Survival in a Drier World: A Study of Rapid Adaptation in Response to Drought in the Sierra Nevada Endemic Forb, *Erythranthe laciniatus*

Or: What to Expect When You're Expecting Climate Change

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CLIMATE CHANGE: How will native plant populations respond?

- The Sierra Nevada are a biological hotspot, home to at least 7,000 vascular plant species, with 400 of those endemic (Ingram and Kocher 2015)
- A warmer, drier climate with higher incidence of climate anomalies is predicted for California
- Little is known about how plants will respond to rapidly changing climatic conditions

THE RESURRECTION APPROACH: Measuring response to extreme drought

- Resurrection experiments (Franks, Hamann, and Weis 2017) provide a framework to quantify change over time
- To determine how plants responded to the historic 2012-2014 drought, seeds of *Erythranthe laciniata* produced before and during the drought were grown out it common conditions.
- A previous growout found that plants from the drought generation emerged almost five days earlier than pre-drought plants

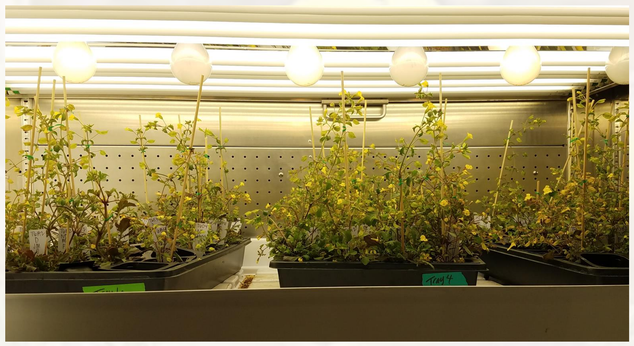
STUDY QUESTIONS:

1. Are the observed phenological changes conserved in a second generation growout?

2. Do responses vary between populations?

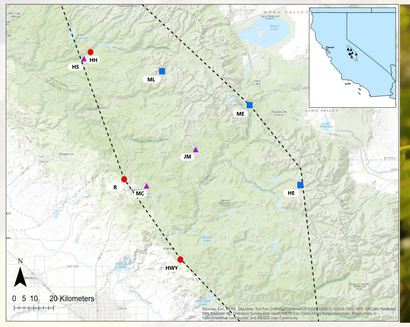
METHODS: Second generation growout

- Second generation of resurrection experiment
- Nine populations across the *E. laciniata* range
  - Pre-drought plants from 2005-2008
  - Drought plants from 2014
- 304 families planted, 94% germinated
- Plants grown in growth chambers, a common environment
- Trays checked daily for phenology: days to emergence, budding, first flower, first fruit, and senescence



Analysis:

- Days to emergence and days to first flower analyzed using a Cox proportional hazards mixed effects model in R



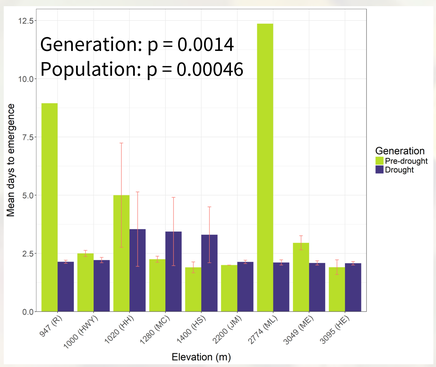
CONCLUSIONS: Drought avoidance?

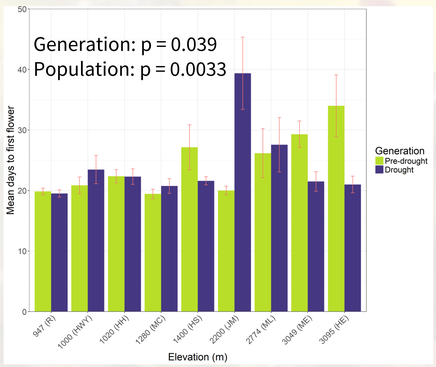
- Differences between the pre-drought and drought lineages are consistent with a drought avoidance strategy
  - Earlier emergence and flowering would result in less exposure to drought
  - Earlier emergence has been shown to be a drought adapted trait (Farooq et al. 2009).
- Population responses differed
  - These responses may be exacerbated as climate continues to change
  - Some populations may be less adaptable and so are more vulnerable to climate change

STUDY SYSTEM: *Erythranthe laciniata*

- Cut-leaf monkeyflower
- Endemic to the Sierra Nevada
- Range restricted to western slopes of the Sierra
- Grows on granite outcrops in mossy snowmelt seeps
- 95% self-fertilizing, but is visited by bees and other insects (Sexton, Strauss, and Rice 2011)

RESULTS





Days to emergence:

- Drought generation plants emerged 1.8 days earlier than pre-drought plants
- Emergence rates differed between populations ($p = 0.003$), but not between generations

Days to first flower:

- Drought generation plants flowered one day earlier than pre-drought plants
- Drought generation plants senesced two days before pre-drought plants, but was not statistically significant

RAPID ADAPTATION VS PLASTICITY: Future directions

- Observed changes may be the result of rapid genetic adaptation, phenotypic plasticity, or genetic diversity in the seed bank
- A drought study is planned to determine whether observed changes are adaptive and whether observed changes are sustained

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Ingram, K, and S Kocher. 2015. "Natural History of the Sierra Nevada." https://doi.org/10.3733/ucanr.8535.
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