Cottonwood lessons: Can best management practices increase restoration effectiveness?

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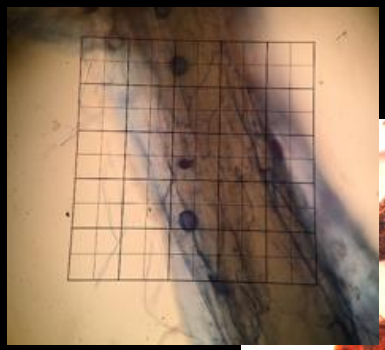
Photo: High Tech Highschool Astronomy Club, Pulliam-Babbit Common Garden

Best management practices

- Assisted migration from 3ºC warmer sites, plus local genotypes
- Willow buddy
- Mycorrhizal inoculation
  - In tamarisk-invaded areas vs. non-tam?
- In combination?
  (up to 75% chance of a reversal if considering 4 factors, Whitham *et al.* 2010)



Photos: Lisa Markovchick

Hypotheses

1) Tamarisk (*Tamarix* spp.) legacy will reduce cottonwood (*Populus fremontii*) survival and growth.

2) Best practices will ameliorate some of the impact of tamarisk legacy on cottonwoods:
    a) 3ºC assisted migration
    b) Mycorrhizal inoculation
    c) Willow (*Salix exigua*) buddies

3) The effects of best practices will be synergistic.

Pulliam-Babbitt Common Garden (PBCG)

Thank you,
sand mining….
Babbitt Ranches &
Pulliam Charitable Trust!


Cool Climate Locals
Las Vegas
Pulliam-Babbit Common Garden
Citadel Wash
Keams Canyon
NAU / Flagstaff
Kingman
Jack Rabbit
Bull Pen
3 º C Climate Transfers
Agua Fria
Arizona
Phoenix

Experimental Design

Sand Mining Legacy

Tam Legacy

Local Cottie Sources

	Cottie		Cottie		Cottie	
	Cottie		Cottie		Cottie	
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump

3º C Transfer Sources

	Cottie		Cottie		Cottie	
	Cottie		Cottie		Cottie	
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump
	Cottie		Cottie		Cottie	
Stump		Stump		Stump		Stump

+ Willow Buddy (or Not)

+ Mycorrhizal Inoculation (or Not)

Planted: 11/2017, data collection ongoing…

Hypotheses

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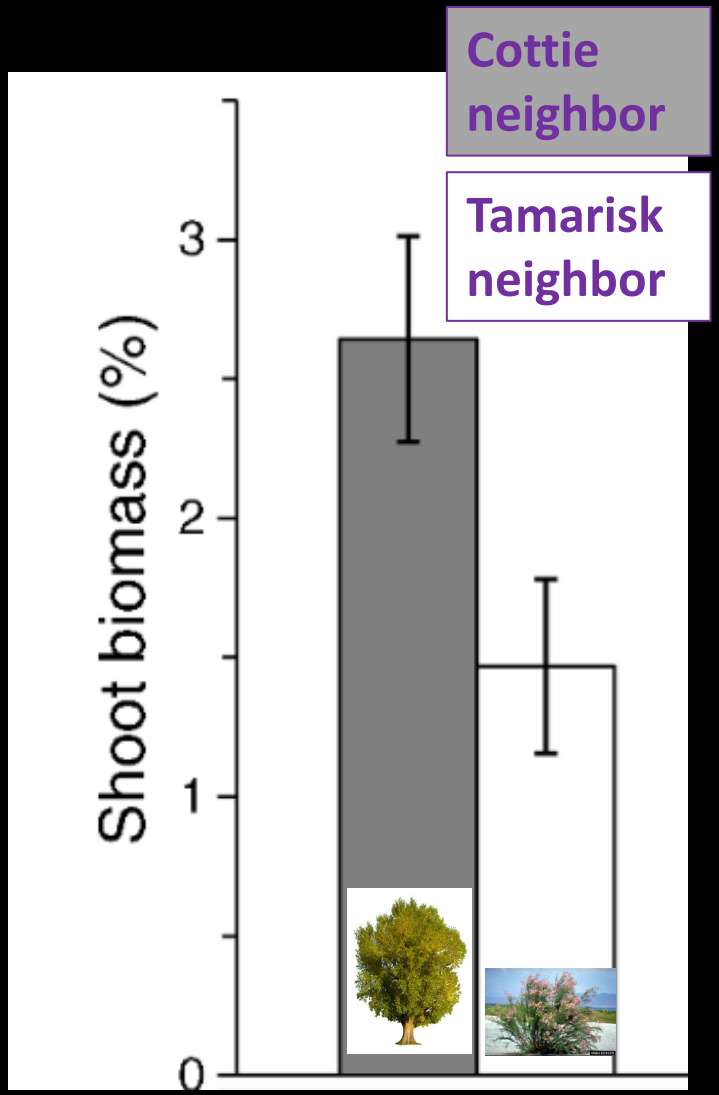
Tamarisk reduces cottonwood success

- Tamarisk decreased cottonwood shoot biomass
- Tamarisk acts as a selection force (e.g. on survival), reducing genetic diversity (Cardall, unpublished data)



Meinhardt & Gehring 2012

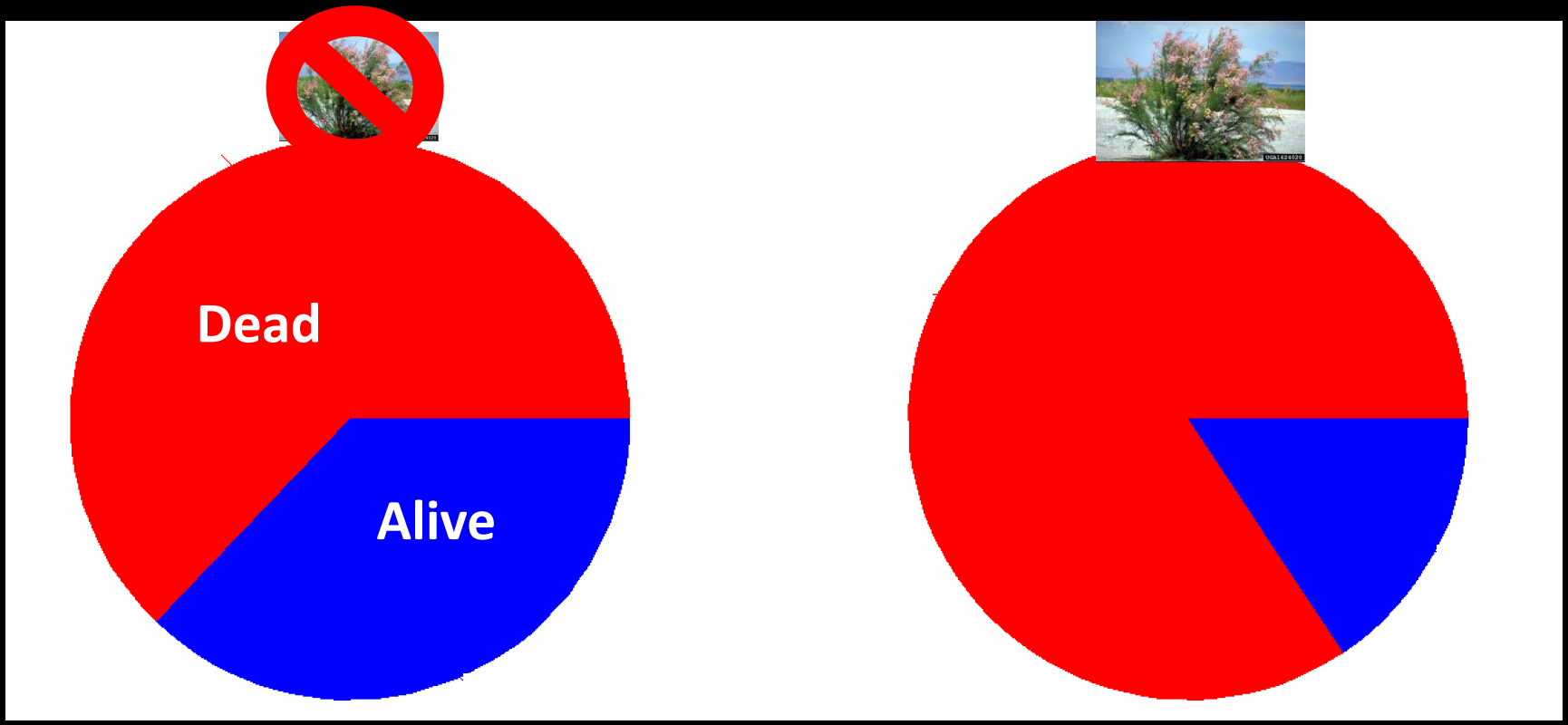
Preliminary 6 mo results:

Did tamarisk legacy soil reduce 6 month survival? Growth?

Tamarisk legacy reduced 6 mo survival

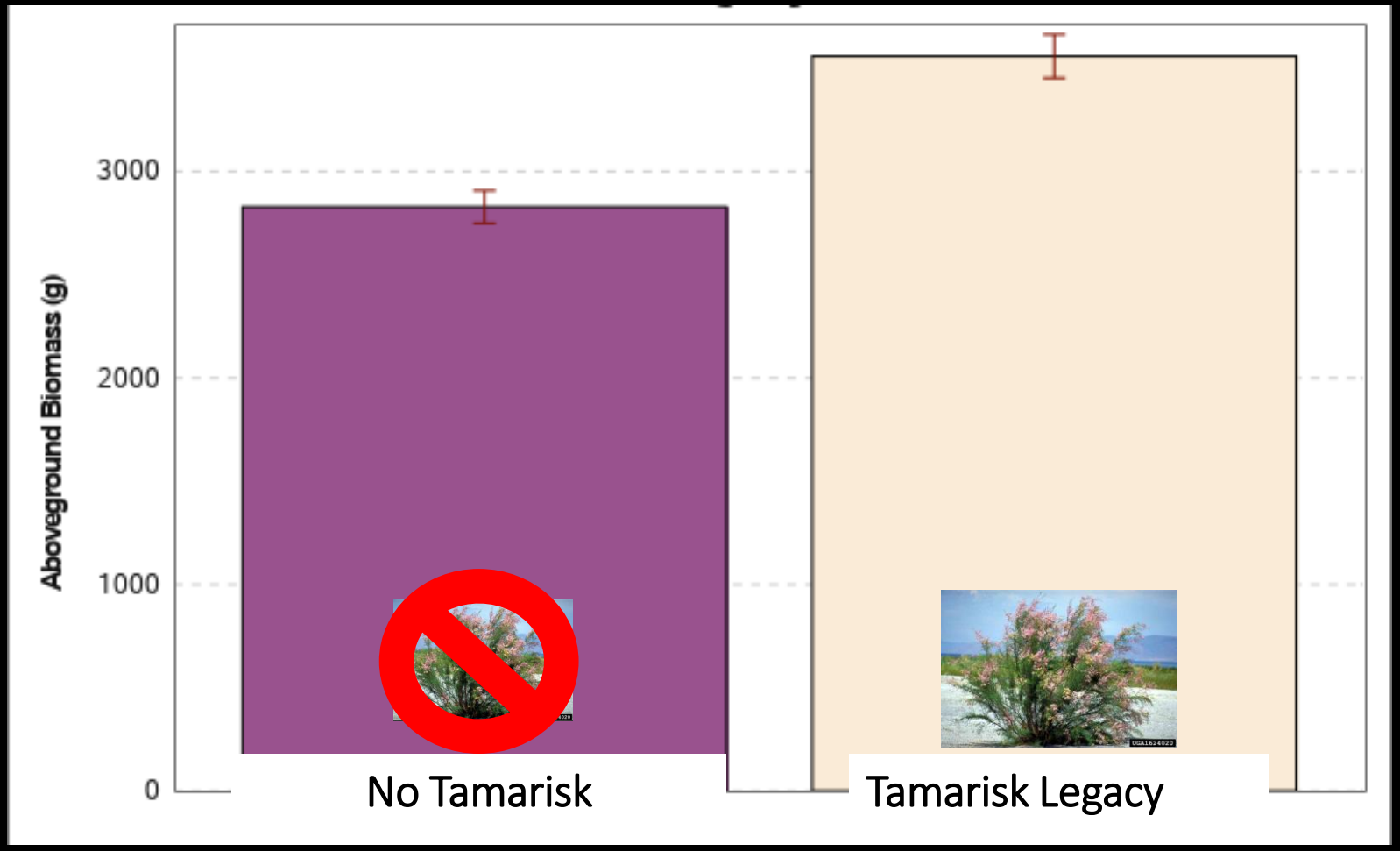
No Tamarisk

Tamarisk Legacy



- n = 955
- p = 0.000

Tamarisk legacy soil increased (?) biomass overall



Surprising, but we are finding mixed results in some other experiments as well

- n = 250
- p = 0.0001
- Error bars = 2 SD

Hypotheses

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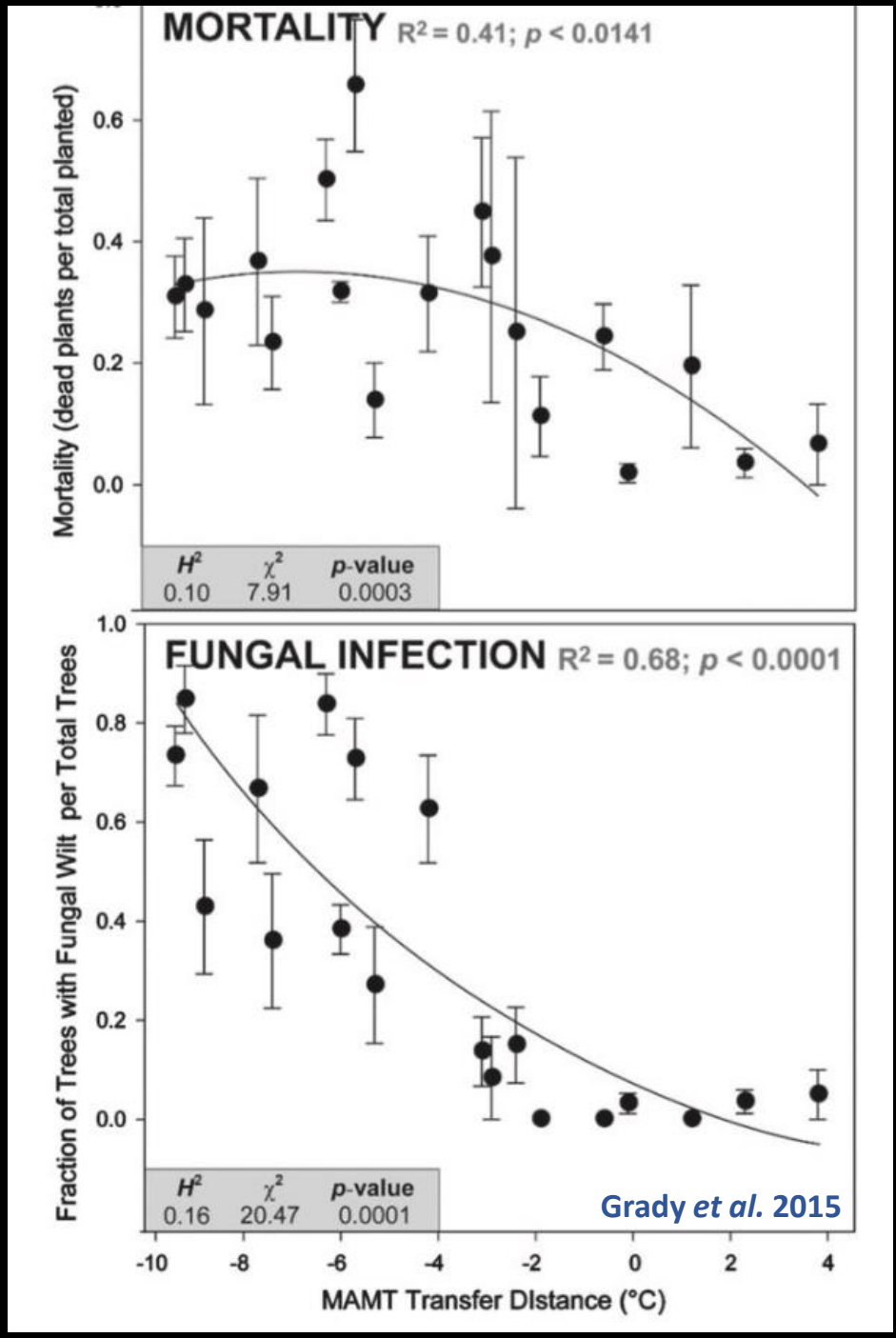
3) The effects of best practices will be synergistic.

Assisted migration: long-term help

- Local trees:
  - higher survival, grow faster, more resistant to *Venturia* shoot blight fungi
- But, to implement assisted migration:
  - Transfers from 3ºC (MAMT) warmer ideal
  - Otherwise current maladaptation to new site overwhelms future benefits



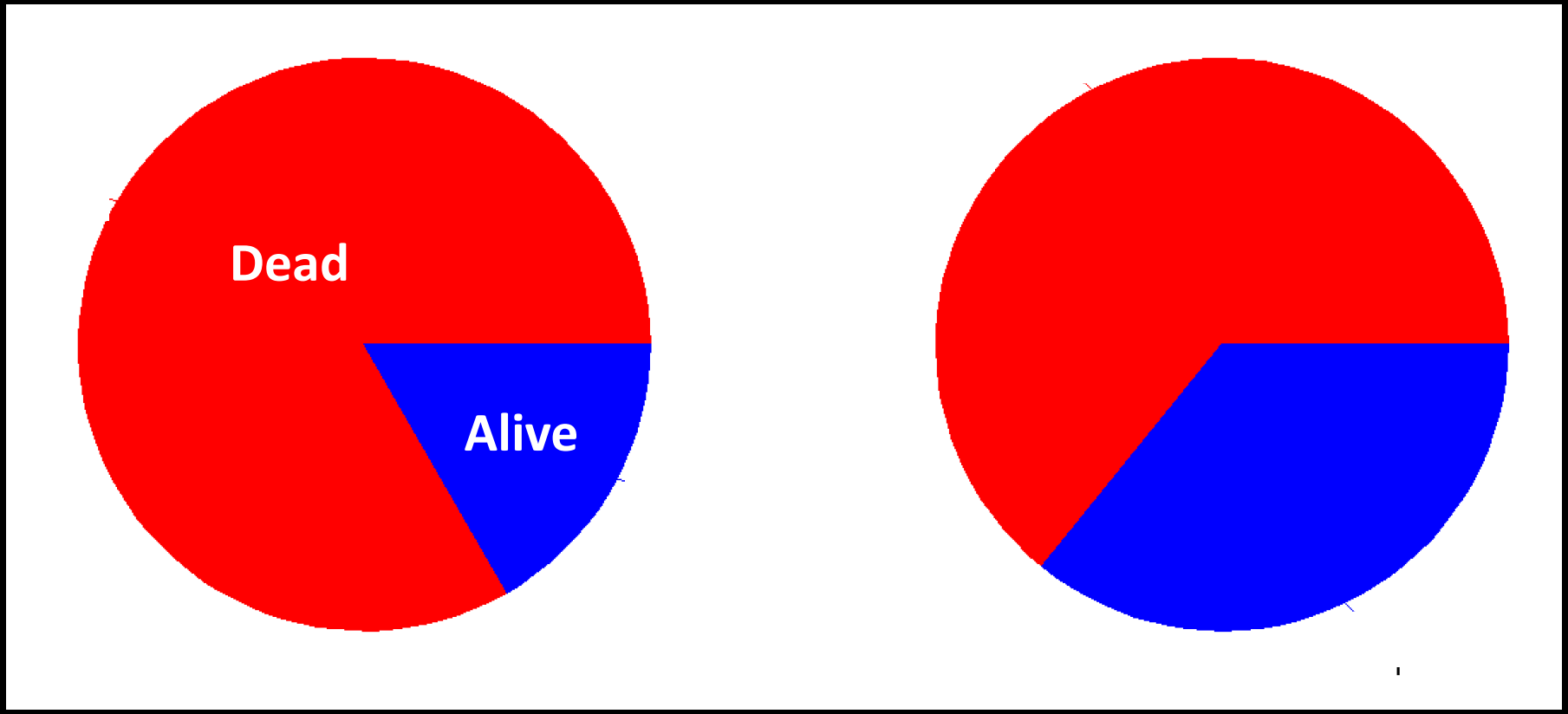
Preliminary 6 mo results:

Did trees from the local climate exhibit better 6 month survival? Growth?

Climate locals demonstrated higher 6 mo survival, but long-term results may differ

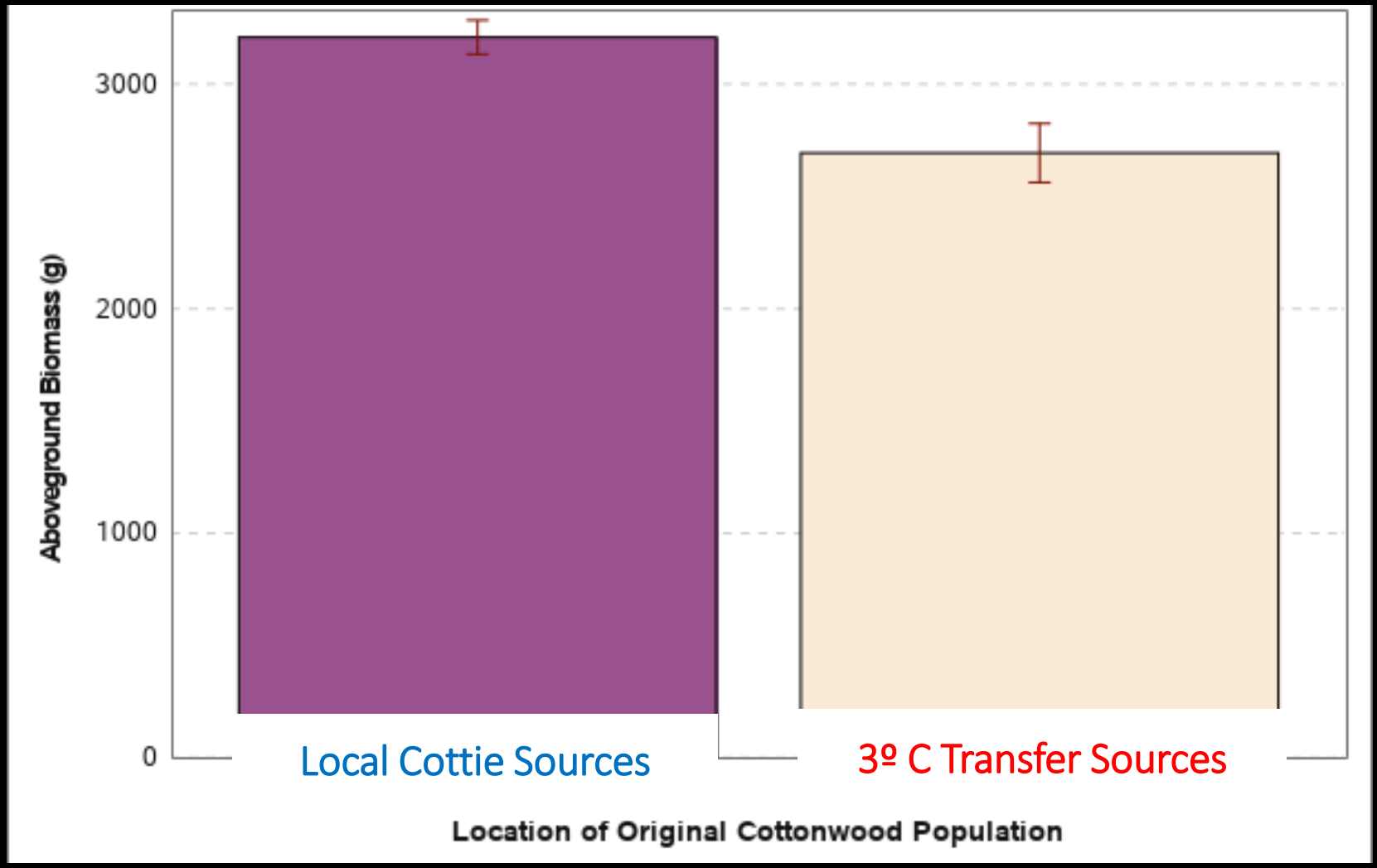
3º C Transfer Sources

Local Cottie Sources



- n = 938
- p = 0.000

Locals show greater above-ground biomass than 3°C transfers



- n = 246, p = 0.003, error bars = 2 SD
- Biomass calculation based on diameter at root collar (DRC) from Lojewski 2009
- DRC, height, and biomass all show the same trend

Hypotheses

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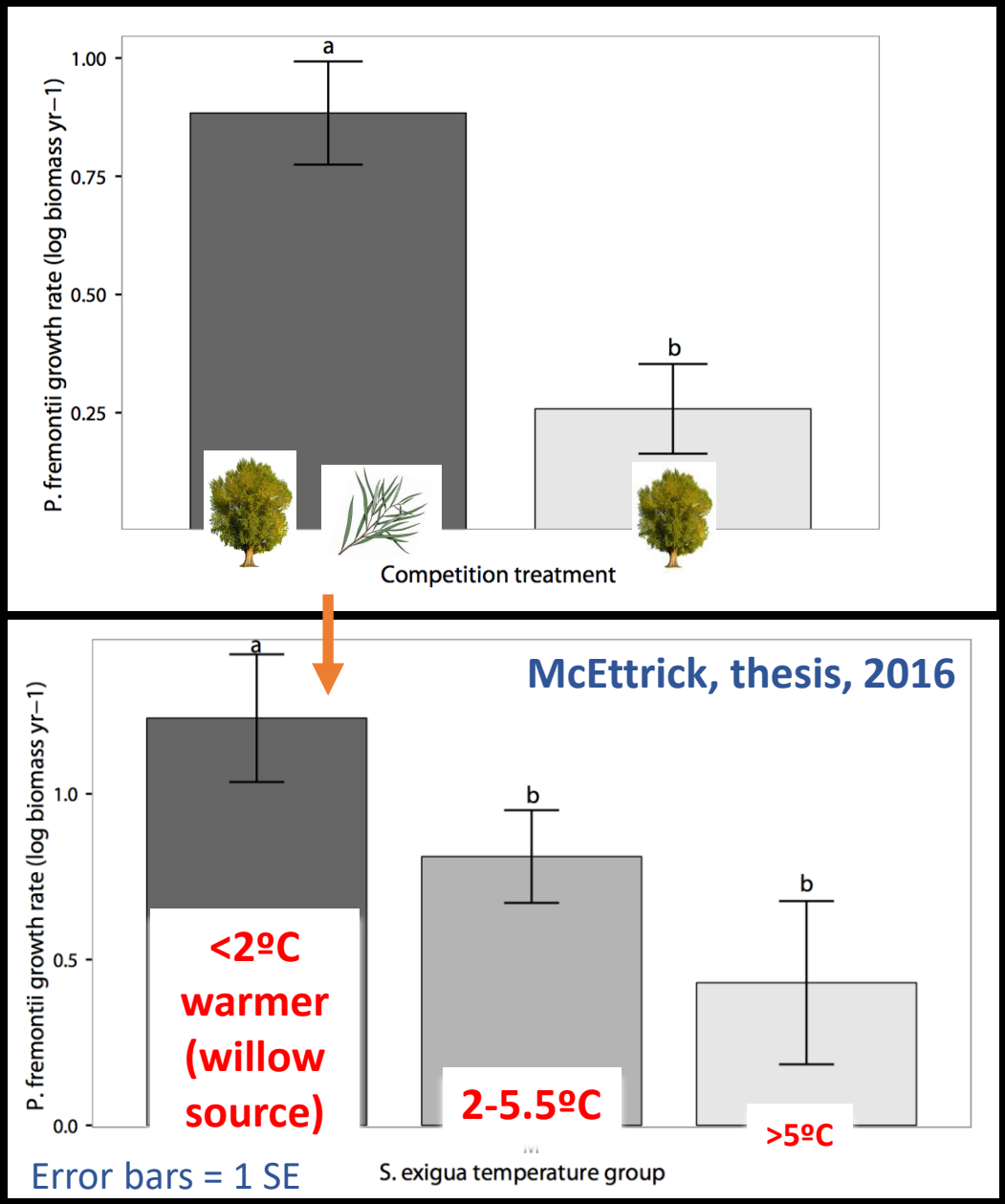
2) Best practices will ameliorate some of the impact of tamarisk legacy on cottonwoods:
   a) 3ºC assisted migration
   b) Willow buddies
   c) Mycorrhizal inoculation

3) The effects of best practices will be synergistic.

Willow buddies: the company you keep

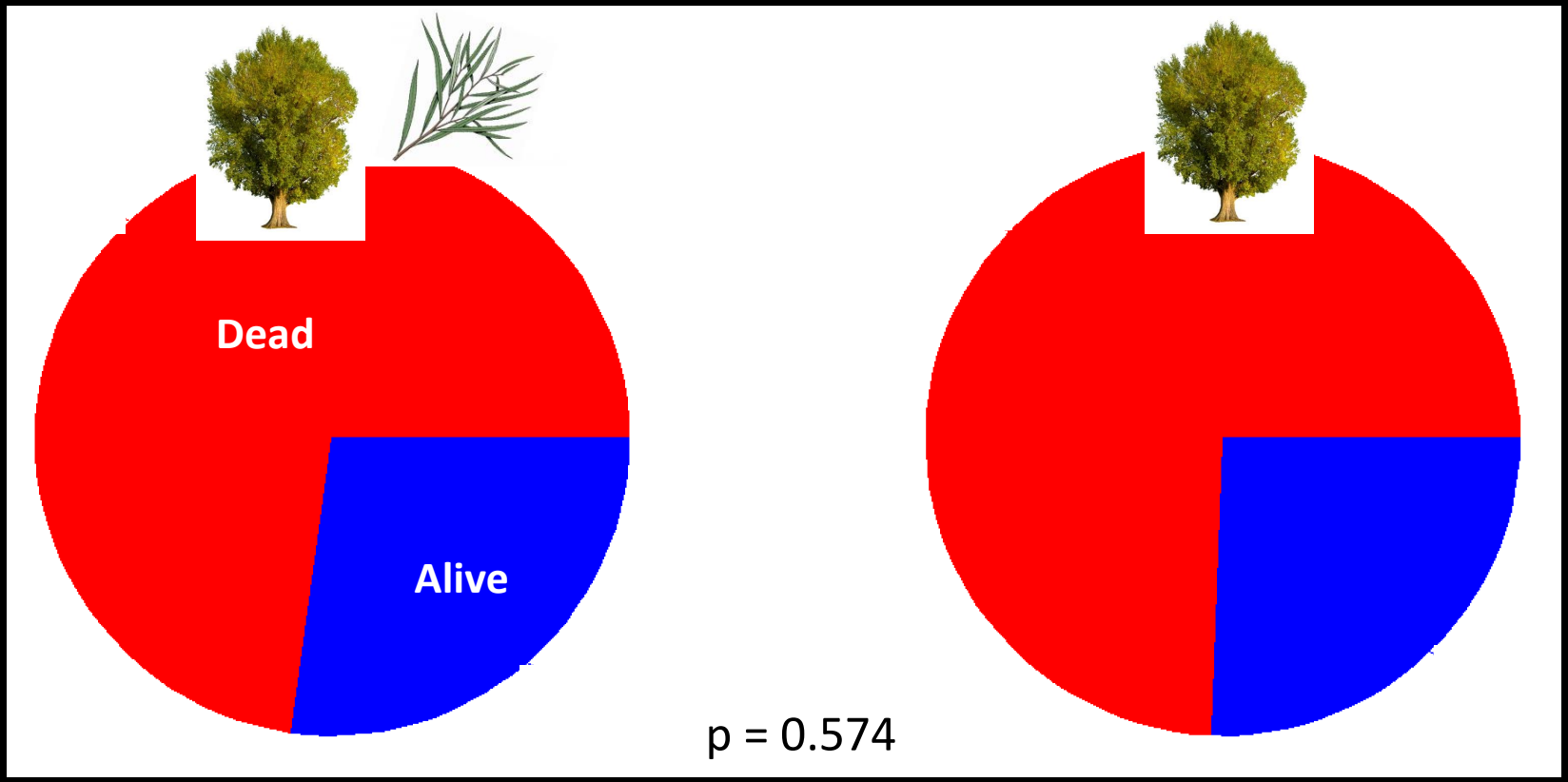
- Willow buddies increased cottonwood growth
- Local climate willows increased growth most
- Also Grady *et al.* 2016



Preliminary 6 mo results:

Did a willow buddy improve survival? Growth?

Willow buddies did not increase 6 month survival



Willow buddies marginally decreased above-ground biomass @ 6 mo

- n = 250
- p = 0.0438
- Error bars = 2 SD

Hypotheses

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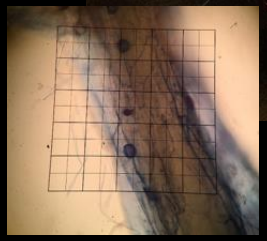
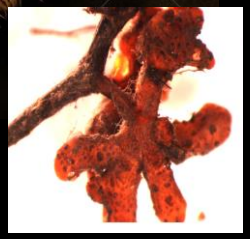
    b) Willow buddy
    c) Mycorrhizal inoculation

3) The effects of best practices will be synergistic.

Mycorrhizas: a helping hand



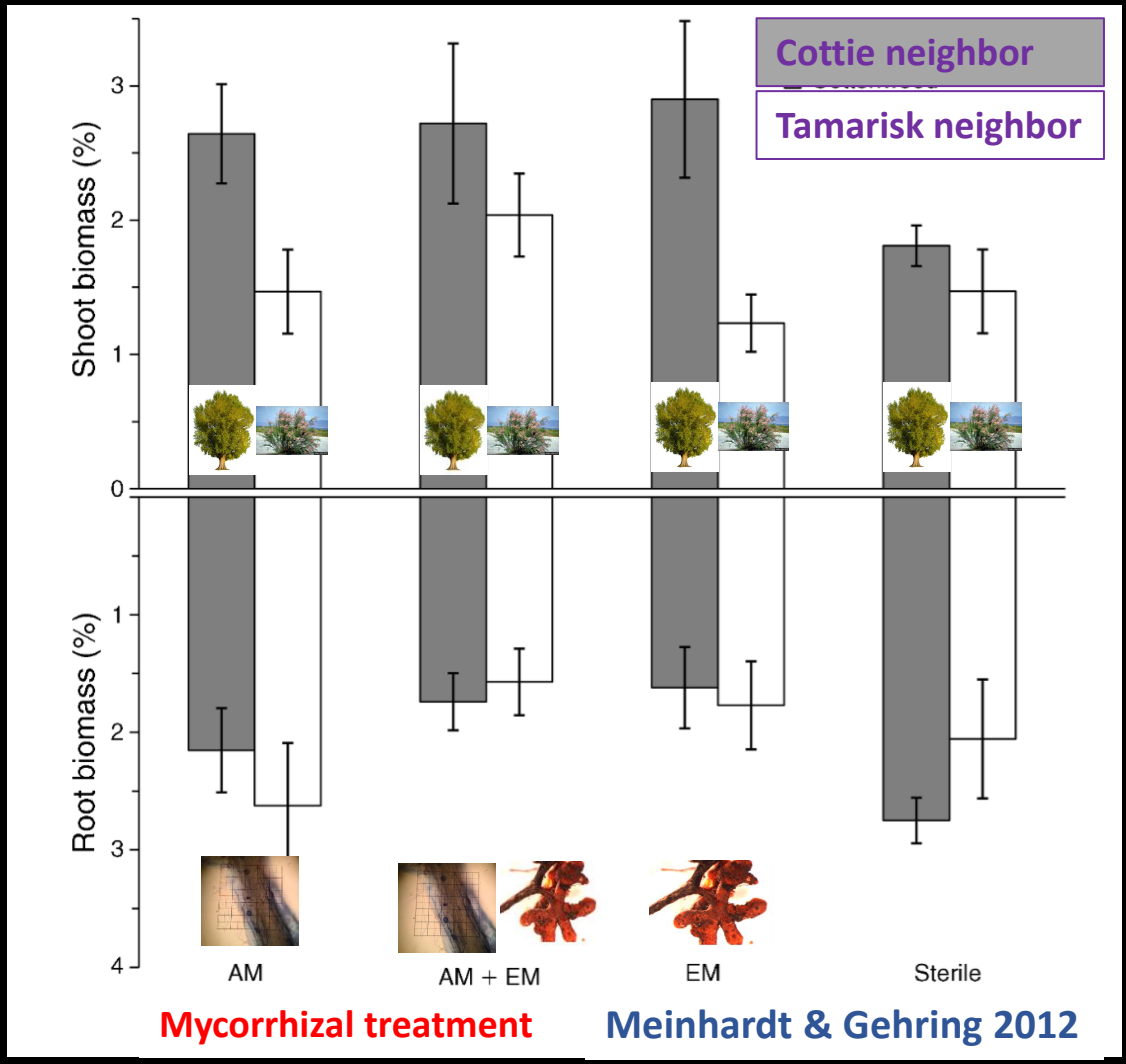


Photos: Lisa Markovchick

- Ancient symbioses: fungi & plants
- 2 main types:
  - arbuscular mycorrhizal fungi (AMF)
  - ecto-mycorrhizal fungi (EMF)
- Vast networks
- Increase access to nutrients
- Assist with stressors (e.g. drought)
- Mediate plant-plant interactions
- Enable swifter tree plasticity
- A great deal to learn: climate change, specific management etc.

Tamarisk & Inoculation: influence of the underworld

- Tamarisk decreased cottonwood shoot biomass
- Tamarisk reduces EMF & AMF colonization
- Inoculation & cottonwood neighbor increased shoot biomass
- Julia Hull's talk – root systems / tam experience



Preliminary 6 mo results:

Did inoculation improve or decrease initial survival? Growth?

Inoculation increased biomass

- n = 250
- p = 0.0100
- Error bars = 2 SD

(survival discussed next)

Hypotheses

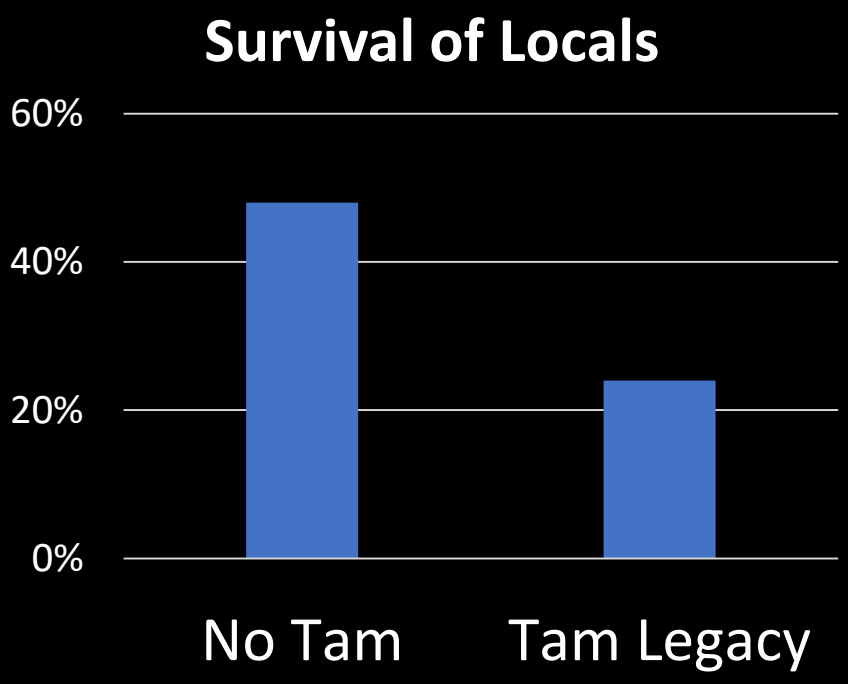
1) Tamarisk legacy will reduce Fremont cottonwood survival and growth.

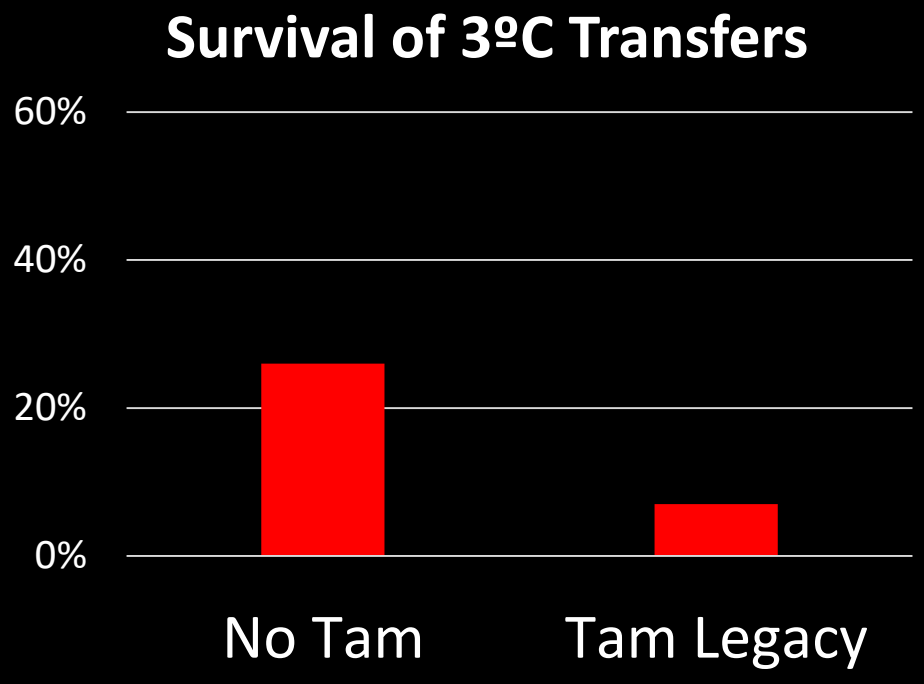
2) Best practices will ameliorate some of the impact of tamarisk legacy on cottonwoods:
    a) 3ºC assisted migration
    b) Mycorrhizal inoculation
    c) Willow buddy

3) The effects of best practices will be synergistic.

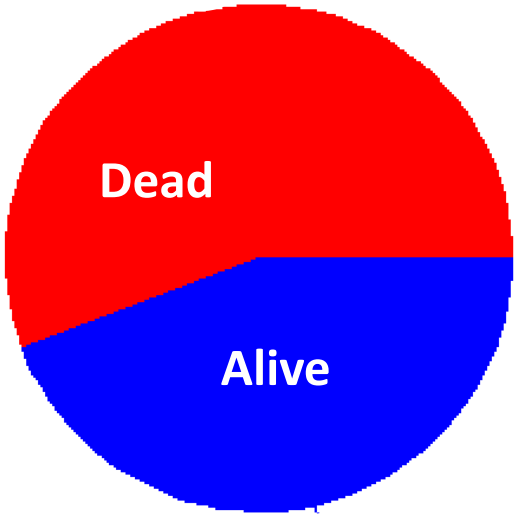
Tamarisk legacy effects greater for climate transfers?

Decreased by 1/2 for locals, by 2/3 for transfers

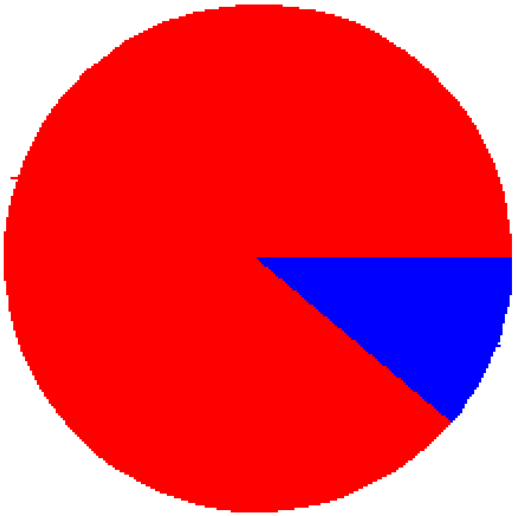




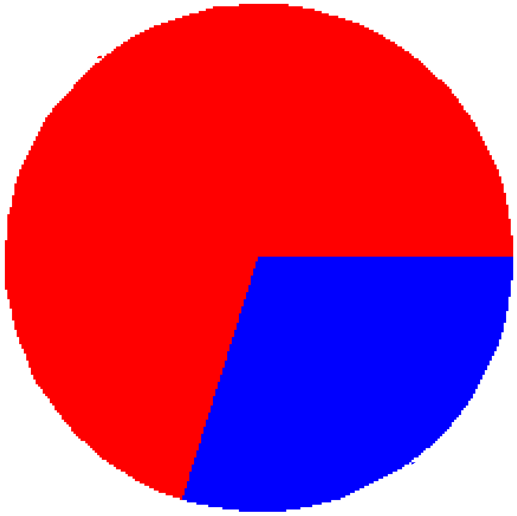
No Inoculation, No Tamarisk



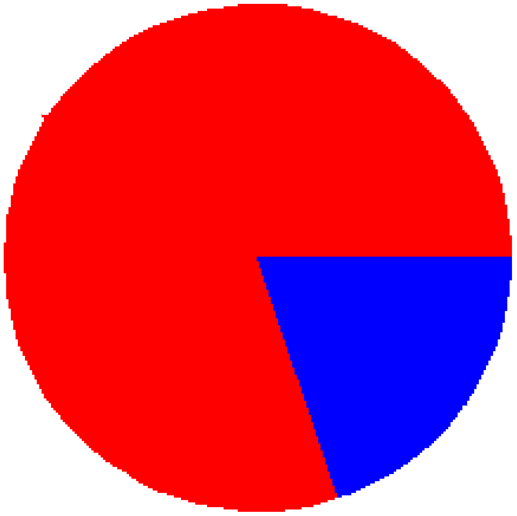
No Inoculation, Tamarisk



Inoculation, No Tamarisk



Inoculation, Tamarisk



Inoculation reduced survival if there was no tamarisk legacy

Inoculation increased survival in tamarisk legacy soil

- n = 952, p = 0.000

Hypotheses

✓ 1) Tamarisk legacy will reduce Fremont cottonwood survival and productivity.

2) Best practices will ameliorate some of the impact of tamarisk legacy on cottonwoods:

a) 3ºC assisted migration Long-term?

✓ b) Mycorrhizal inoculation

c) Willow nurse plant Long-term?

? 3) The effects of best practices will be synergistic.

Management Takeaways

- Inoculation effective at boosting early cottonwood restoration success in tamarisk legacy soils
  - But – could be less helpful in non-tamarisk soils
  - And – inoculate plants prior to planting on-site
- Interactions abound, so working with researchers to navigate subtleties could be beneficial

What's Next?

- Longer-term data
- Identifying taxa / functions
- Understanding mechanisms

Poster session:

Does invasive tamarisk use mycorrhizal fungi?

Abril Belgara-Andrew (St. Mary's College, San Antonio, TX) collecting tamarisk roots at naturalized tam population. Photo: Lisa Markovchick

Photos: Lisa Markovchick & High Tech High

Thank you!

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Questions?