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U.S. Department of Interior
U.S. Geological Survey

Examining variability in arrowweed physiological traits and responses to flooding

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Plants can be adapted to flooding and temperature.

- Riparian plant growth is tightly linked to flow regime and flooding
- Riparian species can be adapted to temperature
- Plants from different temperature provenances can have different traits and environmental responses
  - Phenology, leaf traits
- Niche-modeling suggests that in hot climates, plants grow further away from the river[1]

Photo credit: E. Palmquist

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[1]Butterfield, B. J., E. C. Palmquist, and B. E. Ralston. 2018. Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon. Applied Vegetation Science 21:572-583.

Potential for interactions

Do plants collected from different temperature provenances:

A. Respond differently to flooding?
   - Do individuals from cooler climates perform better in flooded conditions than those collected from hot climates?

B. Exhibit differences in physiological traits?
   - Hot temperature plants: larger roots systems, shorter height, smaller specific leaf area

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Study Species

- *Pluchea sericea*, arrowweed
- Native, clonal shrub up to approximately 3 m tall
- Mojave, Sonoran, Chihuahuan deserts
  - Southwestern U.S., northern Mexico
- Primary species encroaching on high value camping sandbars
- Focal species of LTEMP vegetation removals
- Key component of vegetation/sand feedback loops

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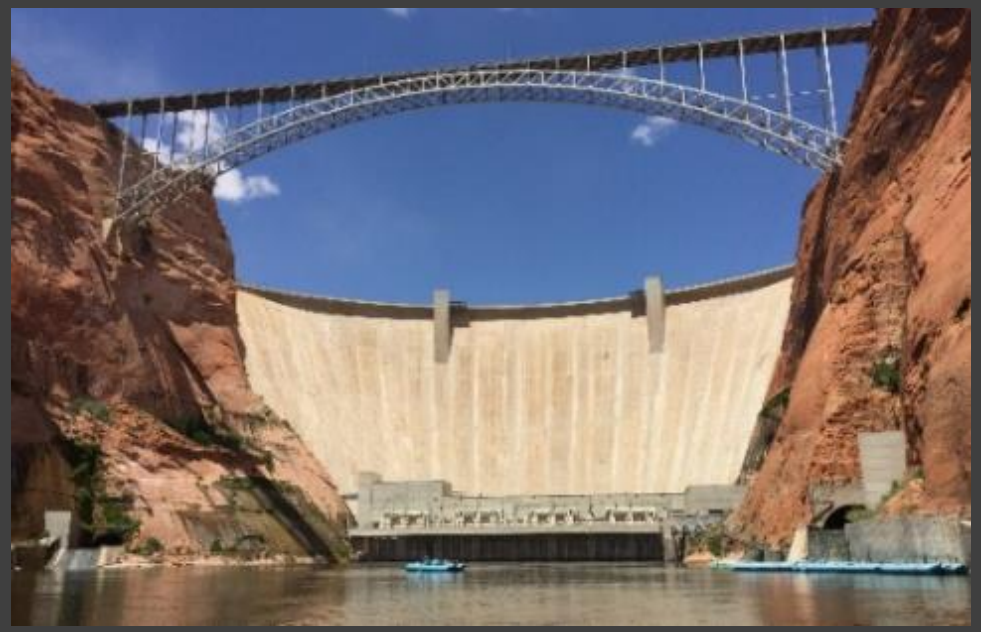
Relevance for river management

- As temperatures increase
  - Plants may not respond to dam operations as they have in the past
  - Physiological traits (and thus plant function) may change
- Learn about an understudied plant species of management importance



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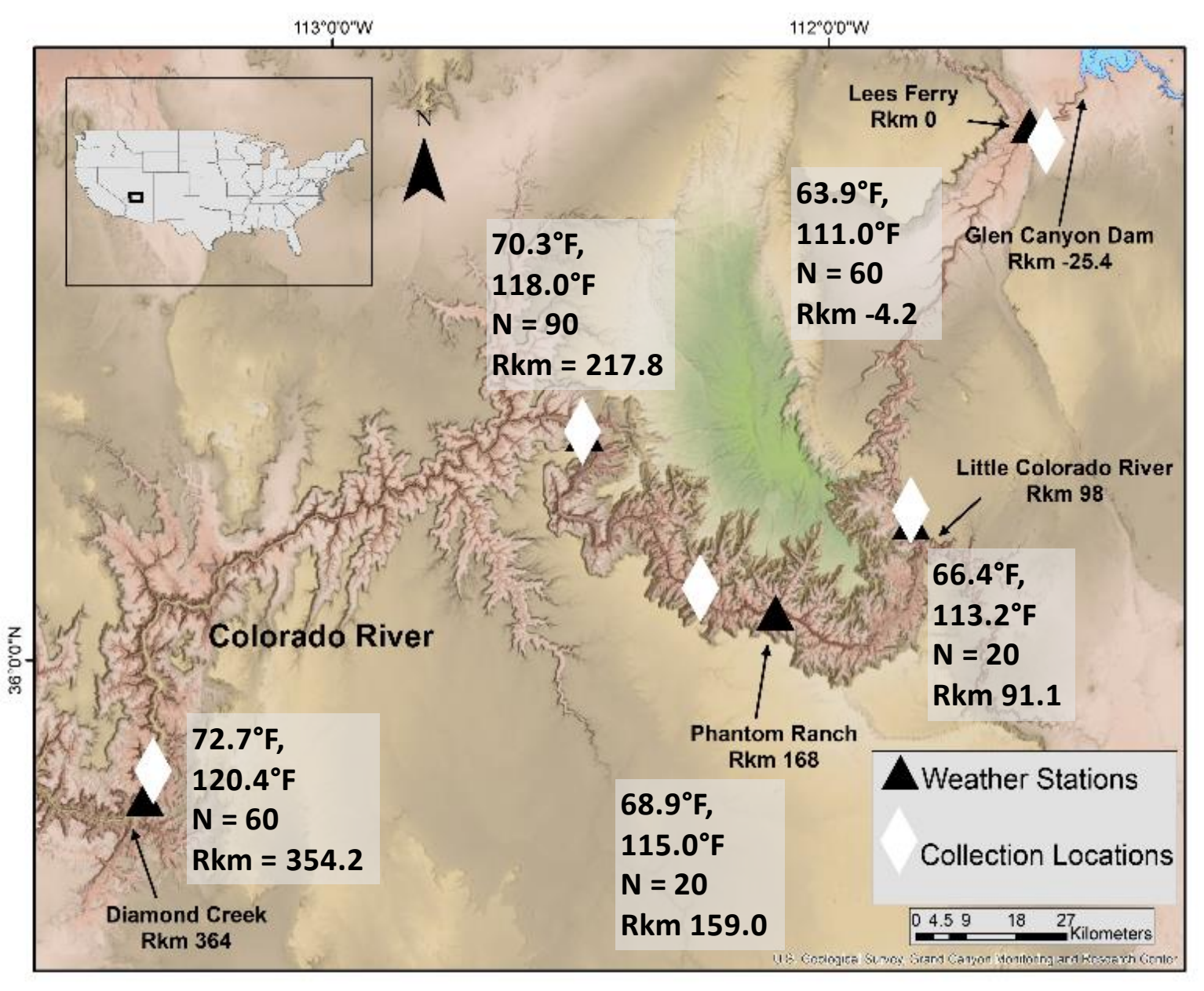
Methods - Cuttings

- 250 cuttings collected across 5 locations along the Colorado River in Grand Canyon, northwestern Arizona
- Provenances indicated with river kilometer
- Locations span 8.8°F average temperature and 9.4°F maximum temperature
- Grown for 1 year in greenhouse



Mean temp, maximum temp, sample size shown for each site.

Methods – Flood Design

- Water moved with pumps
- Plants sat on PVC tubes filled with sand
- Plants from different provenances were randomly assigned to bins
- Treatments maintained for 3 months
- June – Sept 2019

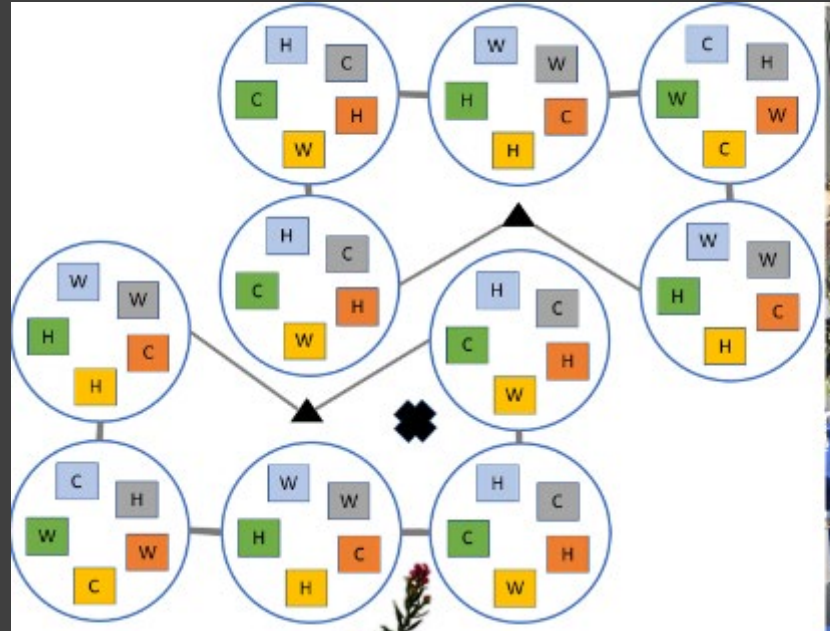


Photo credits: E. Palmquist

Methods - Measurements

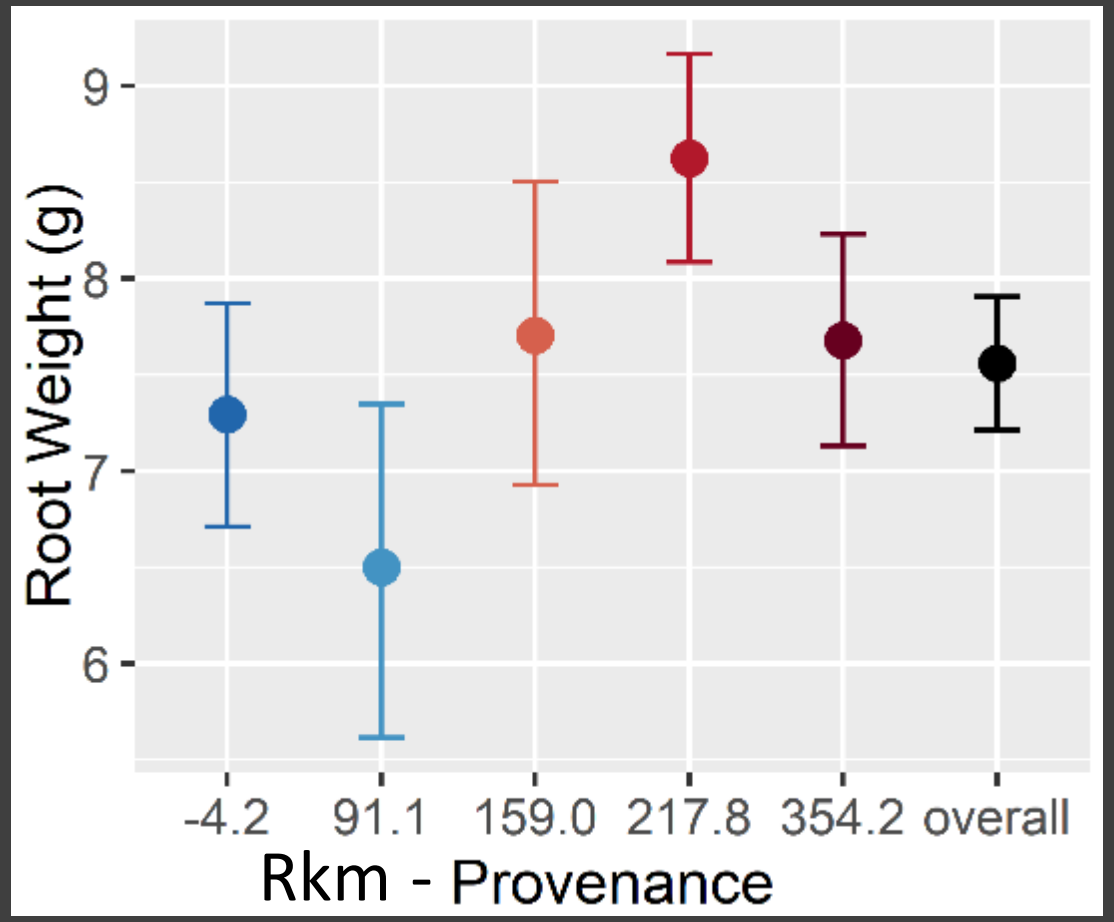
- Root weight (g)
- Maximum height (cm)
  - Initial and Final
- Specific leaf area
  - Subset of 90
- Photosynthesis rate – last day
  - Subset of 90 plants
- Distance above (below) water level
- Greenhouse temperature
  - 5 sensors to record differences

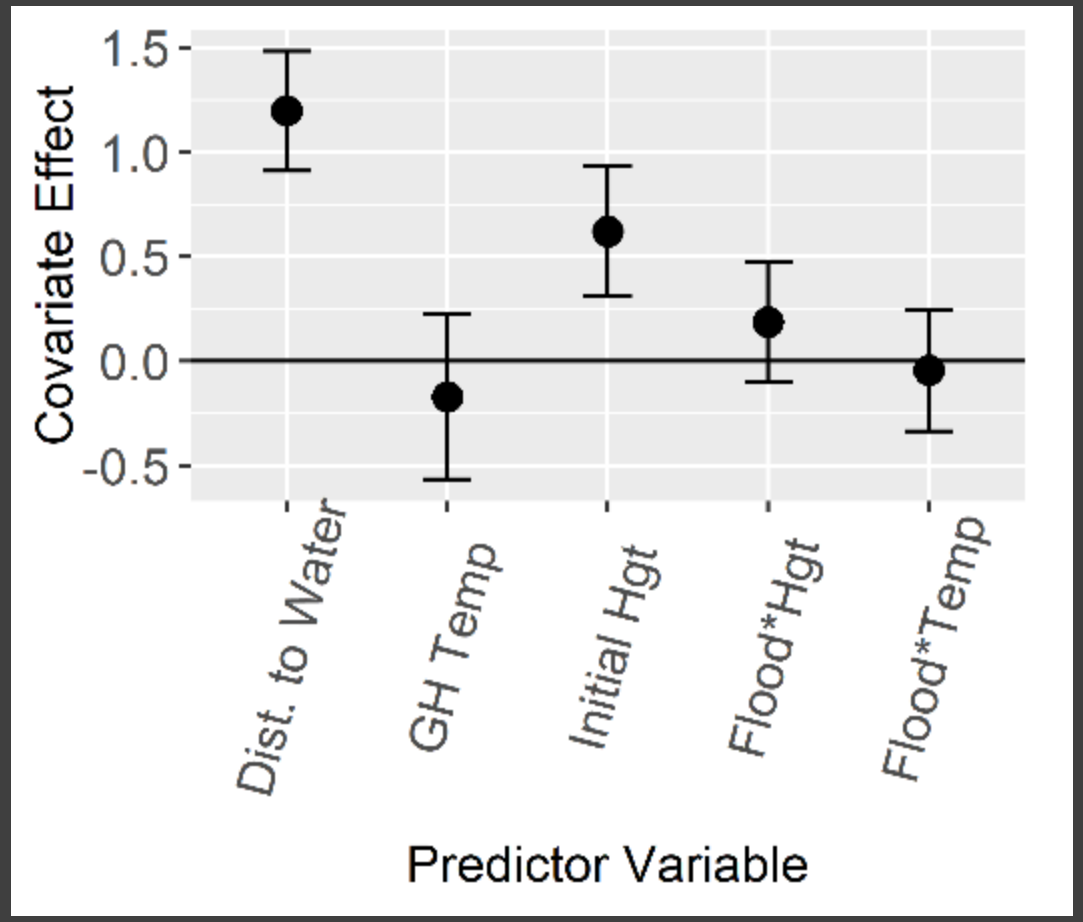
Photo credit: E. Palmquist

Analysis

- Test if physiological measurements were correlated with flooding
- Provenance (collection site) included as random effect
- Bayesian, hierarchical linear models in JAGS
- Other random effects
  - Pump and bin
- Other predictor variables
  - Maximum greenhouse temperature
  - Initial plant height
  - Distance from water table x Initial plant height
  - Distance from water table x Greenhouse temperature
- Compared model that allowed intercepts to vary to model that allowed intercept and slopes to vary by provenance
  - Better model presented

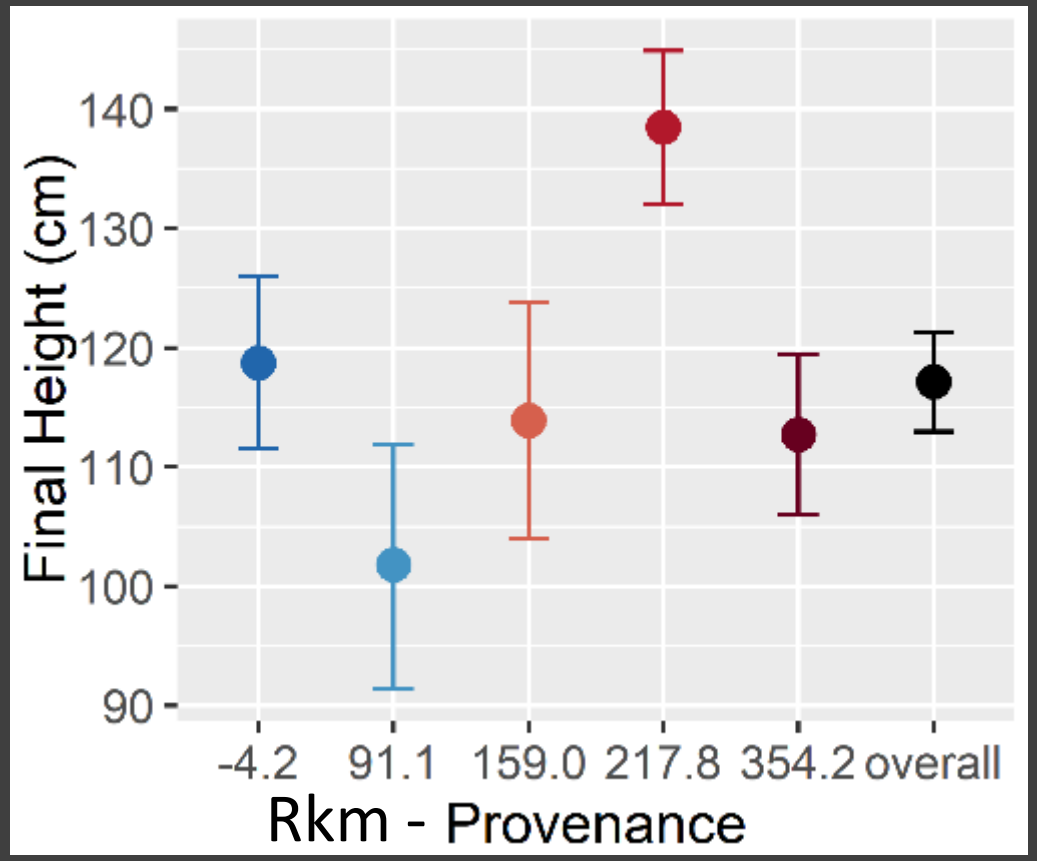
Root weight correlated with provenance, positively related to distance to water table.

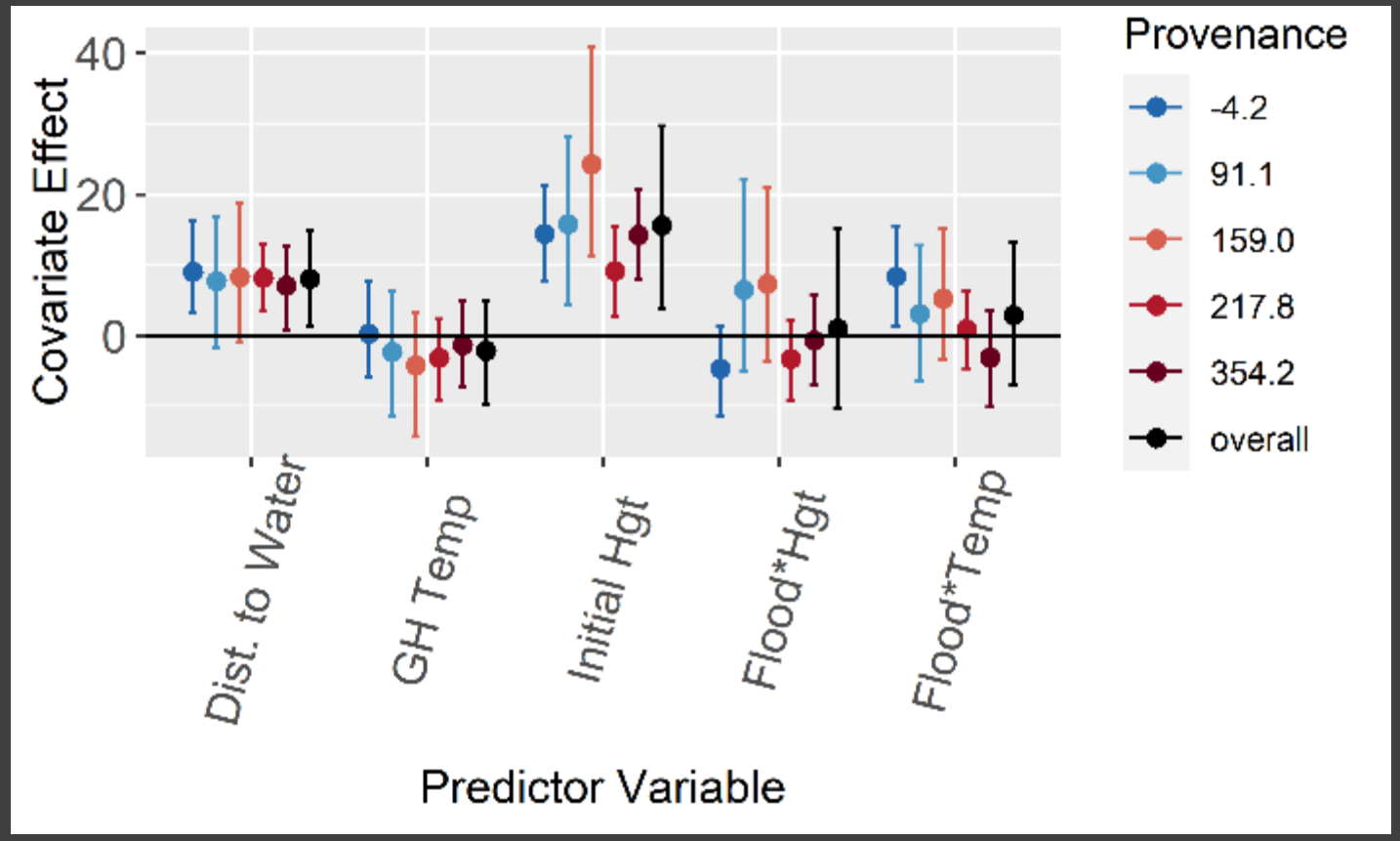




R^2 (predicted ~ observed) = 0.37

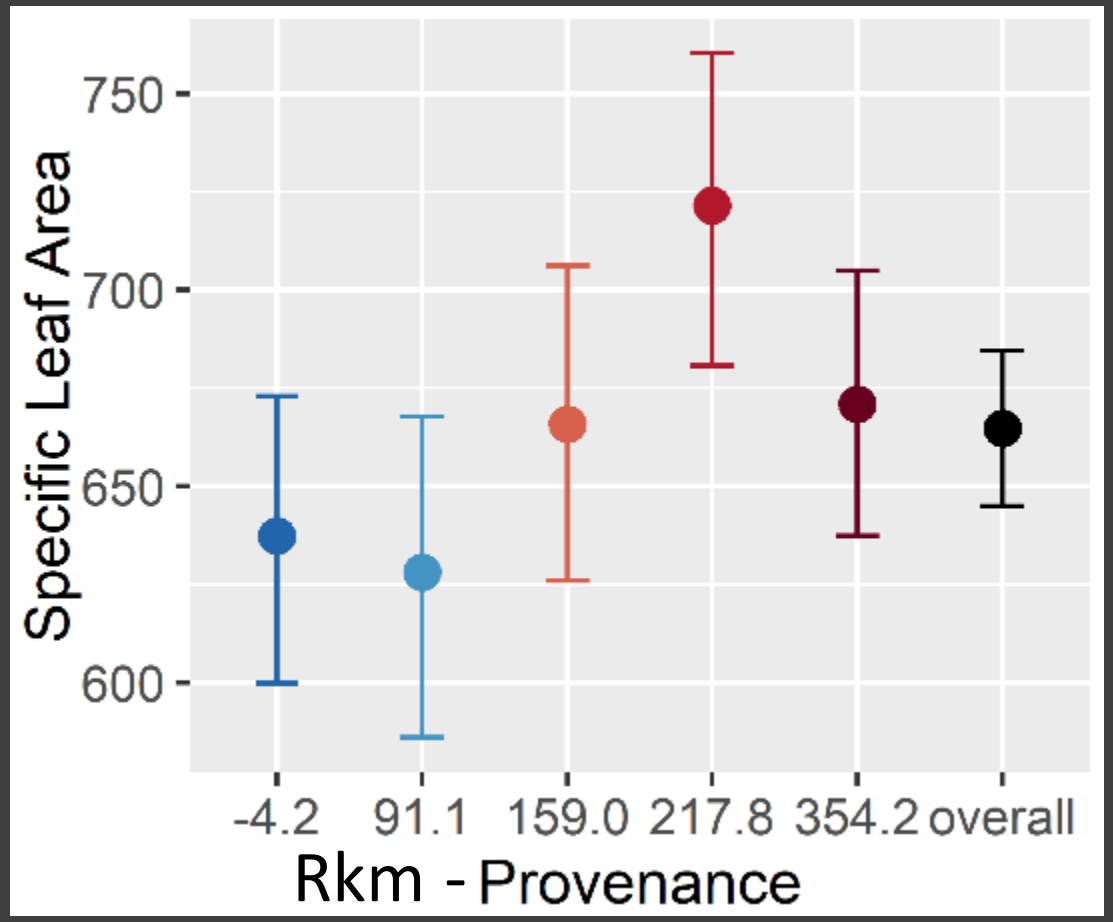
Final height correlated with provenance, positively related to distance to water table.

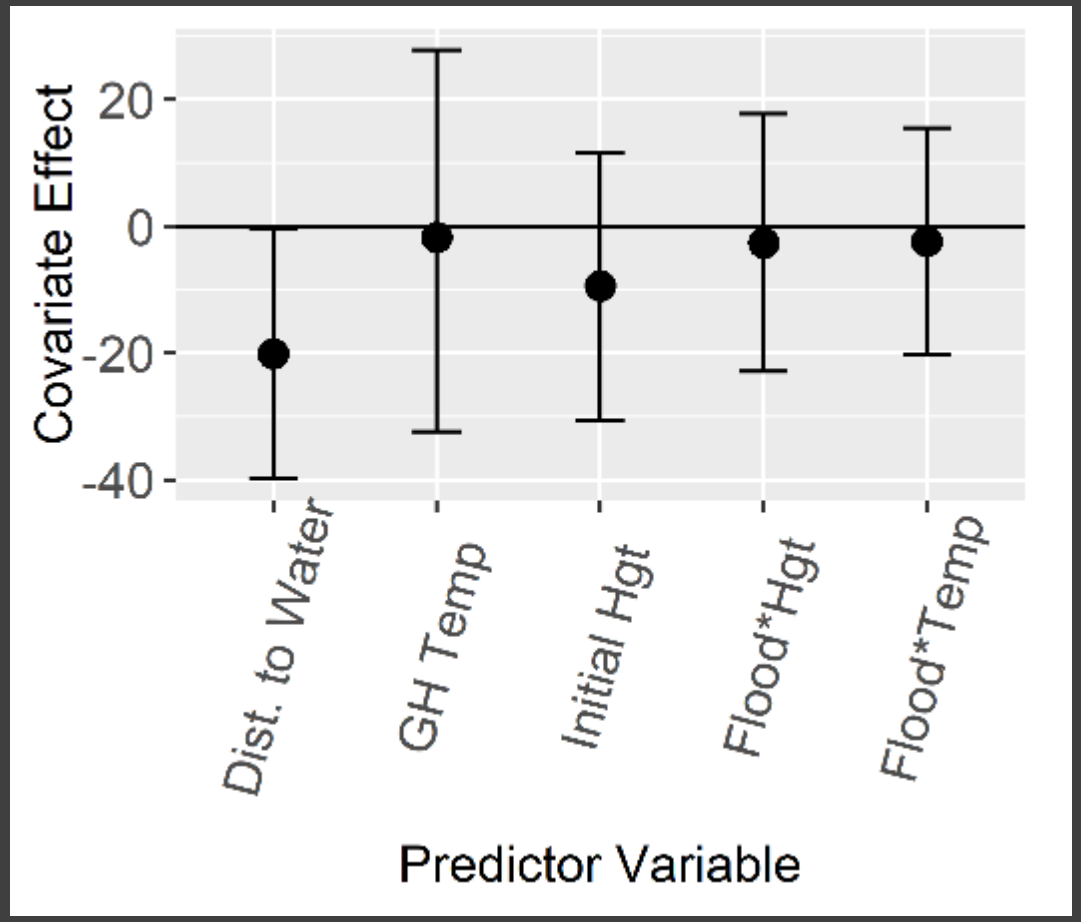




R^2 (predicted ~ observed) = 0.50

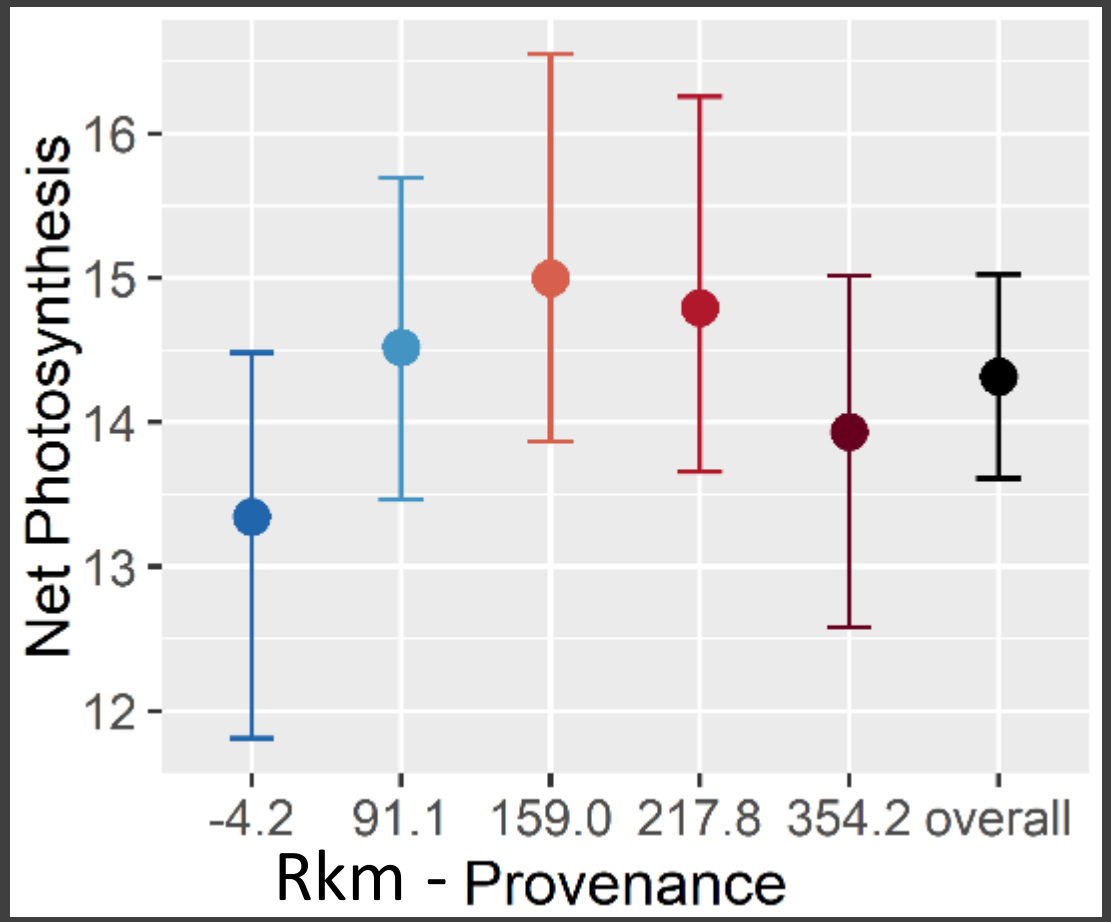
SLA correlated with provenance, negatively related to distance to water table.

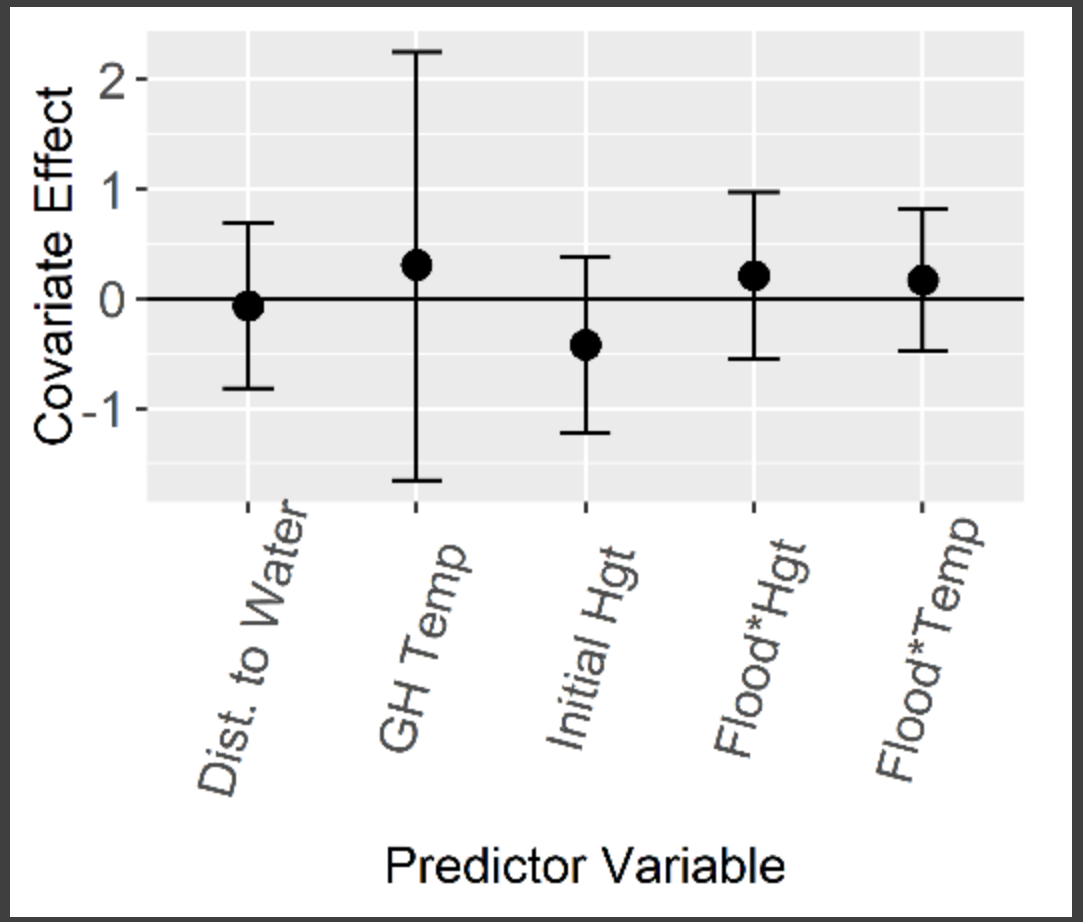




R^2 (predicted ~ observed) = 0.34

Photosynthetic rate correlated with provenance, not related to distance above water level.





R^2 (predicted ~ observed) = 0.49

Conclusions

- Arrowweed is smaller under flooded conditions, and this response is the same across Grand Canyon
- Provenances have inherent differences in physiological traits, independent of flooding
  - Different management strategies
  - Different impacts on natural processes
- Greenhouse conditions less extreme than dryland river conditions

Photo credit: E. Palmquist

Future Directions

- Repeat with more species
  - Likely unique differences
- Manipulate temperatures
- Contrast with dry-down and fluctuating flow experiments

Photo credit: A. Washuta

Thanks!

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