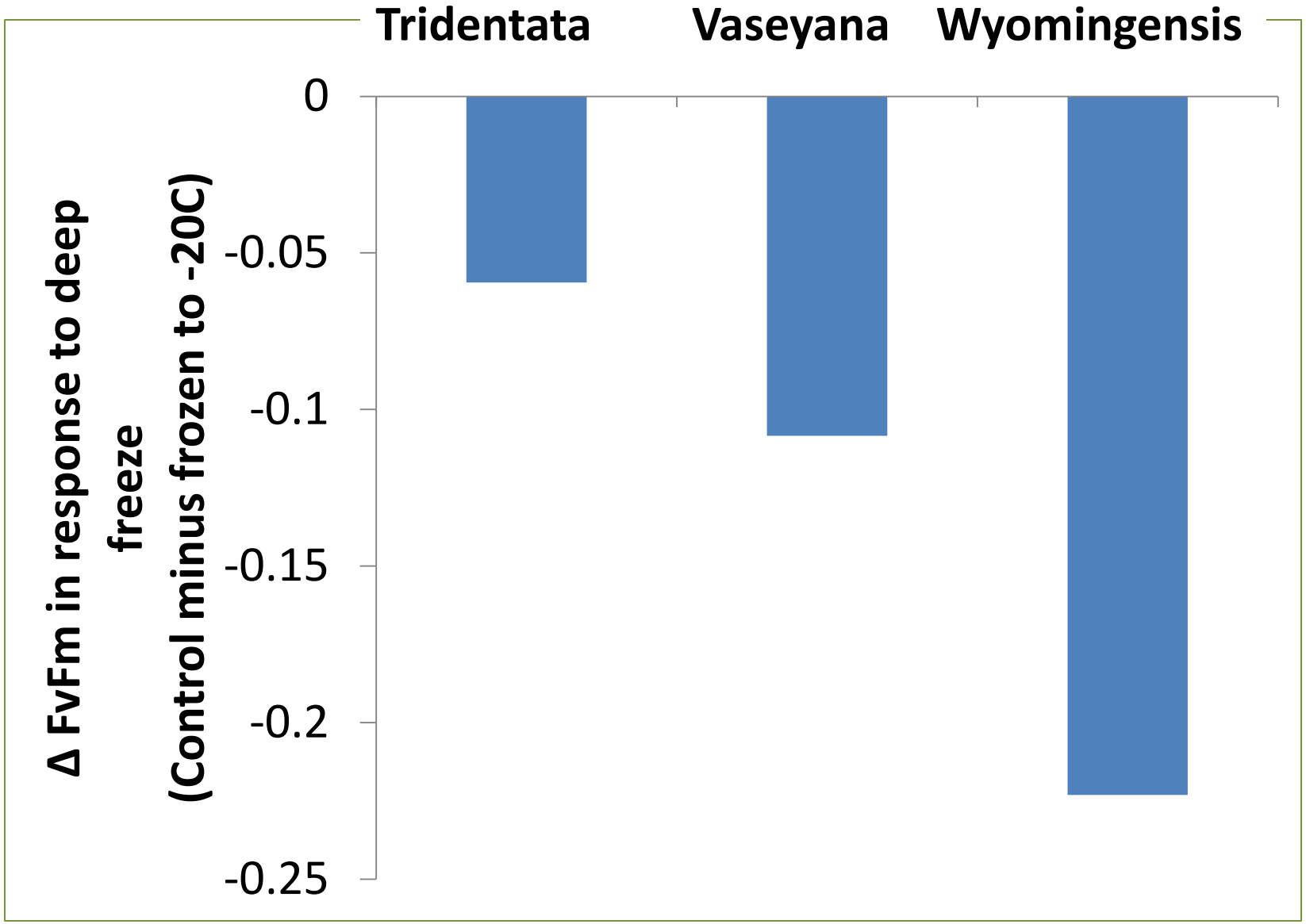
A look at cold tolerance, freezing points:



Subspecies and climate of origin do not influence most mid-winter parameters, except light-use efficiency (photochemistry):



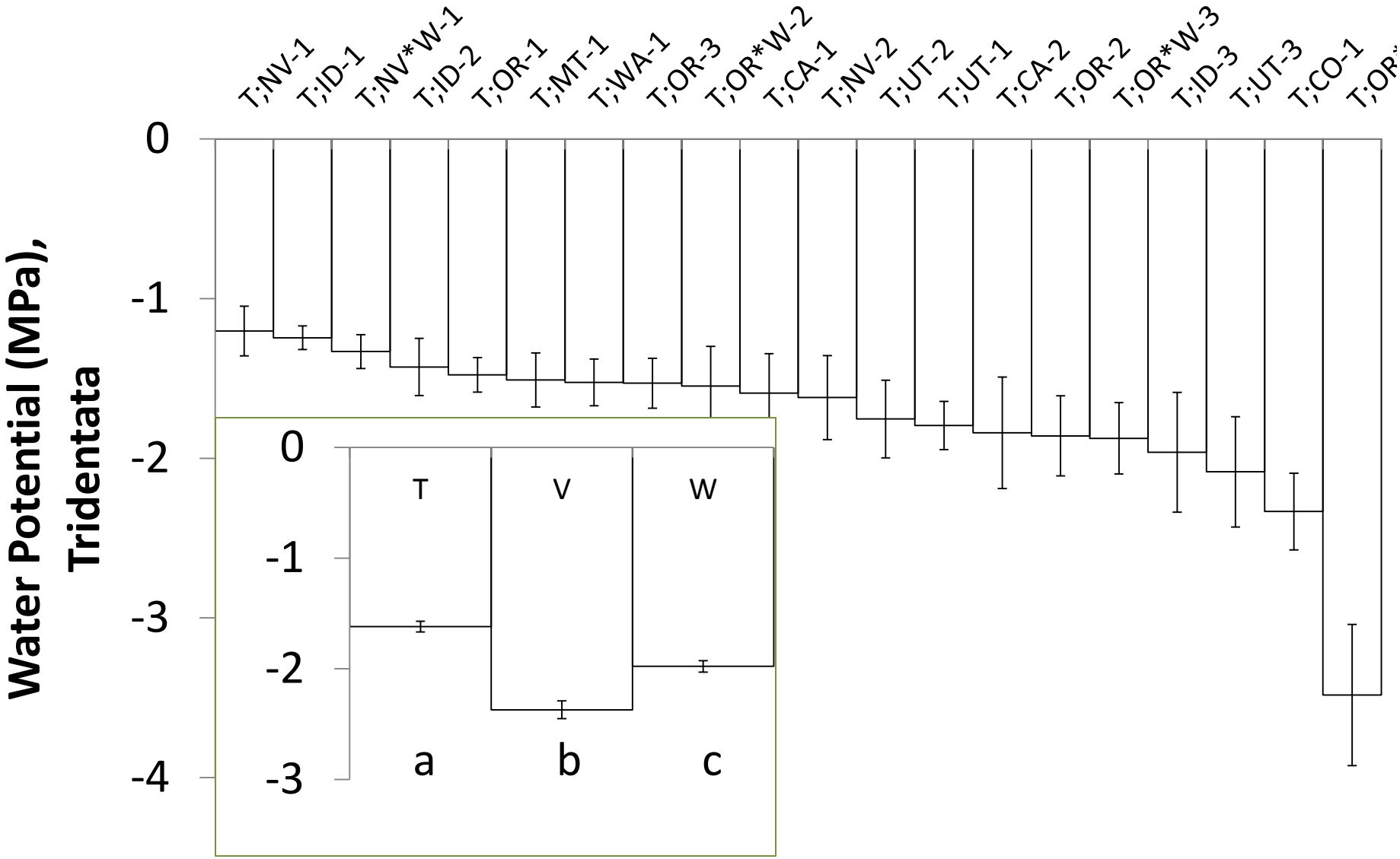
Photochemical stress response to deep freezing:



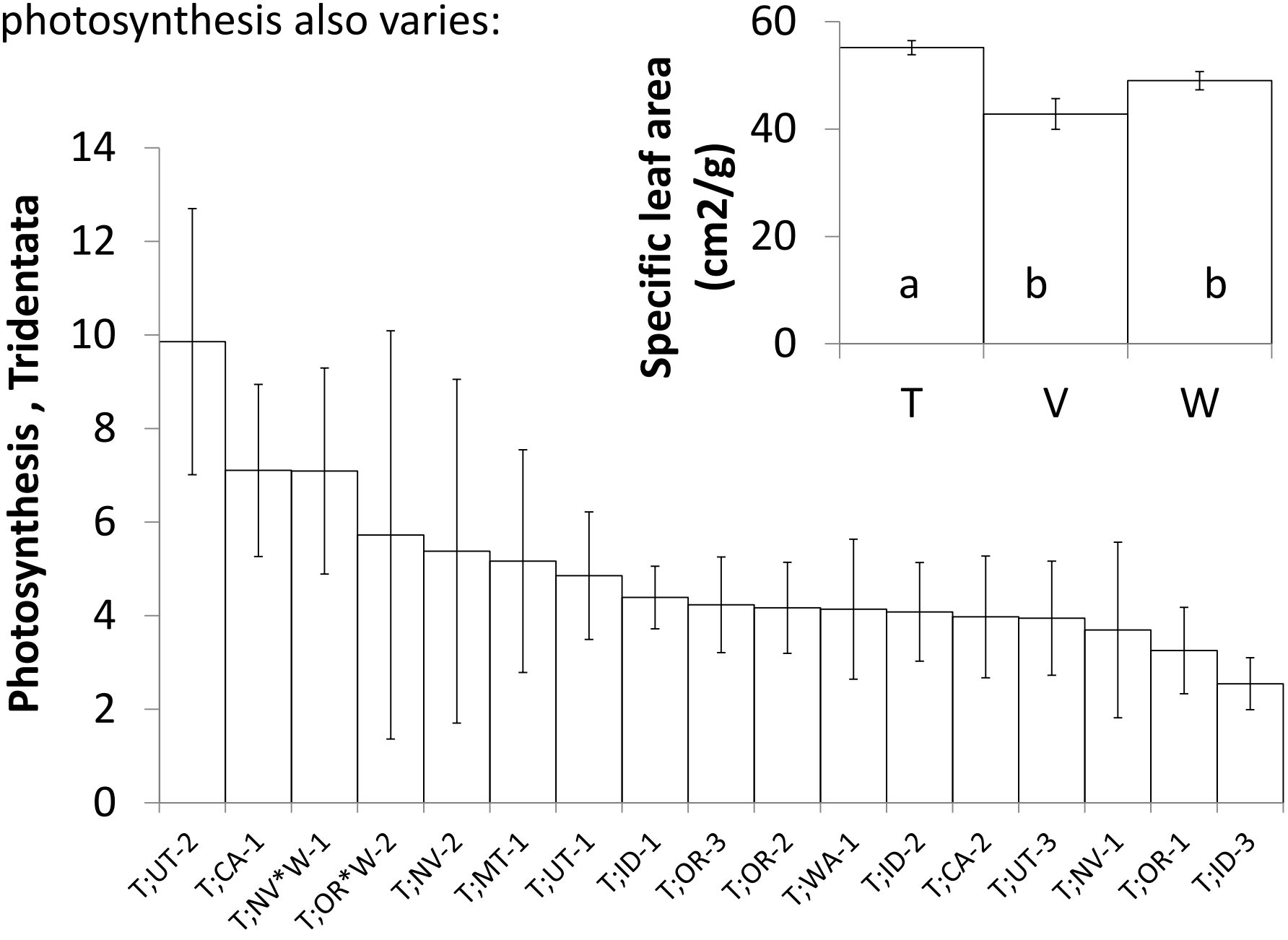
A look at mid-summer limitation:

Tridentata expresses “growthy” traits and yet maintains higher water status

Water status varies among subspecies, and esp. populations:

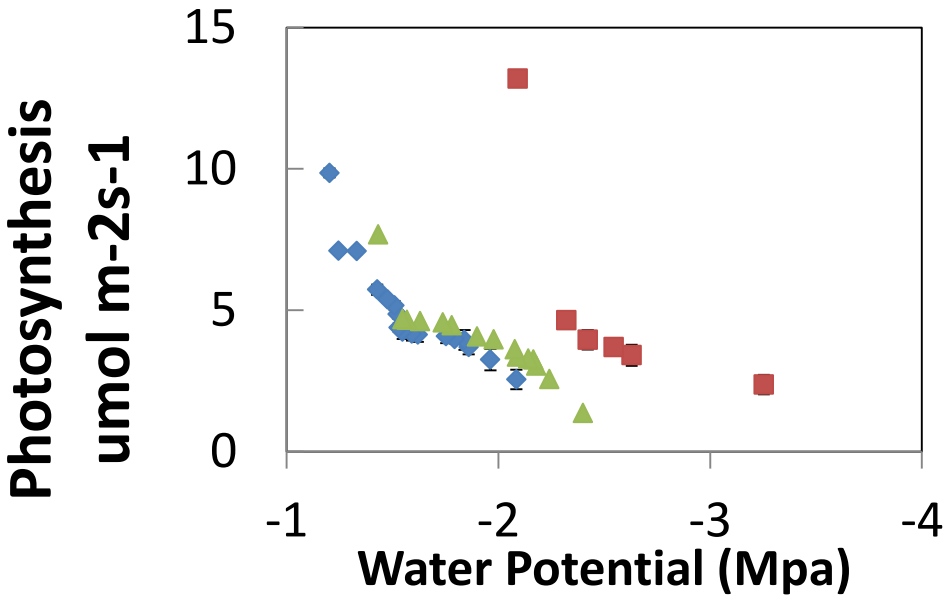


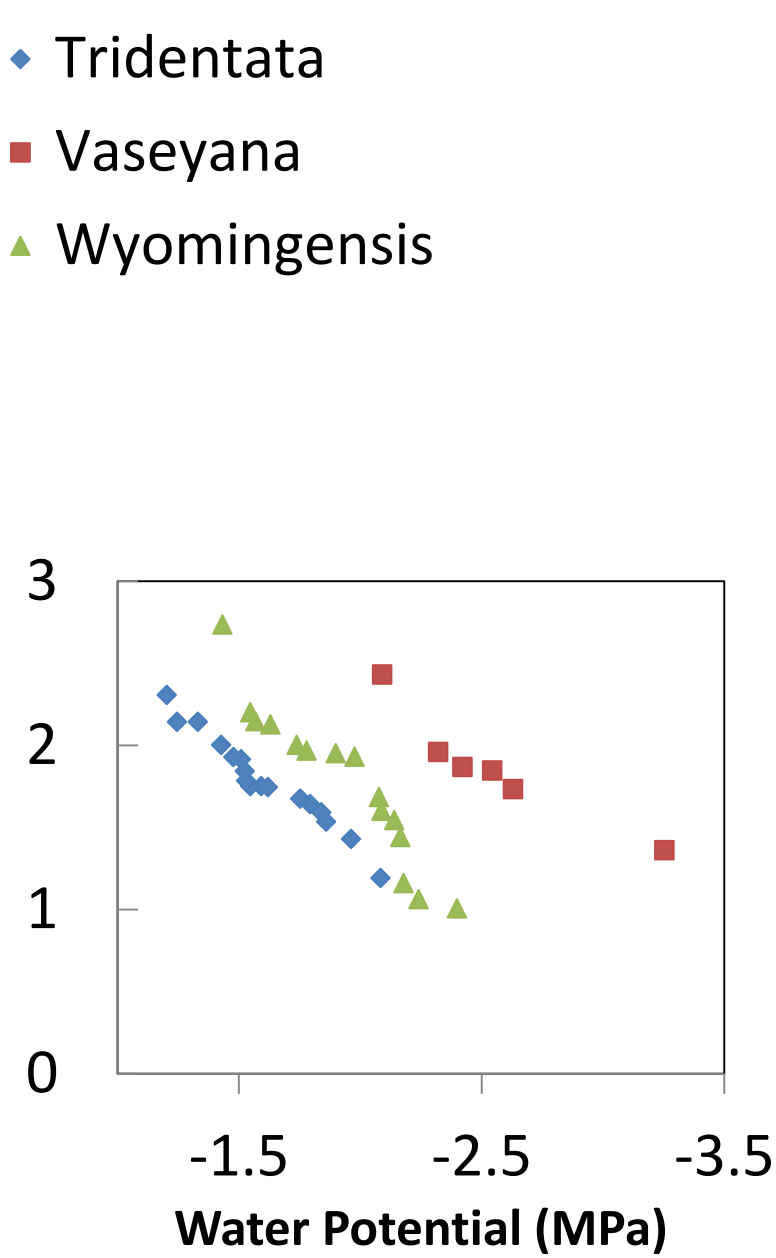
photosynthesis also varies:



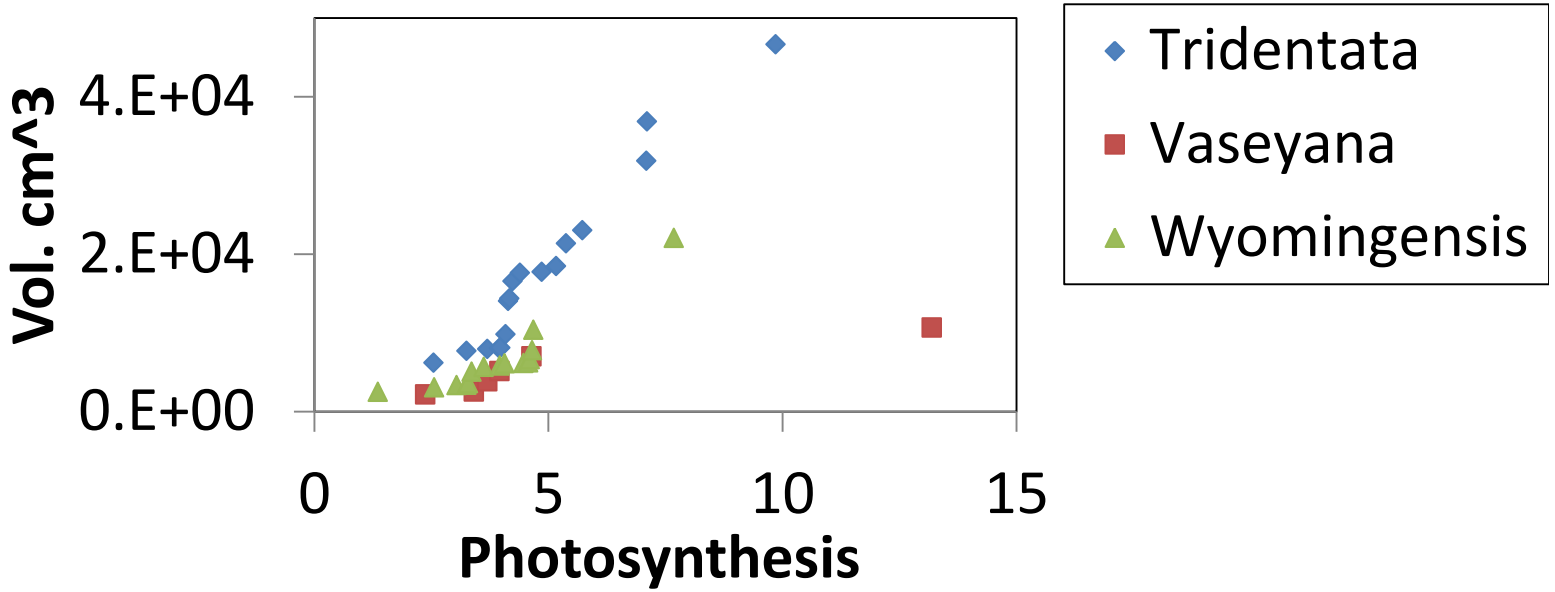
Mechanisms underlying differences in mid-summer photosynthesis

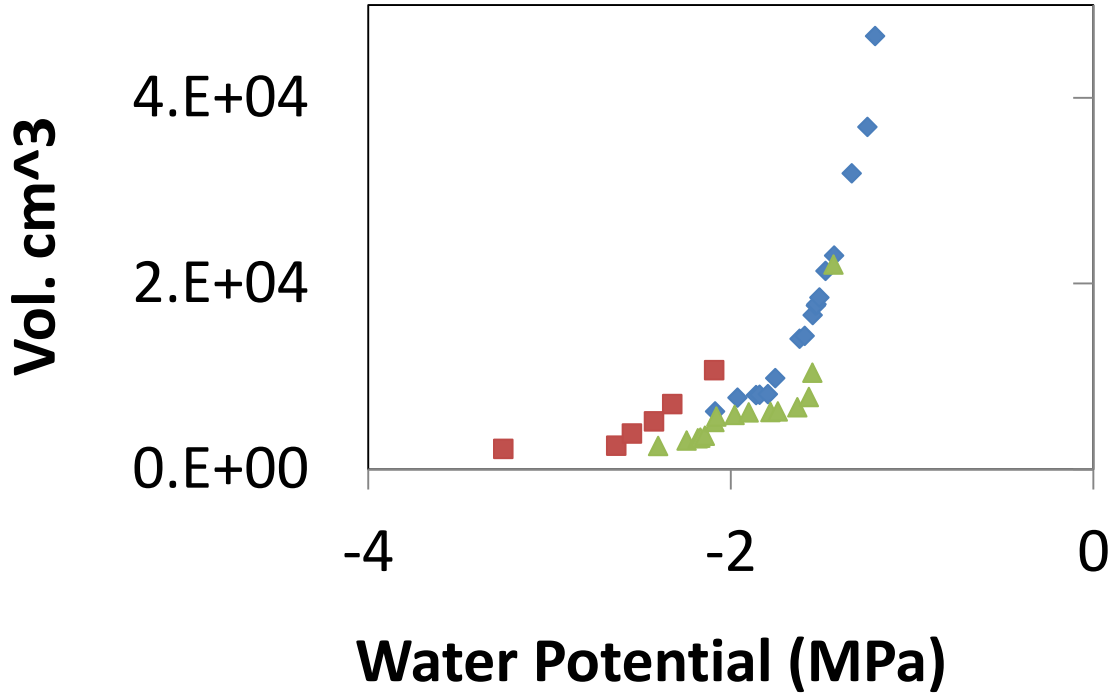
Point to advantages in water uptake for top-performers:





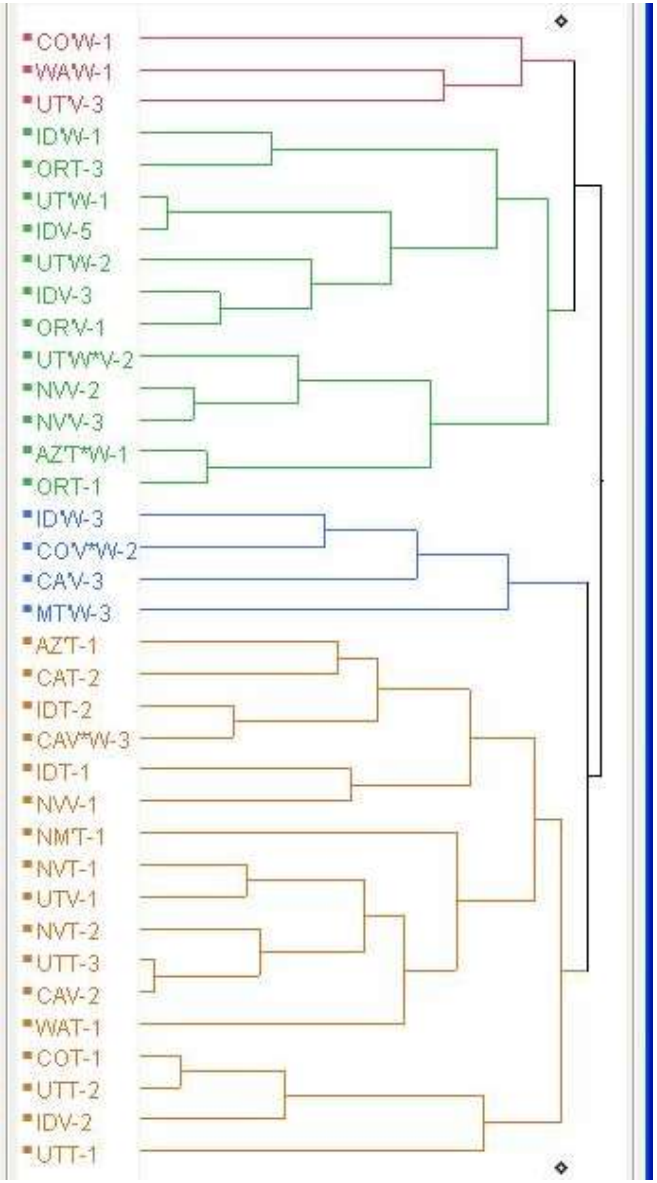
Relating photosynthesis to growth:



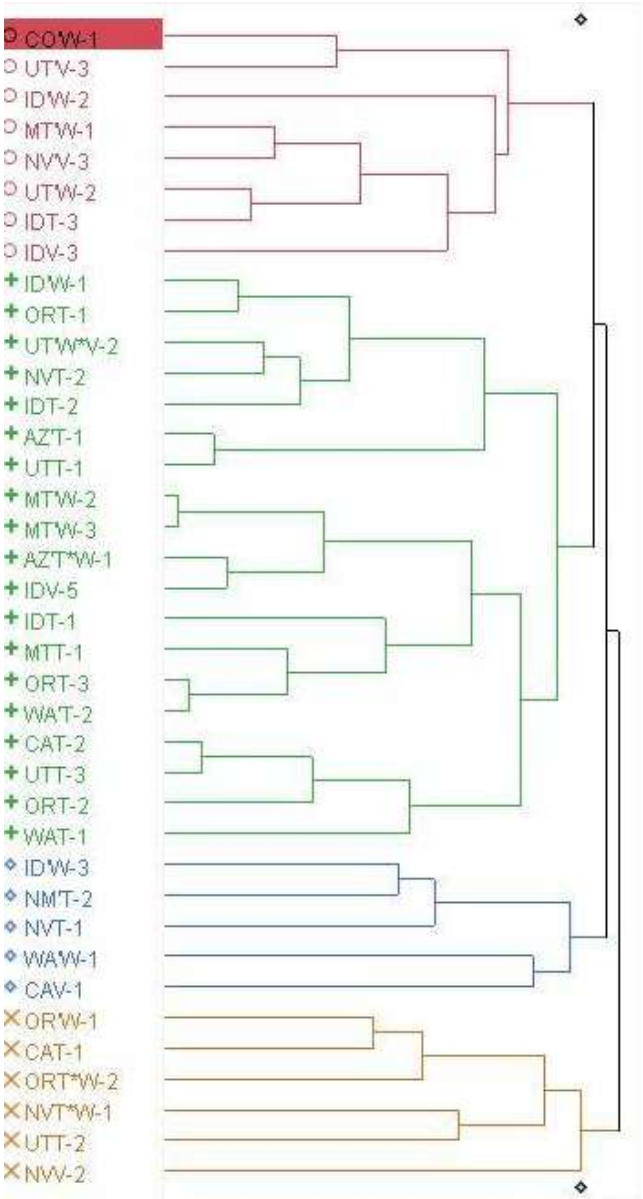


Hierarchical clustering based on taxonomy (Ward's):

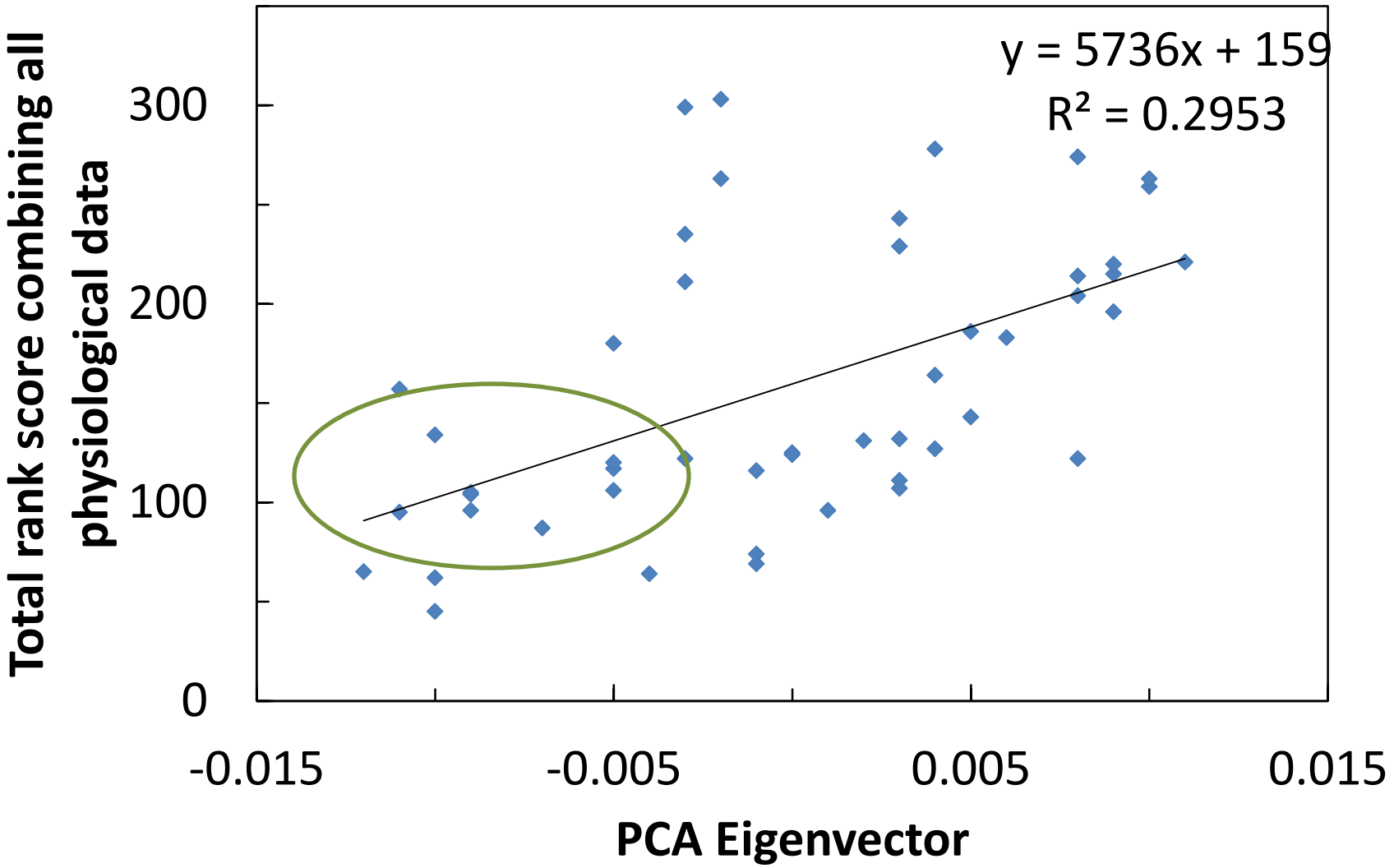
Wintertime:



Summertime:



Relationships based on genetic similarity



Conclusions

- Ecophysiological similarities and differences revealed.
- **Wintertime:**
  - An important growth period, cold stress occurs.
  - Diffs in freezing resistance rather than avoidance
  - Climate-of-origin affects these
  - Min temp is issue for climate change (snowcover, etc)
- **Summertime:**
  - Hydrologic threshholds still need to be determined
  - Water limitations to carbon balance are key
  - Water uptake, possibly from deep soils, likely important
  - Growth vs. efficiency….key issue for selection.
- **Genomic differences are likely**

USGS
science for a changing world

These short-term findings can help glean insight on which seed sources might perform better on a given site/circumstance

Future plans:

- Determine if patterns hold up in additional years
- Distinguishing perennial VS. ephemeral leaf effects (enabling scaling our leaf-level data to whole-plant)
- Isotopes to better substantiate the WUE-depth of water uptake effect
- Evaluate seedlings during critical establishment phase
- Anti-defense compounds – assessing palatability

THE END

USGS
science for a changing world