Photos by Hillary Cooper (top) & Tom Whitham (bottom)
Cottonwood mortality on Bill Williams River National Wildlife Refuge – March 28, 2017

Genetics- Based Restoration in Response to Climate Change and Invasive Species

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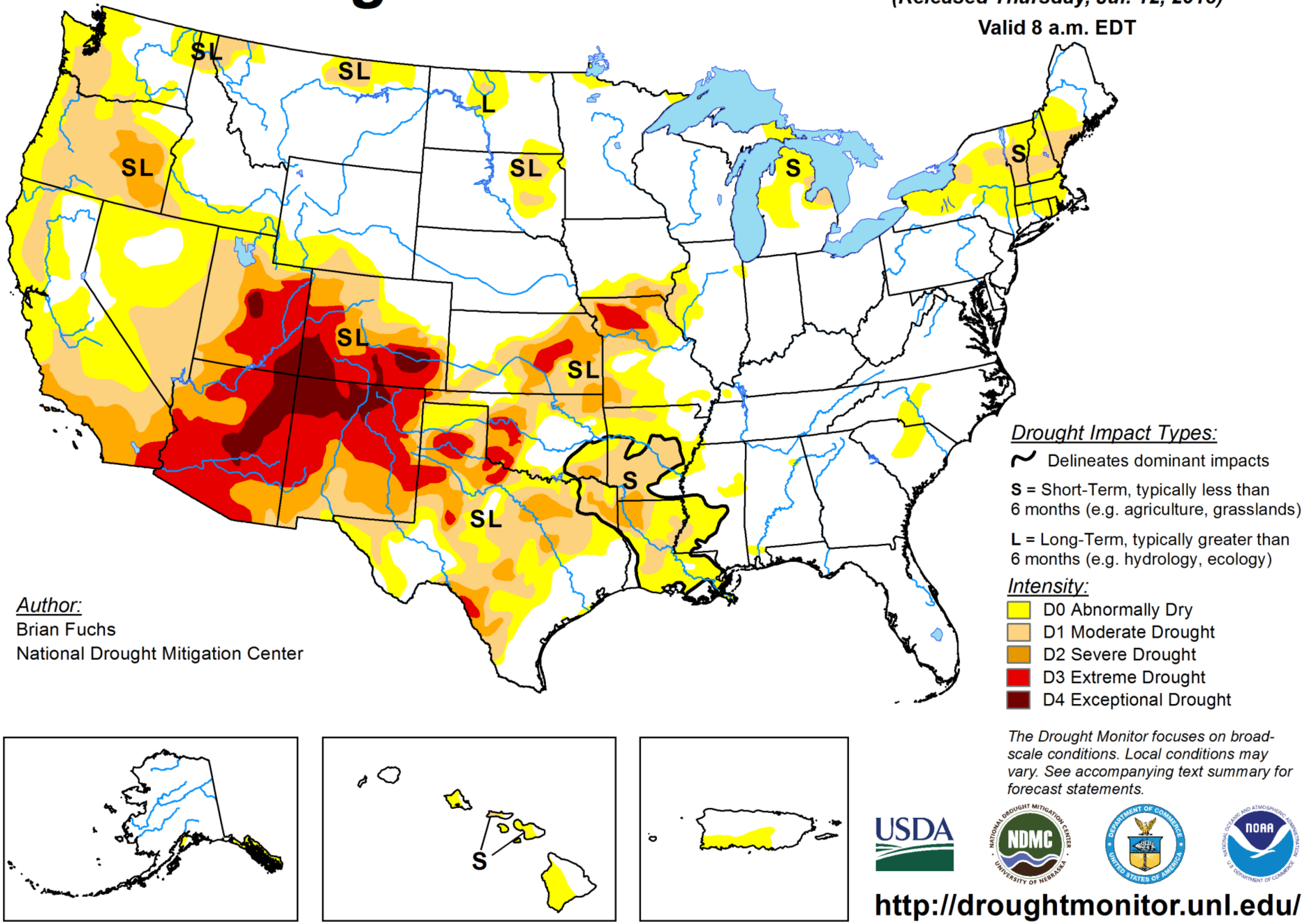
NORTHERN ARIZONA UNIVERSITY

U.S. Drought Monitor

July 10, 2018

(Released Thursday, Jul. 12, 2018)

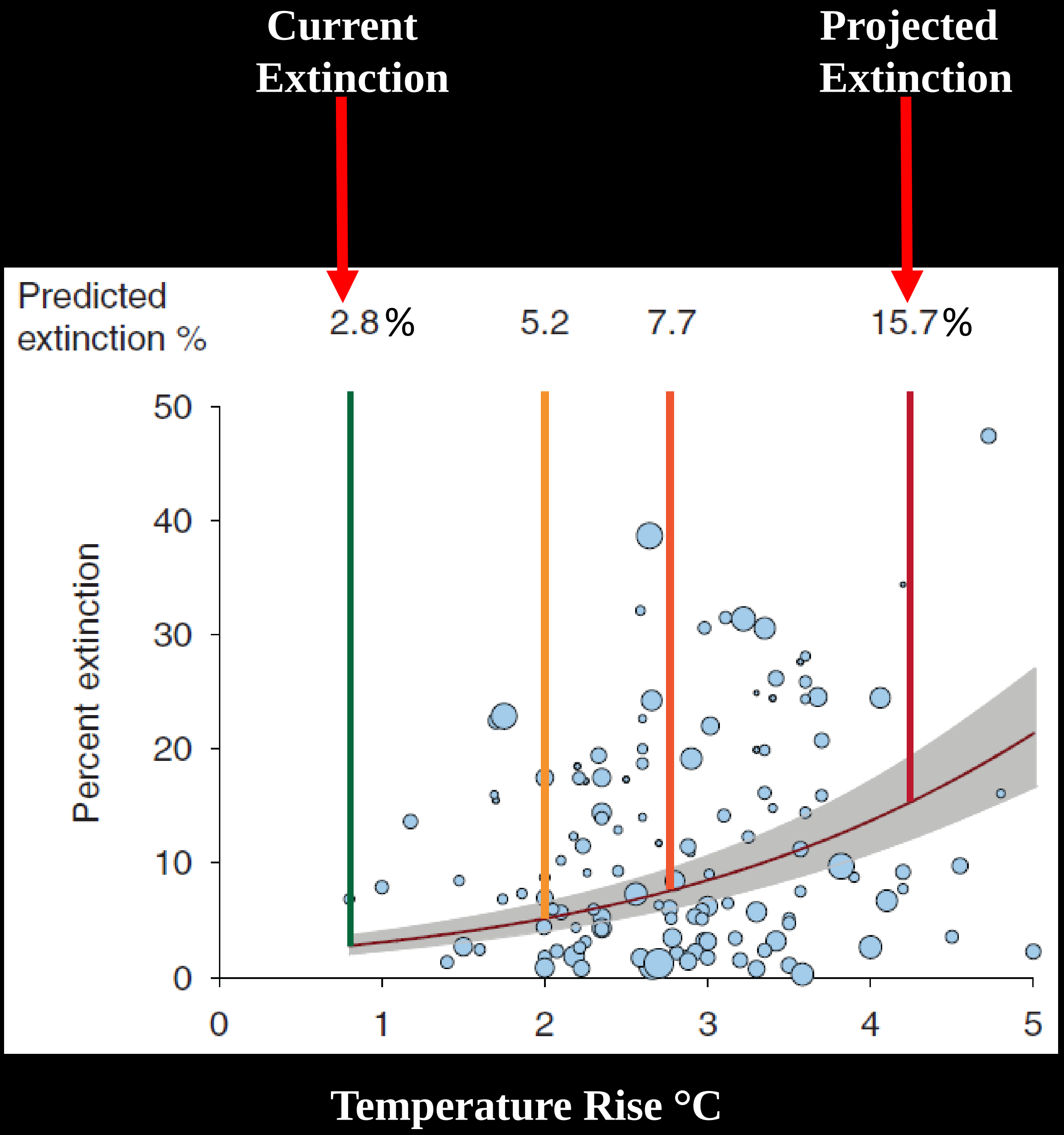
Valid 8 a.m. EDT



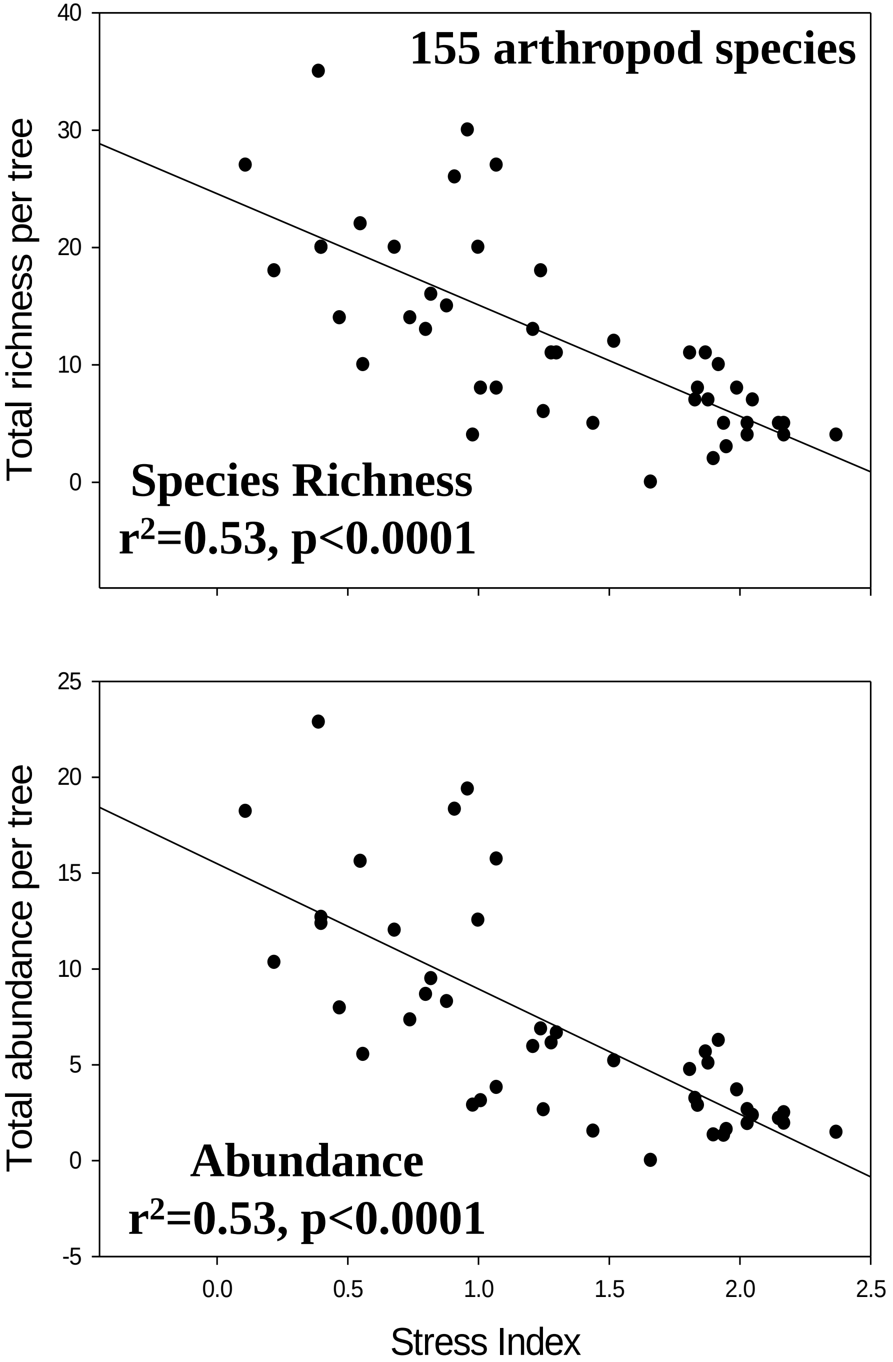
http://droughtmonitor.unl.edu/

Increased extinction with global warming

Every degree increase in temperature increases extinction risk so planners need to build this into their designs. <u>With current practices 1 in 6 species will go extinct.</u>



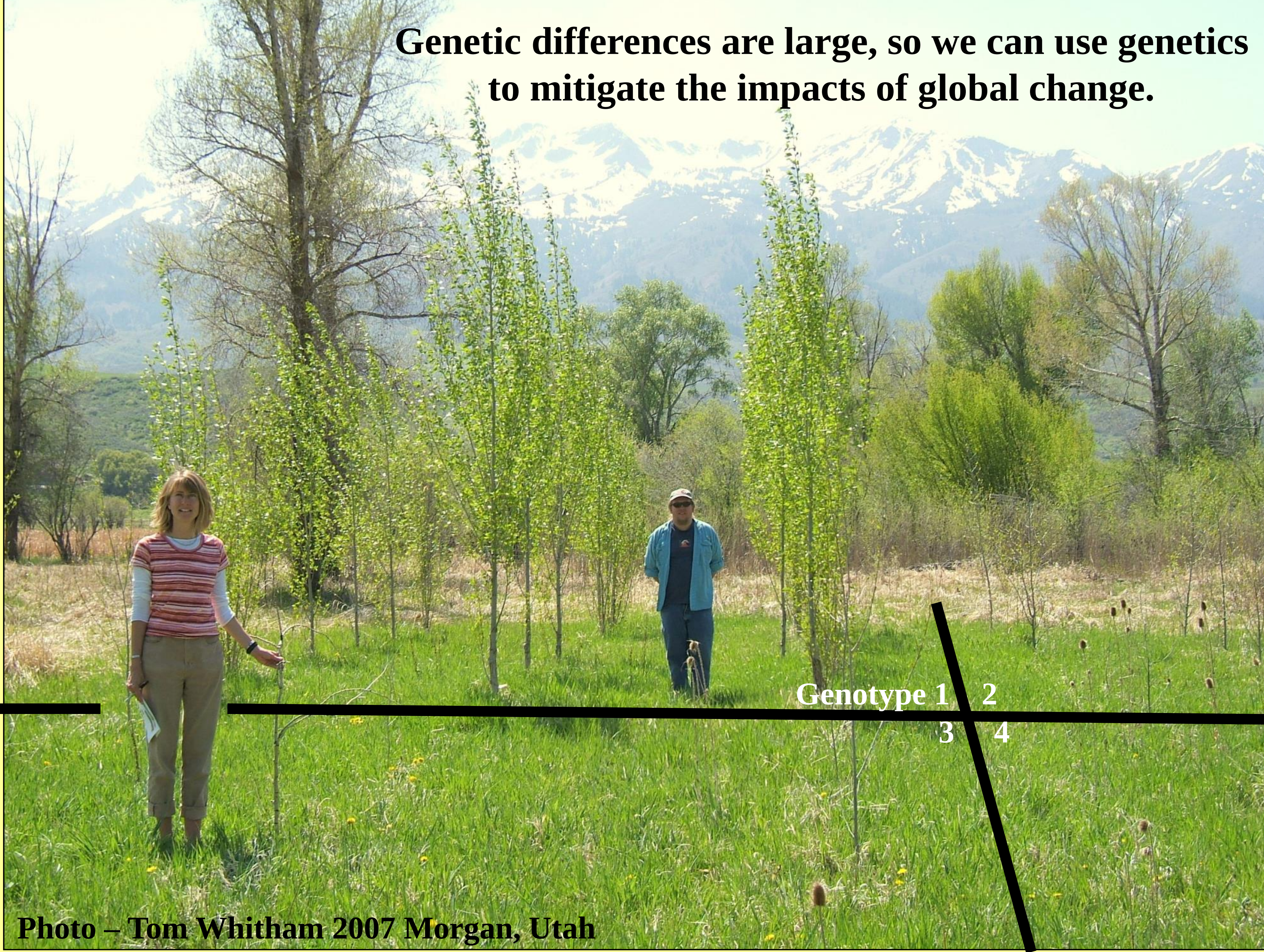
Urban 2015 Science



Within a site, increased stress negatively affects arthropod diversity.

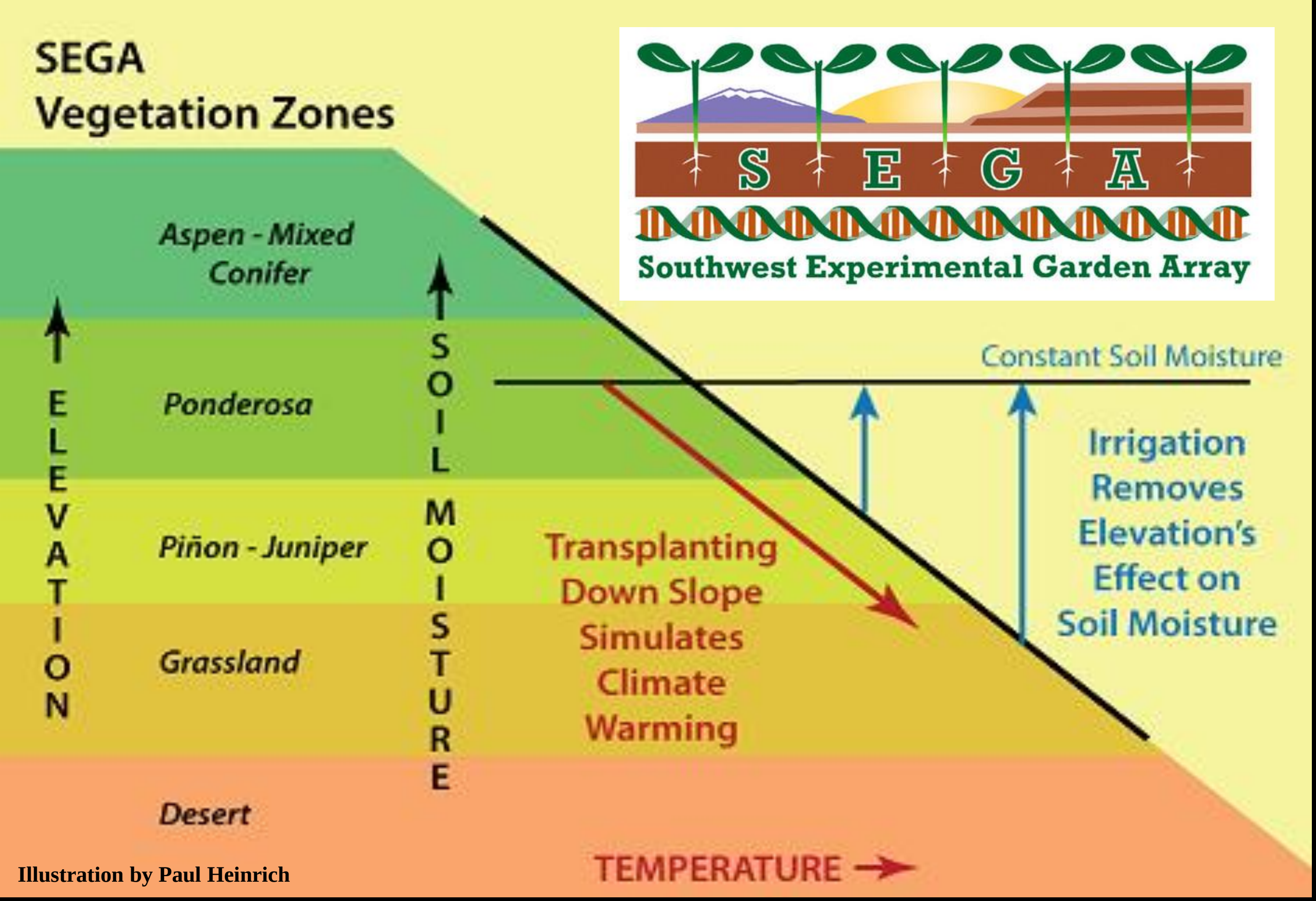
Stress Index = (standardized branch dieback + number of needle cohorts + radial trunk growth)

Stone et al. 2010 Oecologia


Genetic differences are large, so we can use genetics to mitigate the impacts of global change.
Genotype 1
2
3
4
Photo – Tom Whitham 2007 Morgan, Utah

SEGA site at The Arboretum at Flagstaff – A network of 10 common gardens along an elevation gradient to develop solutions to global change

The more locally adapted, the greater the impacts of climate change

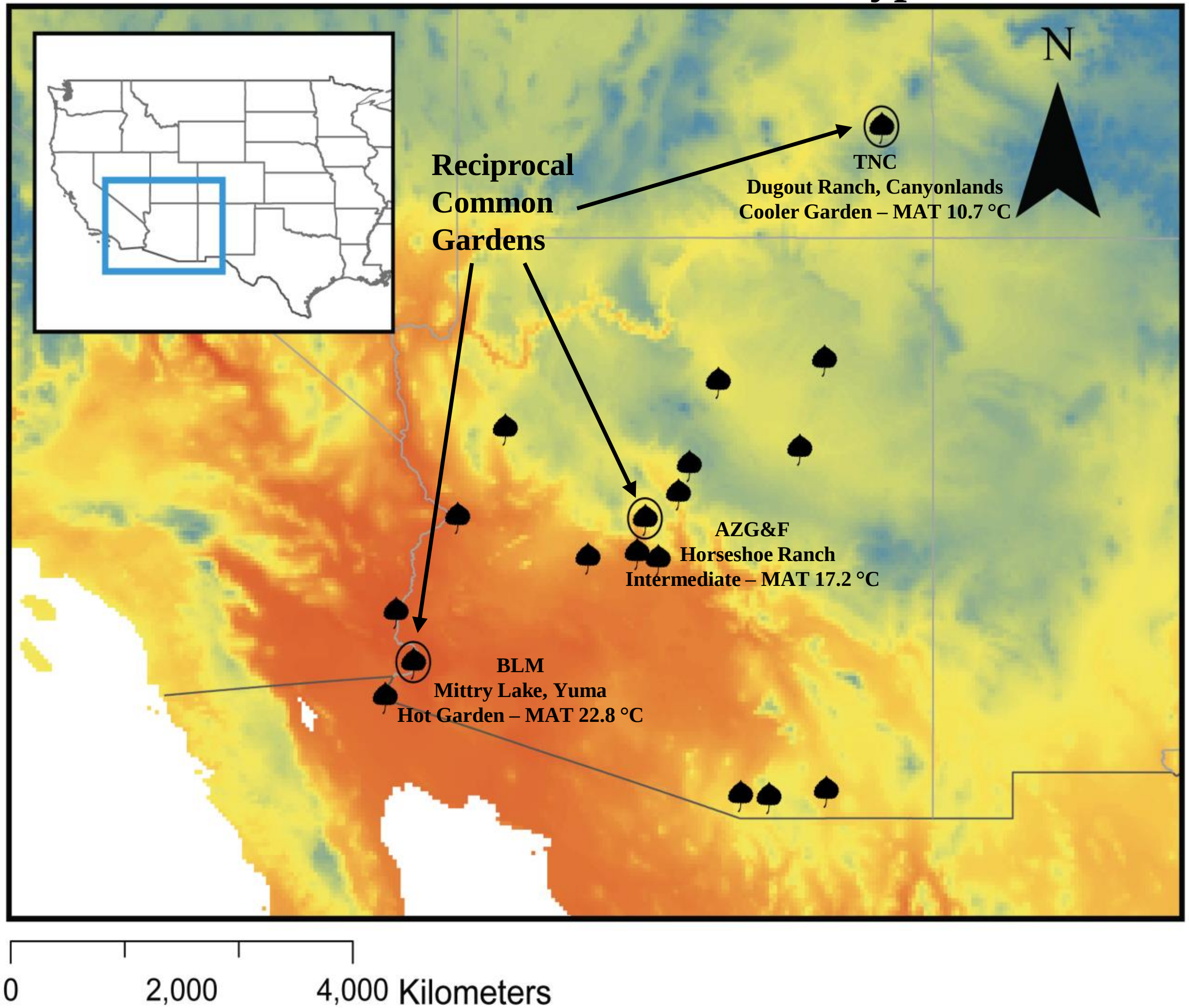


(sega.nau.edu)

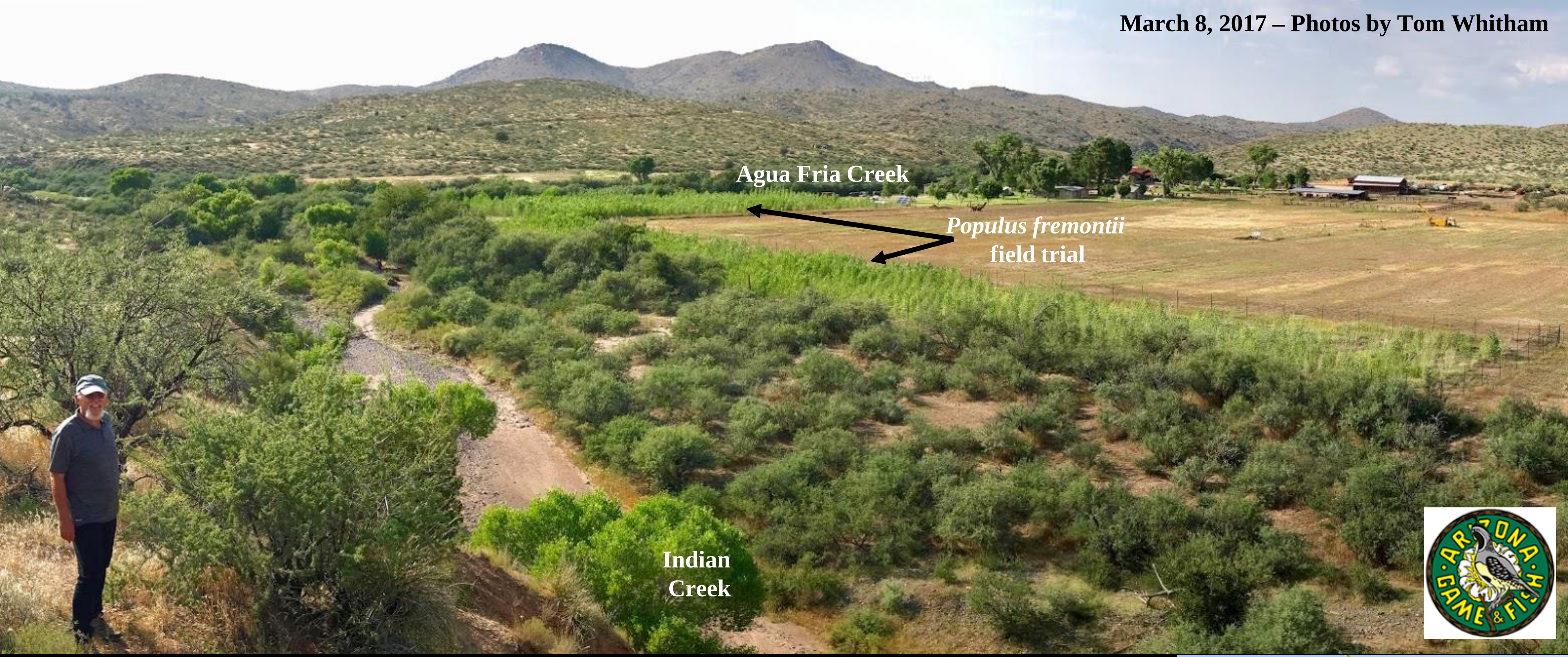
$4.5 million NSF/NAU, GO, and NGO Participants: USFS, NPS, BLM, BOR, TNC, AZ Game & Fish, Babbitt Ranches, Grand Canyon Trust, & The Arboretum at Flagstaff

If plants must move to survive future climate conditions, how do we decide on which ecotypes and genotypes to use in restoration projects? SEGA network provides next generation genetics-based infrastructure to scientifically make such decisions.

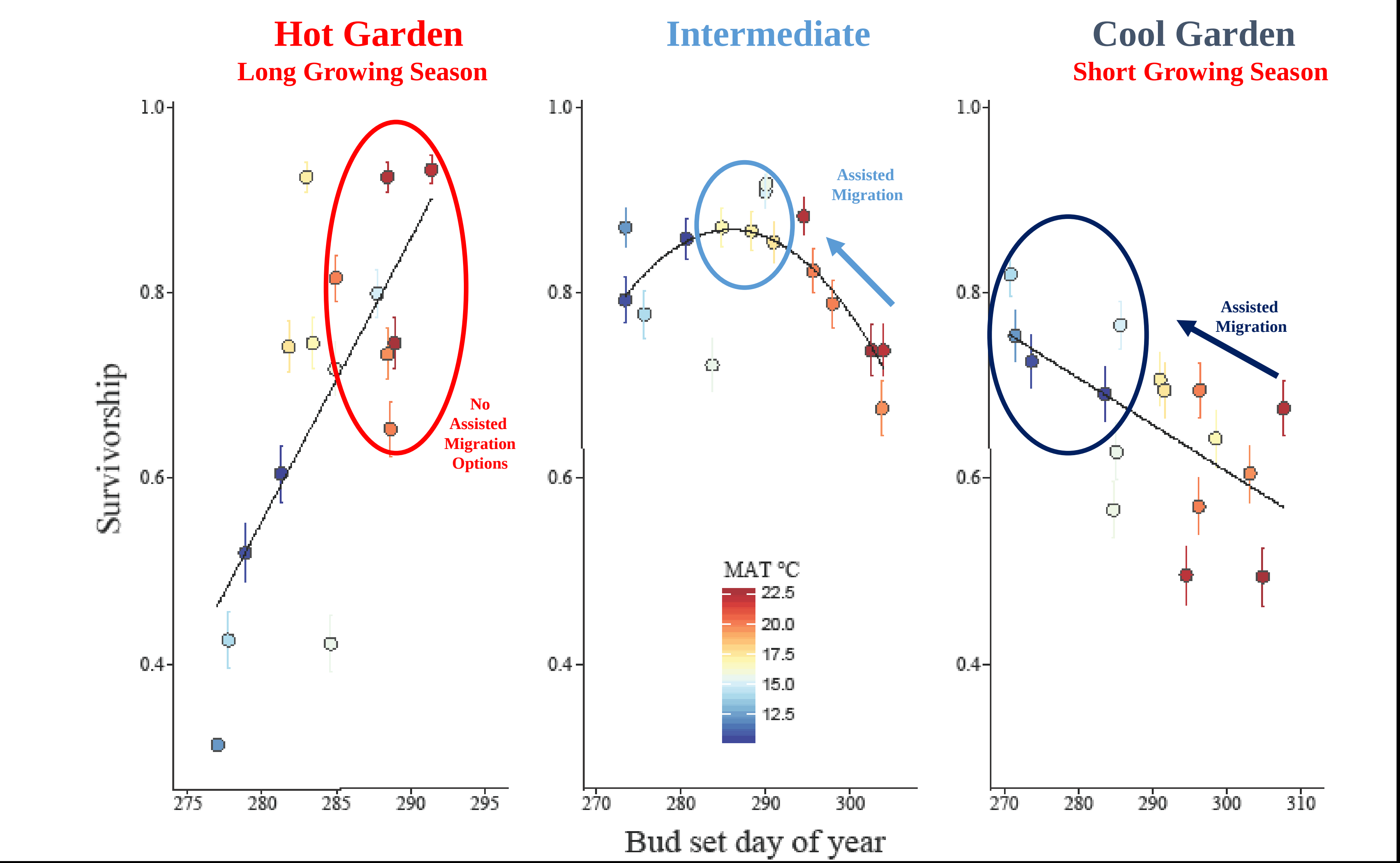
Reciprocal common gardens show fine scale local adaptation within the Sonoran desert ecotype



Location map of 16 provenance collection sites (leaf icon) of *Populus fremontii* and the three common garden locations (leaf with circle). The central garden is also a collection site. The shading corresponds to the degree-days above 5°C (DD5) throughout the region: red represents high DD5, blue low DD5. **Cooper et al. 2019 Global Change Biology**



4600 tree common garden on Arizona Game & Fish Dept. lands at Horseshoe Ranch surrounded by Agua Fria National Monument.



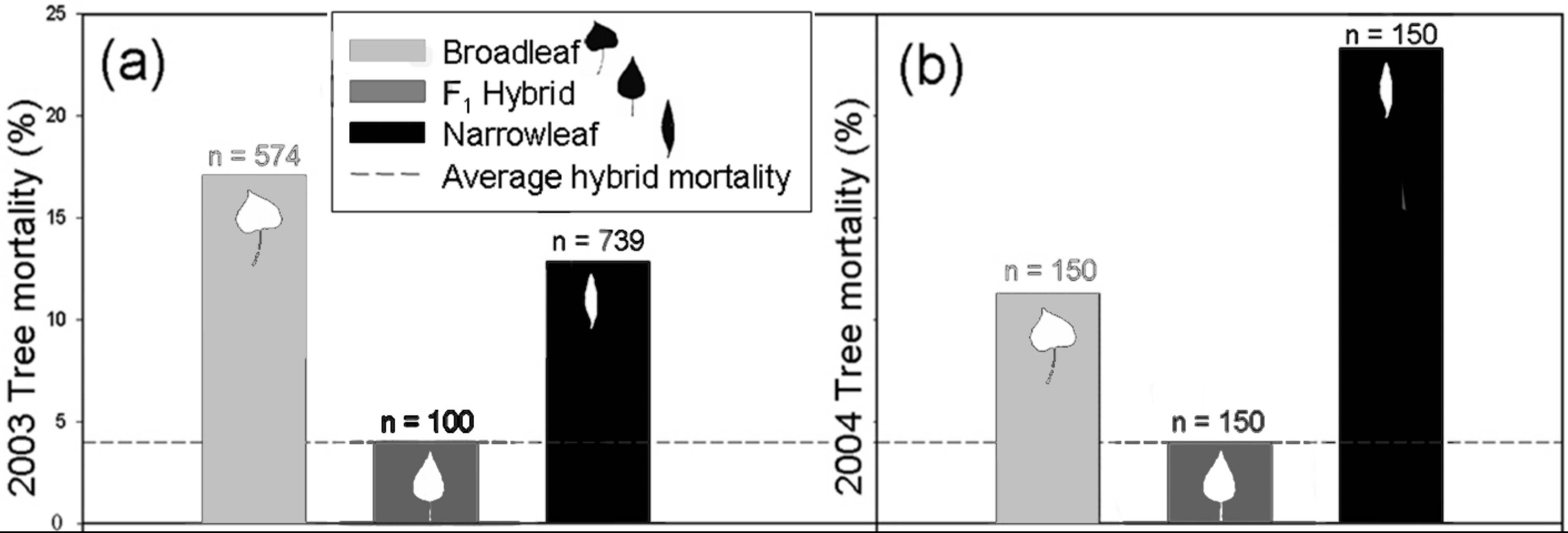
Solution #1 – Use populations from other sites that are already adapted to what the new environment will become.

Population level mean (+/- 1 SE) survival correlations with bud set date in each of the three common gardens. Populations are colored by the mean annual temperature (MAT °C) of their source provenance. In Yuma, survival is highest in the hotter source populations and is positively correlated with later bud set. The opposite is true in the coldest Canyonlands garden. Cooper et al. 2019 Global Change Biology.

Solution #2 – Genetics-based differences in architecture make upright and spreading trees more competitive with invasive tamarisk

Sean Mahoney et al. 2018 Restoration Ecology; Photos by Heather Gillette

Solution # 3 – Use naturally occurring hybrids that are more drought adapted than their parental species.



Woolbright et al. 2014 Trends in Ecology & Evolution; Gitlin et al. unpub. data

Solution # 4 – Use genotypes from desert populations that root deeper and faster than genotypes from higher elevation populations.

Jackie Parker's rooting expt., unpub. data

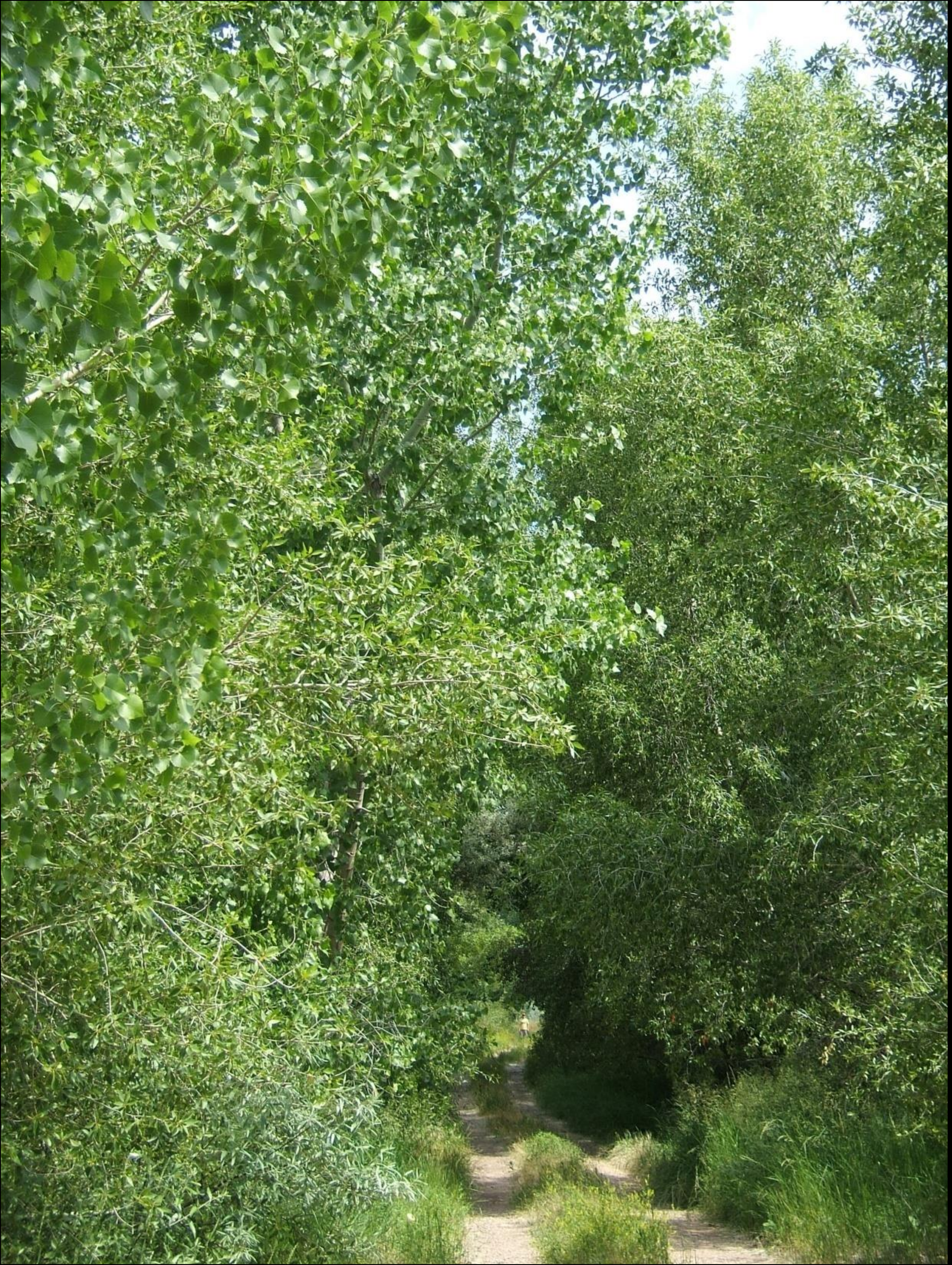
Seedling from Drought Tolerant Mother

Seedling from Drought Intolerant Mother

Solution # 5 – Inoculate plants with better mutualists. A 2000 tree pinyon pine common garden experiment shows that drought tolerance is genetically based and the mycorrhizae on drought tolerant trees are better mutualists (Gehring et al. 2017 PNAS). Similar findings with cottonwoods (Markovchick unpub. data)

Solution # 6 – Use tree genotypes that are very plastic (resilient) with environmental change.

Reaction norms show significanat G, E, and G x E interactions in the arthropod communities of *Pinus edulis* (Stone et al. 2019 Frontiers in Plant Science).

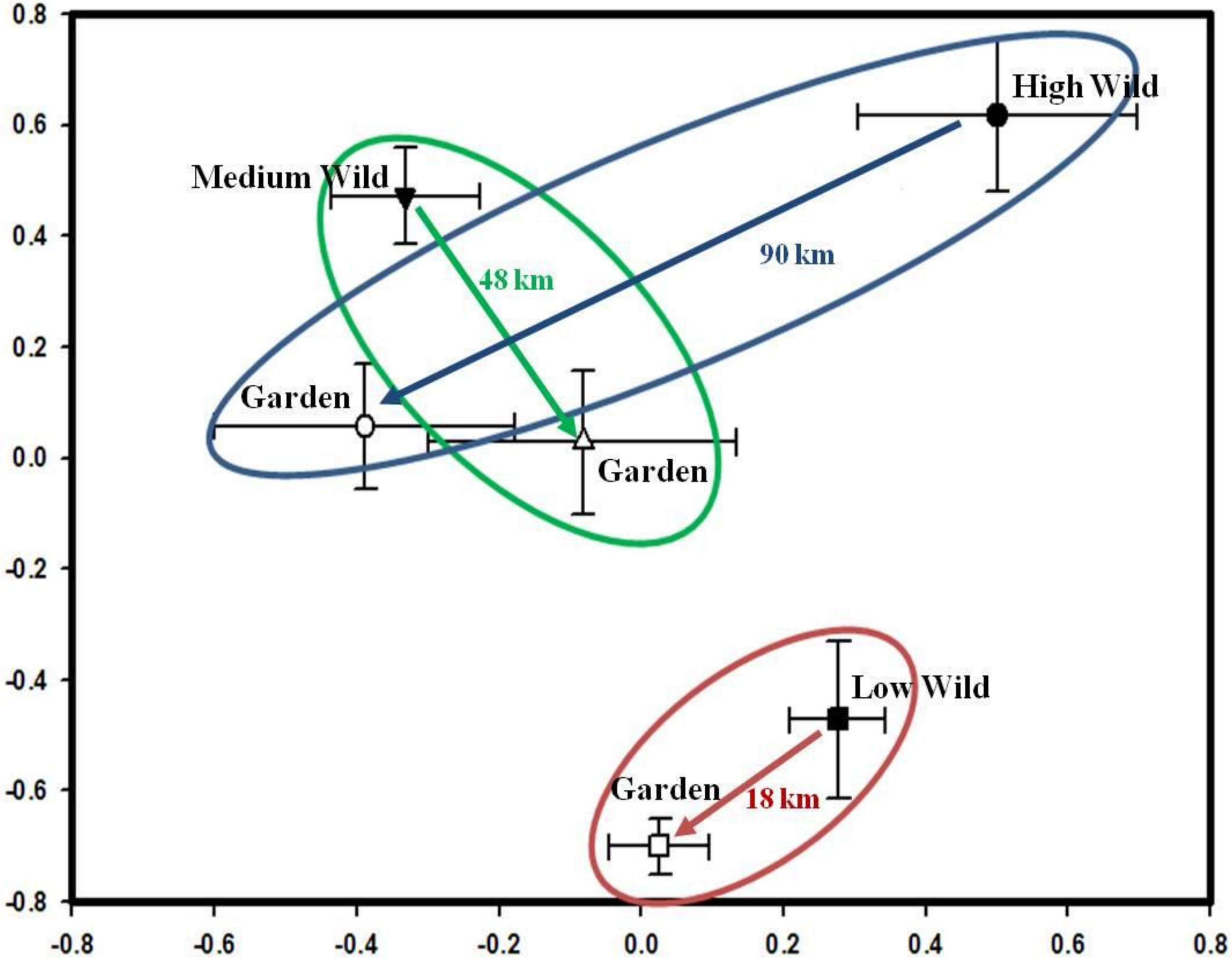


Solution # 7 – Assisted migration distances should be as short as possible to assist migrating communities.

A fundamental issue in assisted migration is if you move plants to mitigate the impacts of climate change, will plants acquire the communities of their home sites? In other words, if you build it will they come?

Odgen Nature Center restoration site
Photo by Tom Whitham

Up to a point, if you built it they will come.



With transfers of 18 and 48 km, garden and wild trees support similar communities, but at 90 km they are quite different (Keith et al. unpublished data).

Removing invasive tamarisk and camelthorn on the Little Colorado River and restoring using new genetic guidelines with the support of Babbitt Ranches, the Nina Mason Pulliam Charitable Trust and the Wildlife Conservation Society.

BABBITT RANCHES ARIZONA

NINA MASON PULLIAM
CHARITABLE TRUST
Building a Legacy of Community Grantmaking since 1998

Wildlife Conservation Society

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Kevin Grady – restoration
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Dana Ikeda – climate modeling
Karl Jarvis – phylogeny
George Koch – ecophysiology
Jamie Lamit – microbial ecology
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Brad Potts – quantitative genetics
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Macrosystems MRI