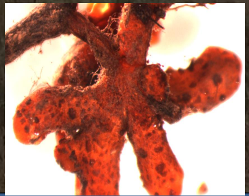
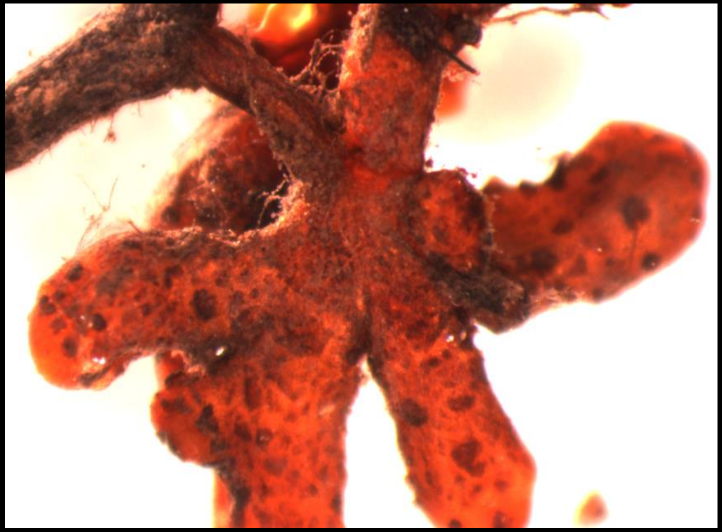
Incorporating Key Restoration Decisions into Habitat Suitability Models to Forecast SWFL Outcomes



James Tracy
Lisa Markovchick
Catherine A. Gehring


Photo: halcyonenv.com/swfl



SWFL fecundity in decline, linked to defoliation & nest temperatures

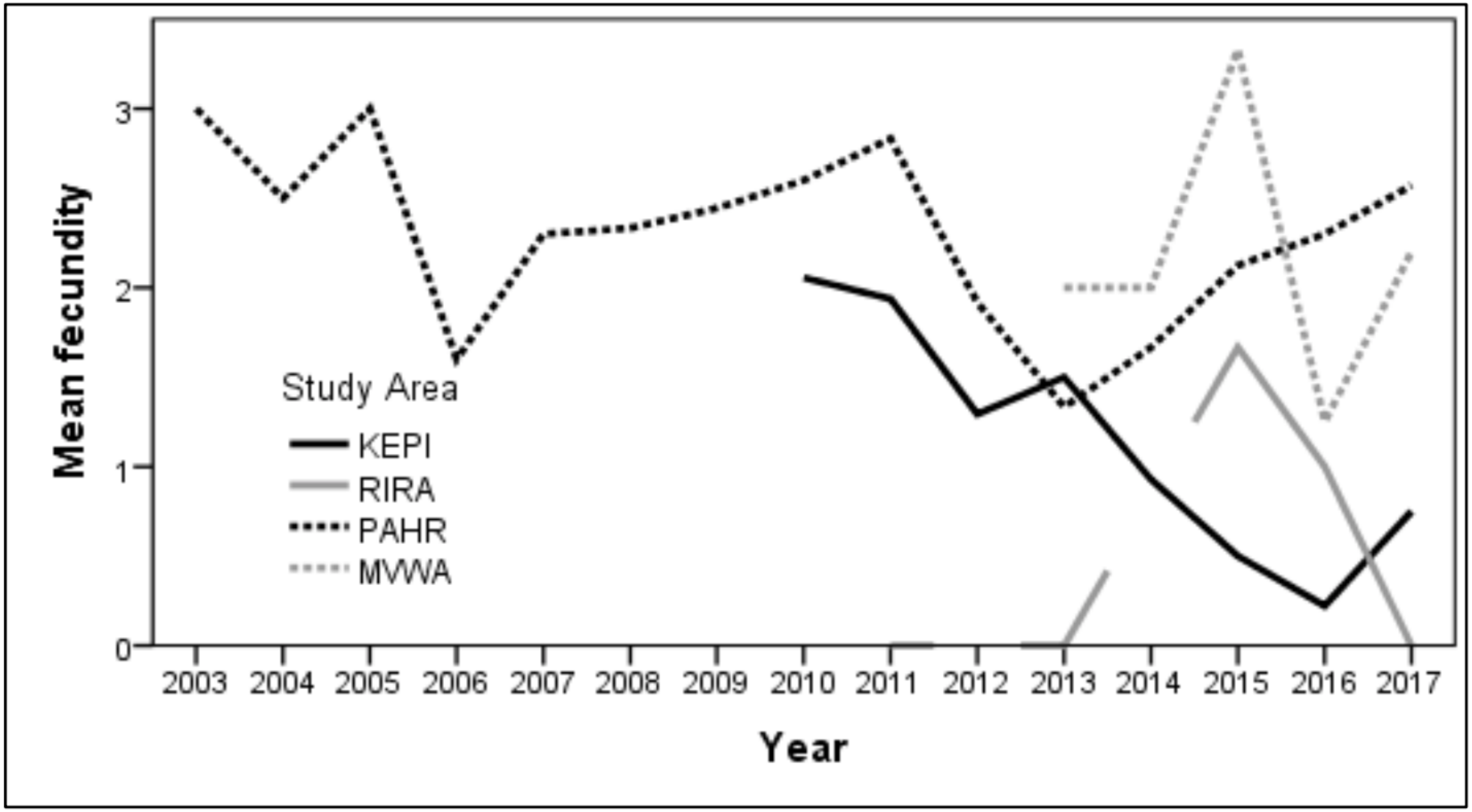
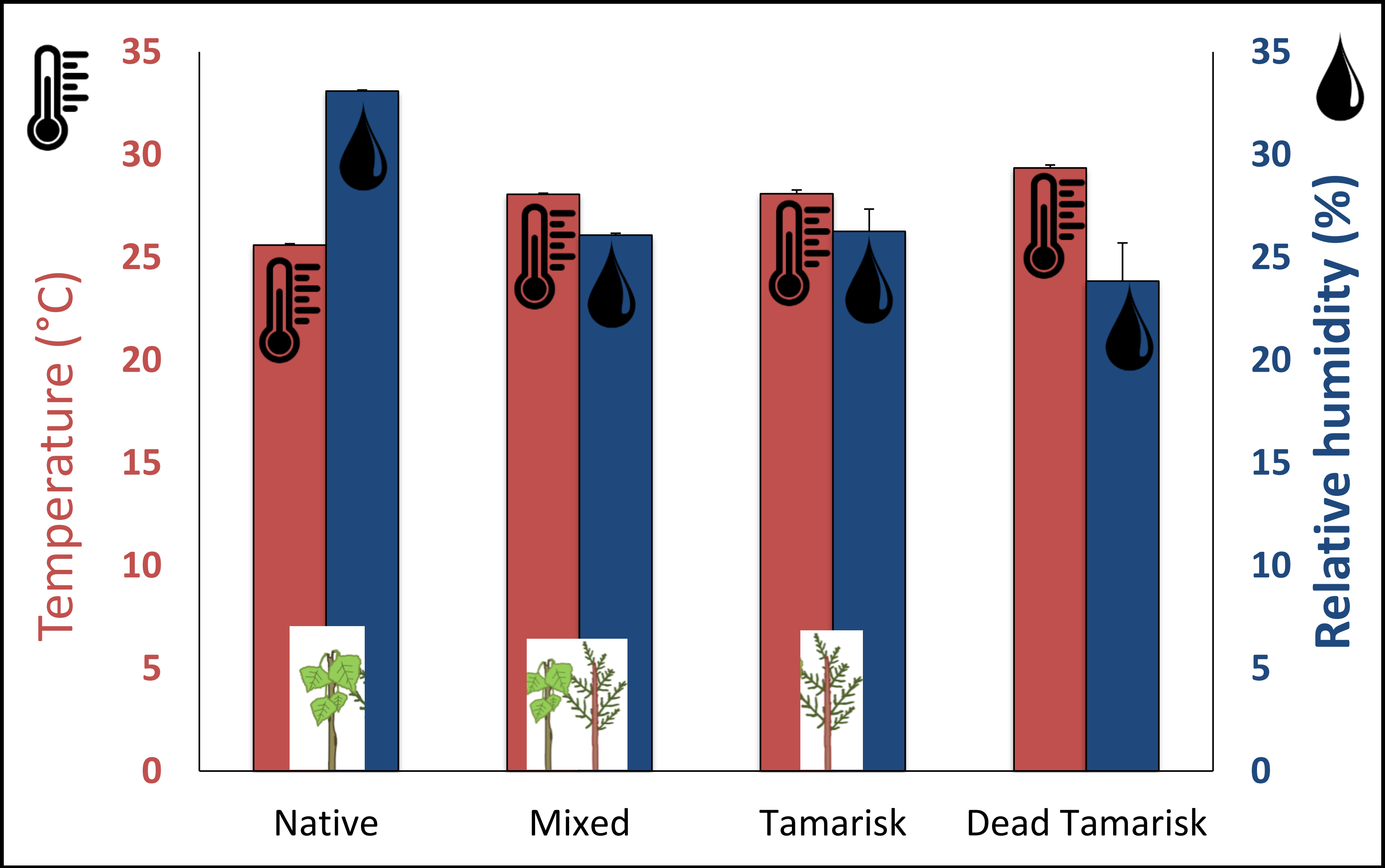


Figure 4-5.—Mean annual fecundity (young produced per female southwestern willow flycatcher) at Key Pittman (KEPI), River Ranch (RIRA), Pahranagat (PAHR), and Meadow Valley Wash (MVWA), 2003–17.

Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2013–2017 Summary Report, May 2019

Mixed, tamarisk & dead tam sites warmer & drier – restoring native veg even more important

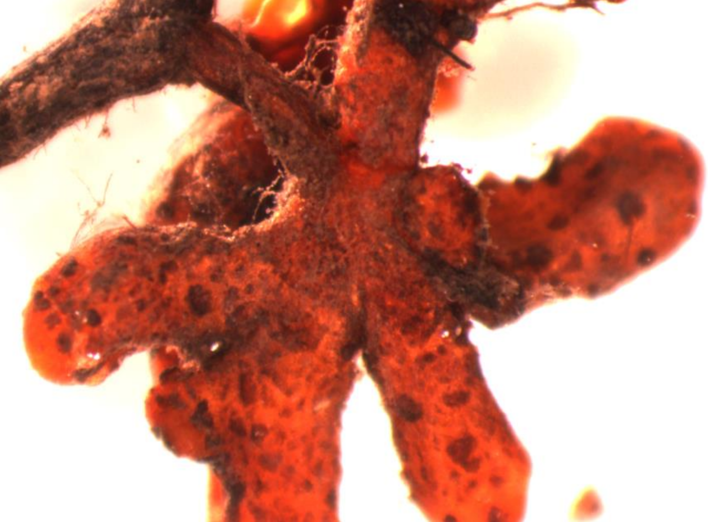


Temperature: F=273.9, p<0.00001

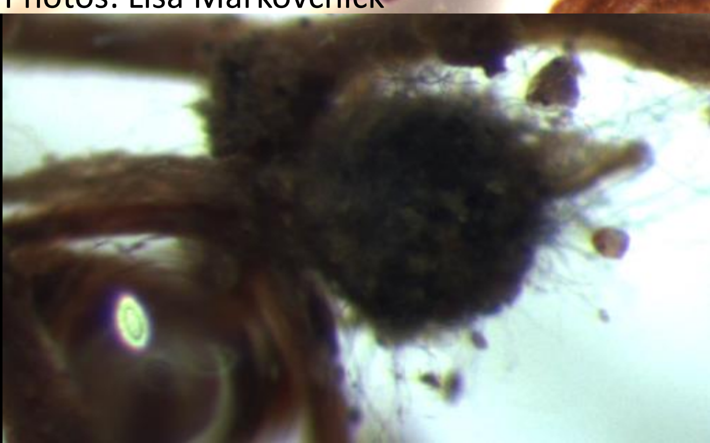
Relative Humidity: F=590.2, p<0.00001

Data by Sean Mahoney


Photos: Lisa Markovchick




Photos: Lisa Markovchick



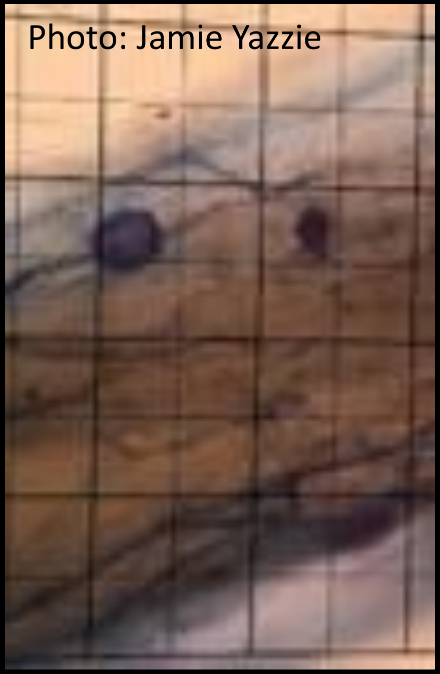
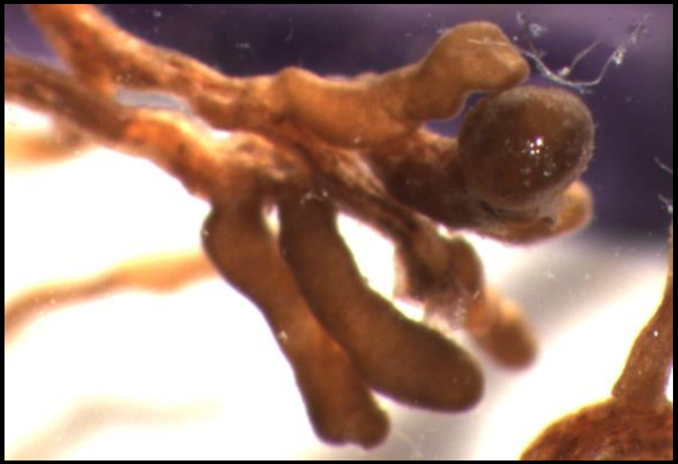


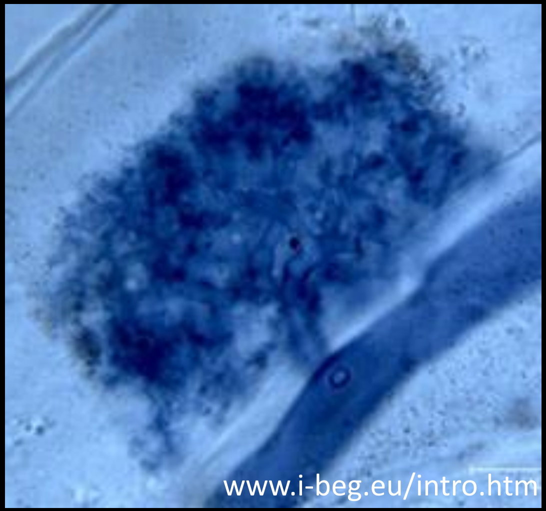
Photo: Jamie Yazzie

Mycorrhizal fungi

Ecto-mycorrhizal fungi (EMF)

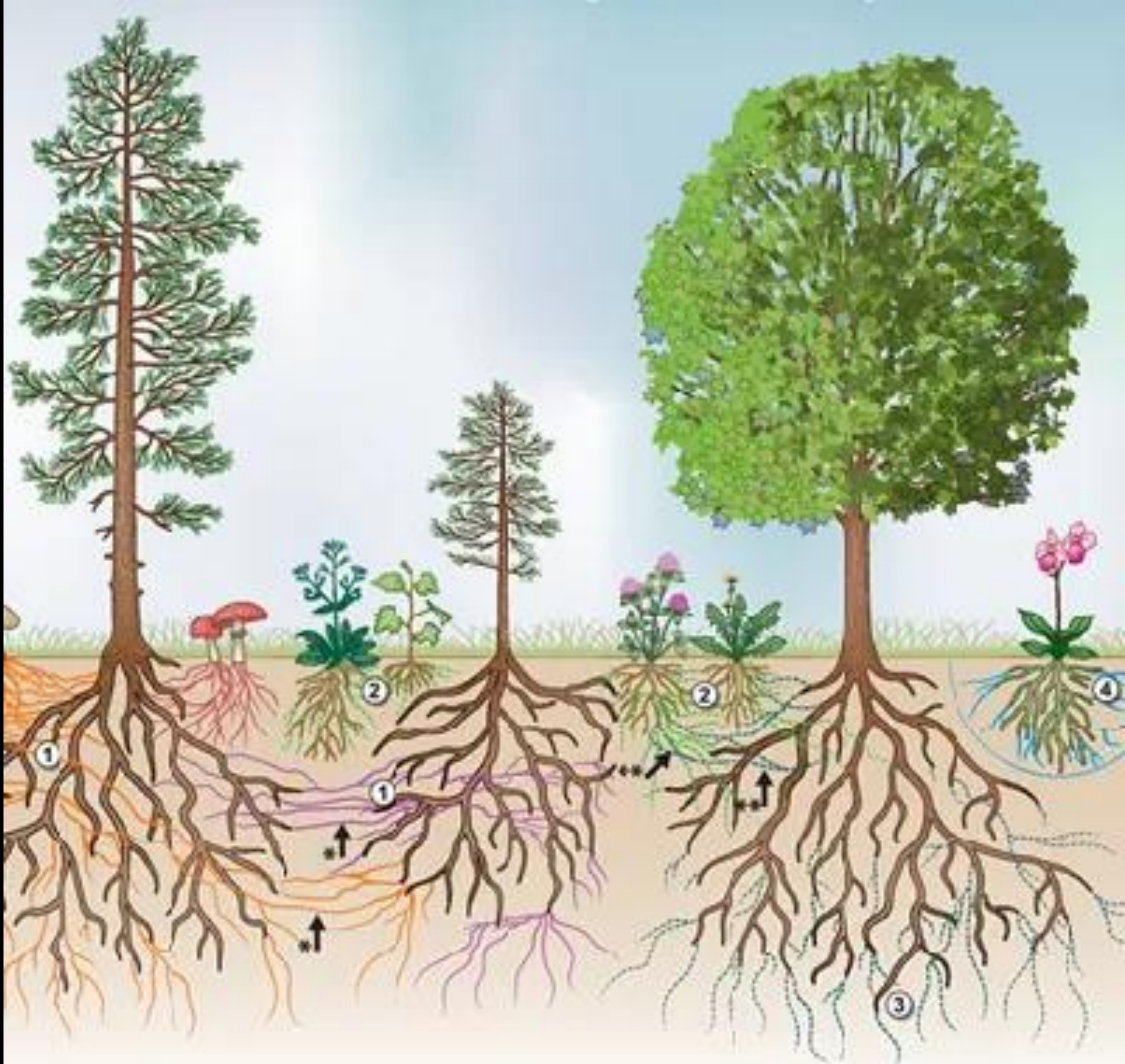


Arbuscular mycorrhizal fungi (AMF)



- Ancient symbioses (450+ mya)
- ~85% land plants
- 2 types main: EMF & AMF
  - Cottonwoods & willows partner with both
- Specialized exchange structures = symbionts
- Receive plant photosynthate in return for resources

Vast networks share resources & warning signals



van der Heijden et al. 2014

Mycorrhizal effects on plants

Data from Ag,
growing body in ecology

- Boost survival/growth
- Pest control
- Water/drought survival
- continued…

Not negligible impacts:
~25-50%+

Invasive vegetation reduces mycorrhizas

- Spotted knapweed
  (Mummey & Rillig 2006)
- Garlic mustard
  (Stinson et al. 2006)
- Canada goldenrod
  (Zhang et al. 2010)
- Italian thistle
  (Vogelsang & Bever 2009)

Riparian-specific field data: Pulliam-Babbitt / SEGA common garden

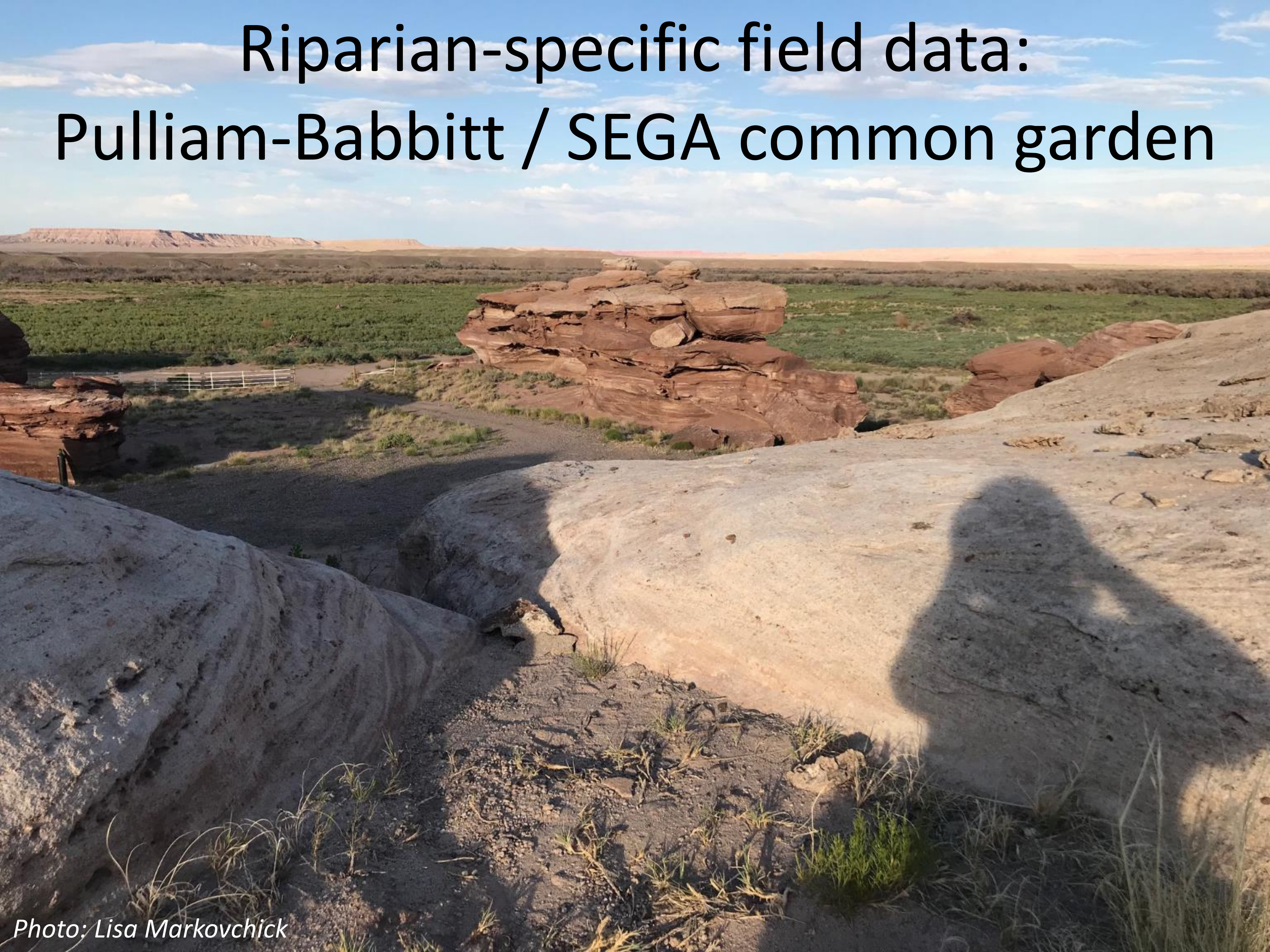


Photo: Lisa Markovchick

Tam legacy reduces cottonwood survival

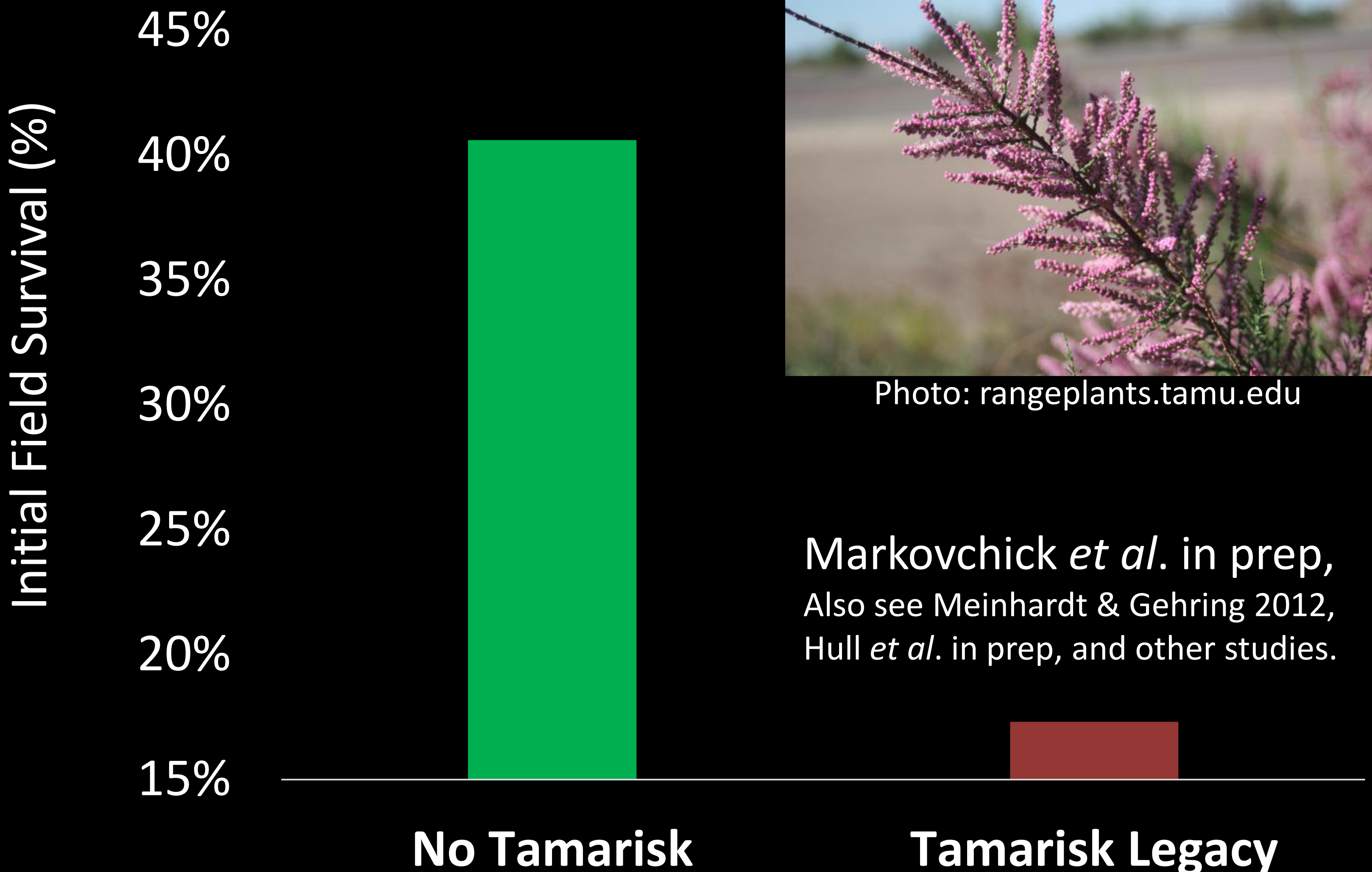
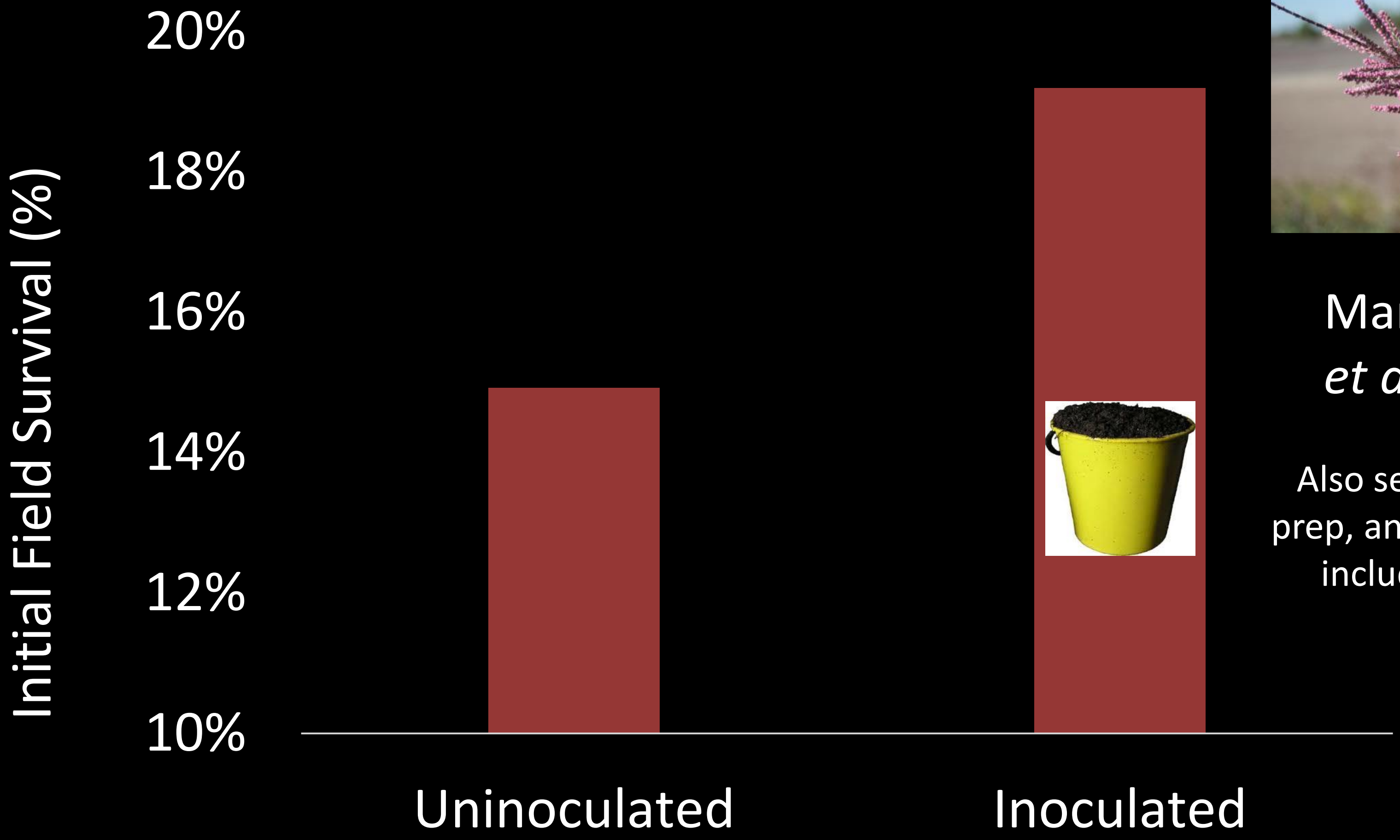


Photo: rangeplants.tamu.edu

Markovchick *et al*. in prep,
Also see Meinhardt & Gehring 2012,
Hull *et al*. in prep, and other studies.

Bars represent total survival proportions in study, thus no error bars are provided.

Inoculation can help counteract

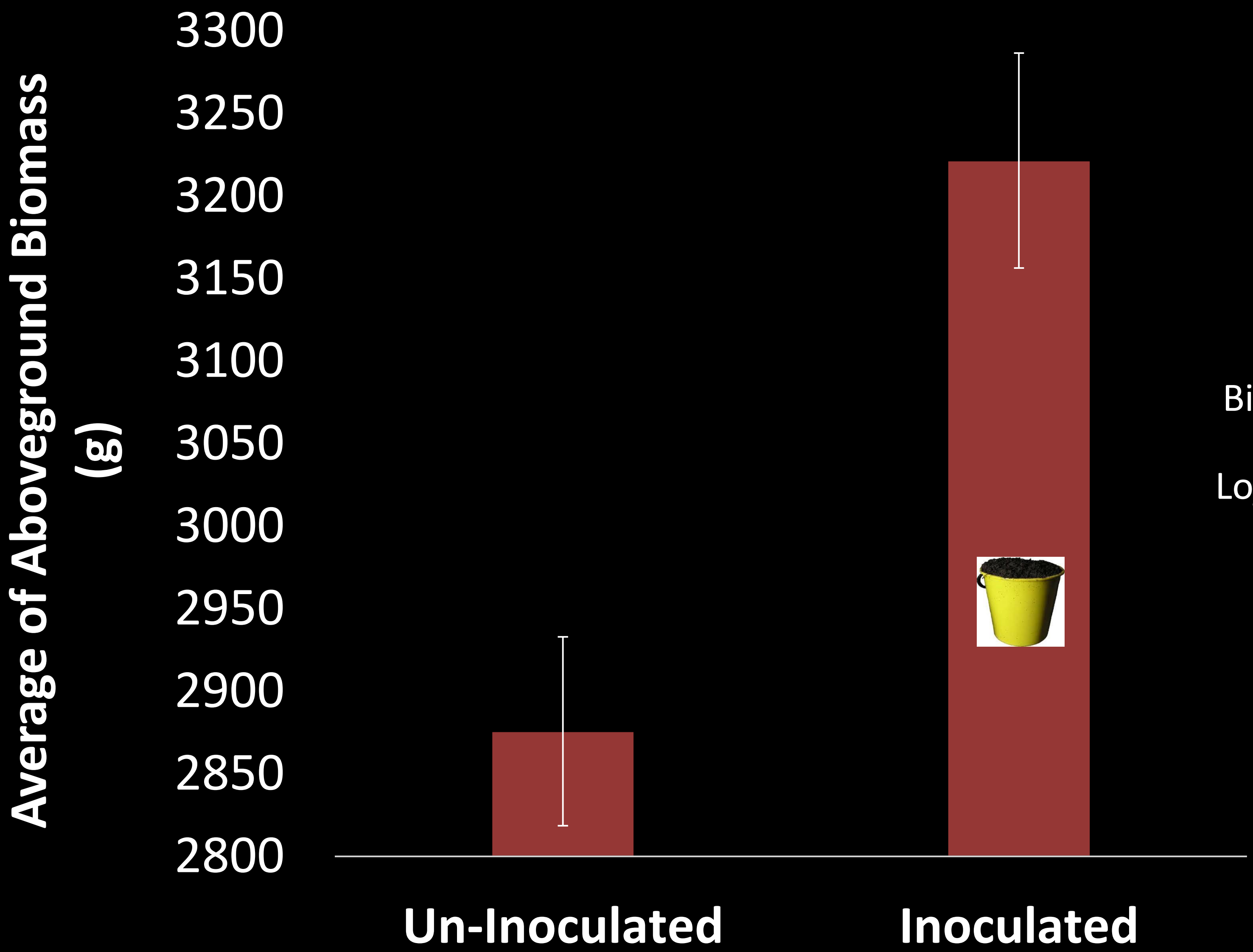


Markovchick
et al. in prep

Also see Hull *et al*. in prep, and other studies, including willows.

Bars represent total survival proportions in study, thus no error bars are provided.

And increase above-ground biomass/plant



Biomass equations from Lojewski *et al.* 2009

Markovchick *et al*. in prep

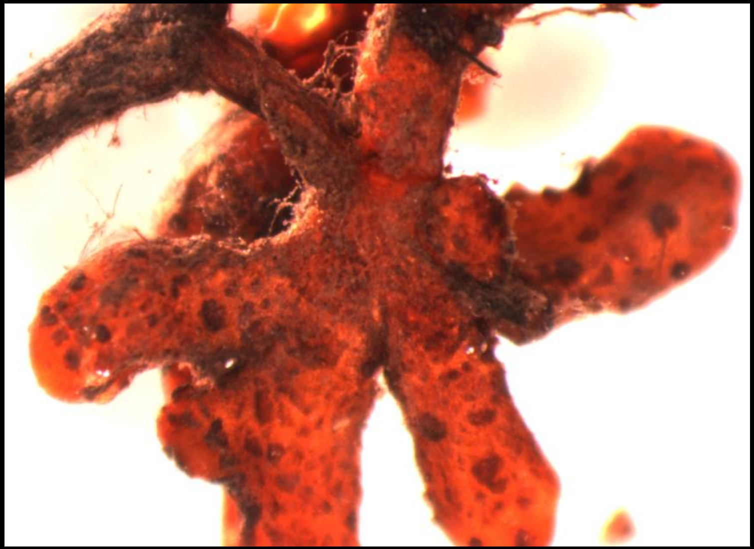
Similar results in Hull *et al*. in prep, and other studies.

Error bars = 2 SE.

Research questions

1) Will inoculation boost SWFL habitat suitability?

2) Can fine-scale SWFL habitat models discriminate between specific restoration decisions at a site?



Hypotheses

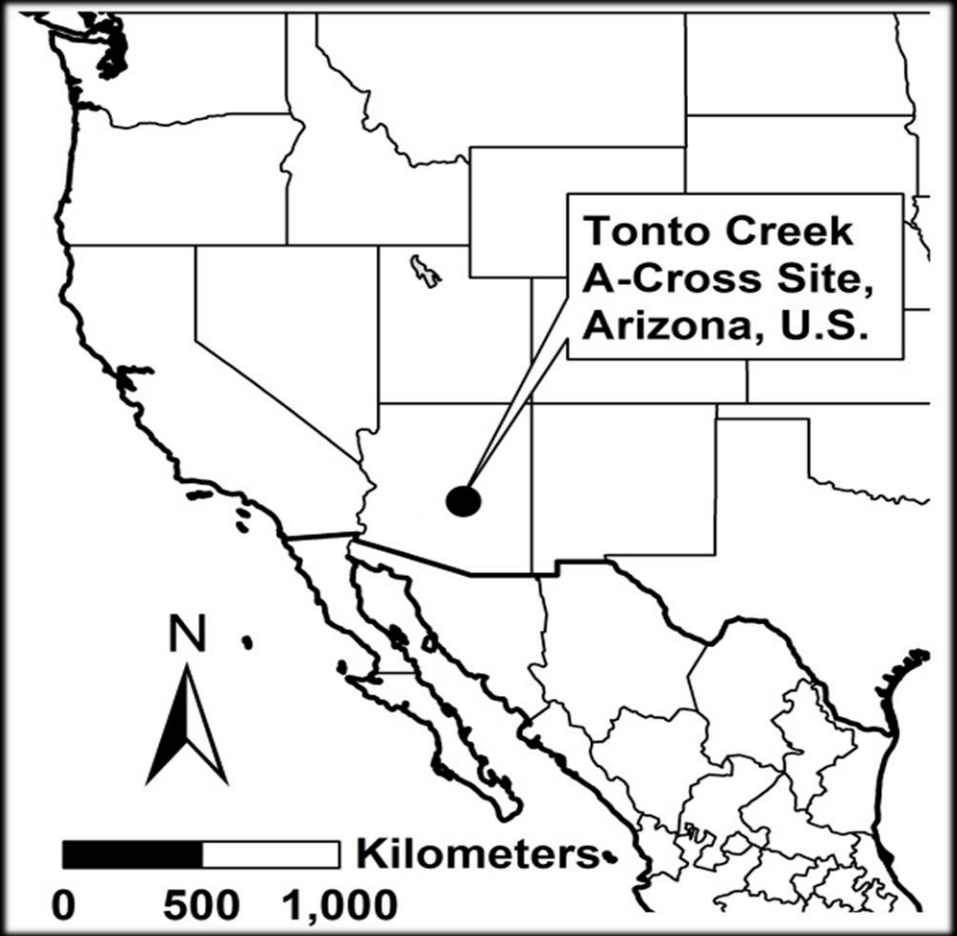
1) Appropriate mycorrhizal inoculations can improve SWFL habitat suitability in tamarisk restoration.

2) Appropriate mycorrhizal inoculations can decrease the time to achieve suitable SWFL habitat.

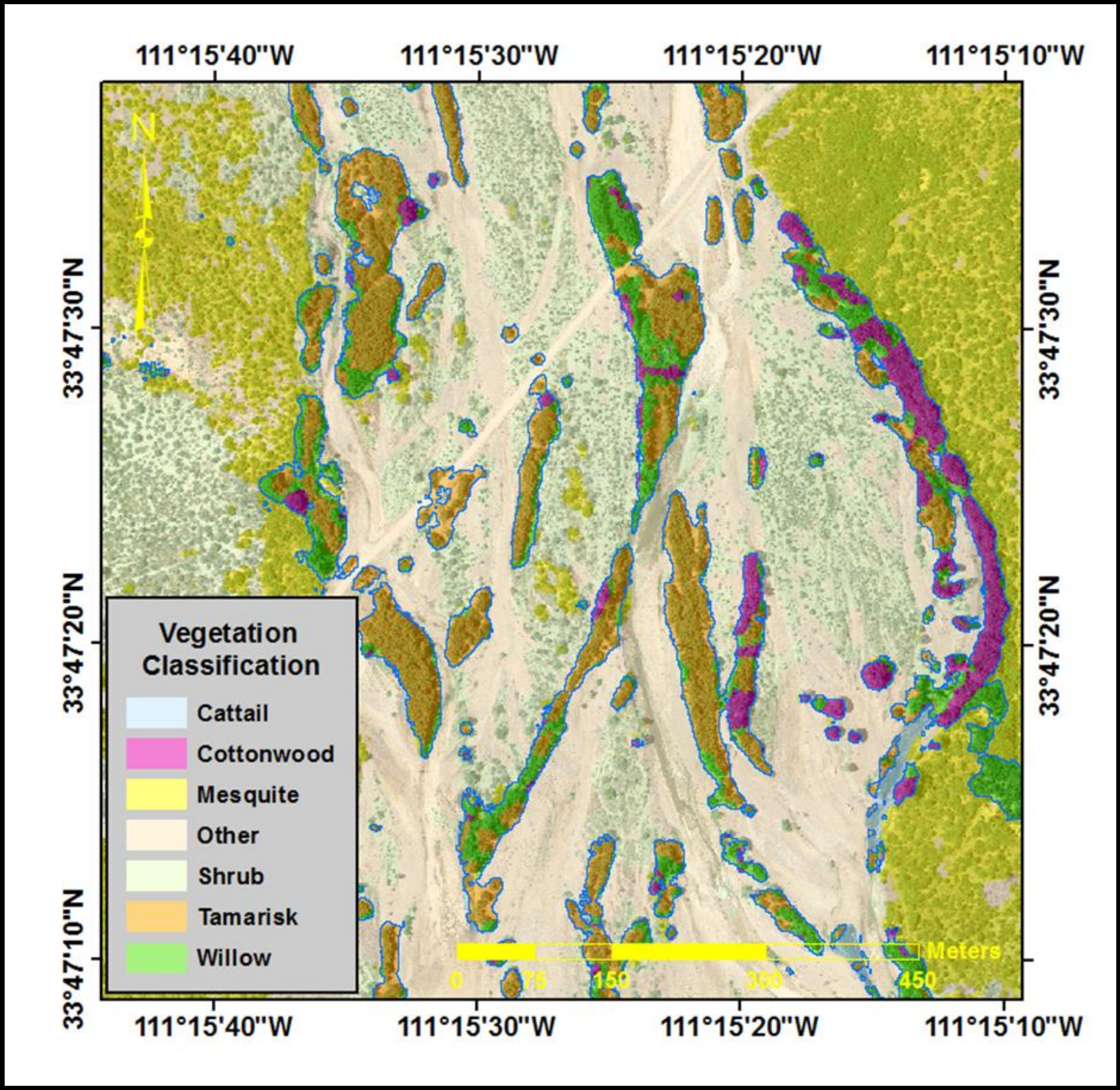
3) Fine-scale models can discriminate between SWFL outcomes based on key restoration decisions -> to evaluate the importance of specific decisions compared to their cost, ahead of action in the field.

Original fine-scale GIS SWFL Habitat Suitability Index (HSI) model

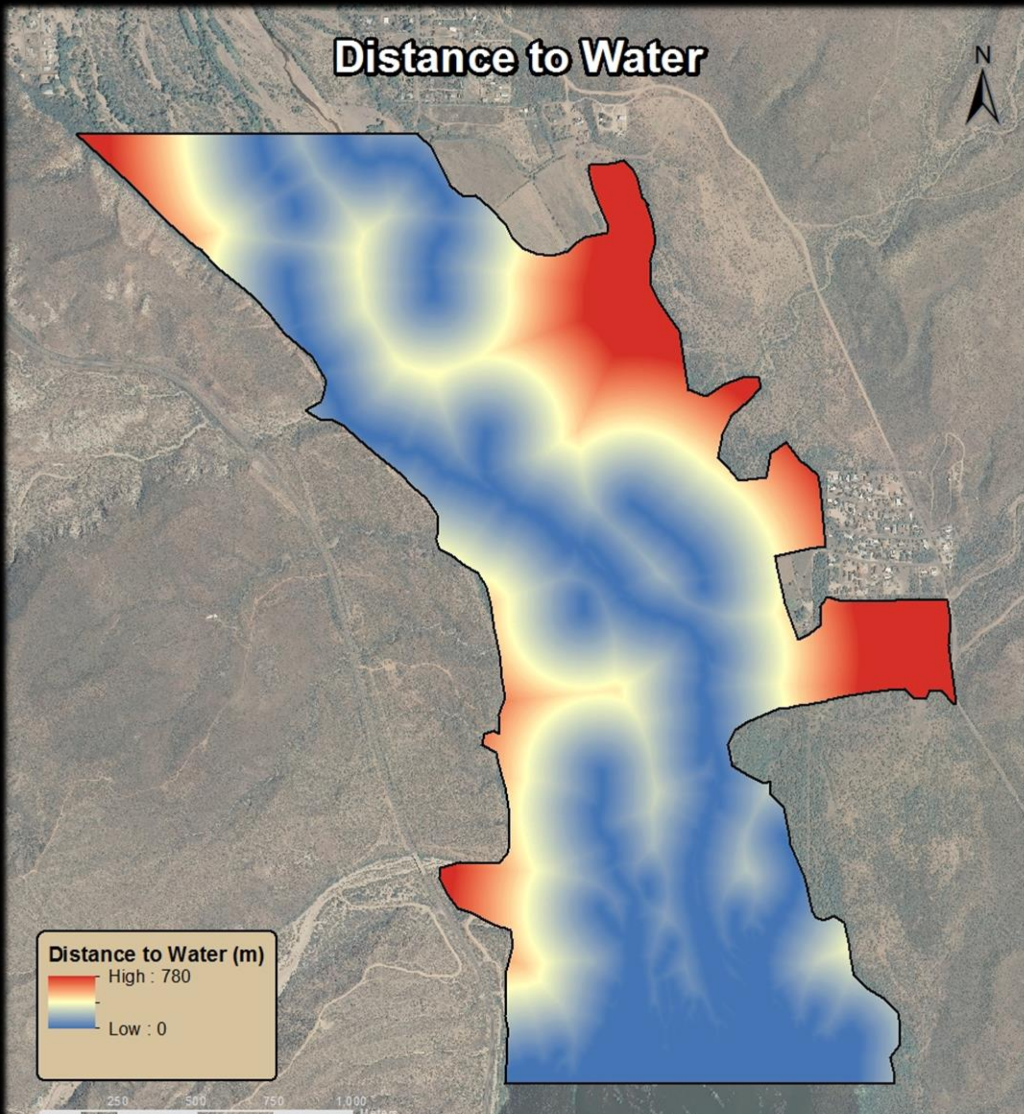
- 1 m resolution
- Tracy *et al*. 2016



Classify & field verify existing vegetation



Calculate distance to water

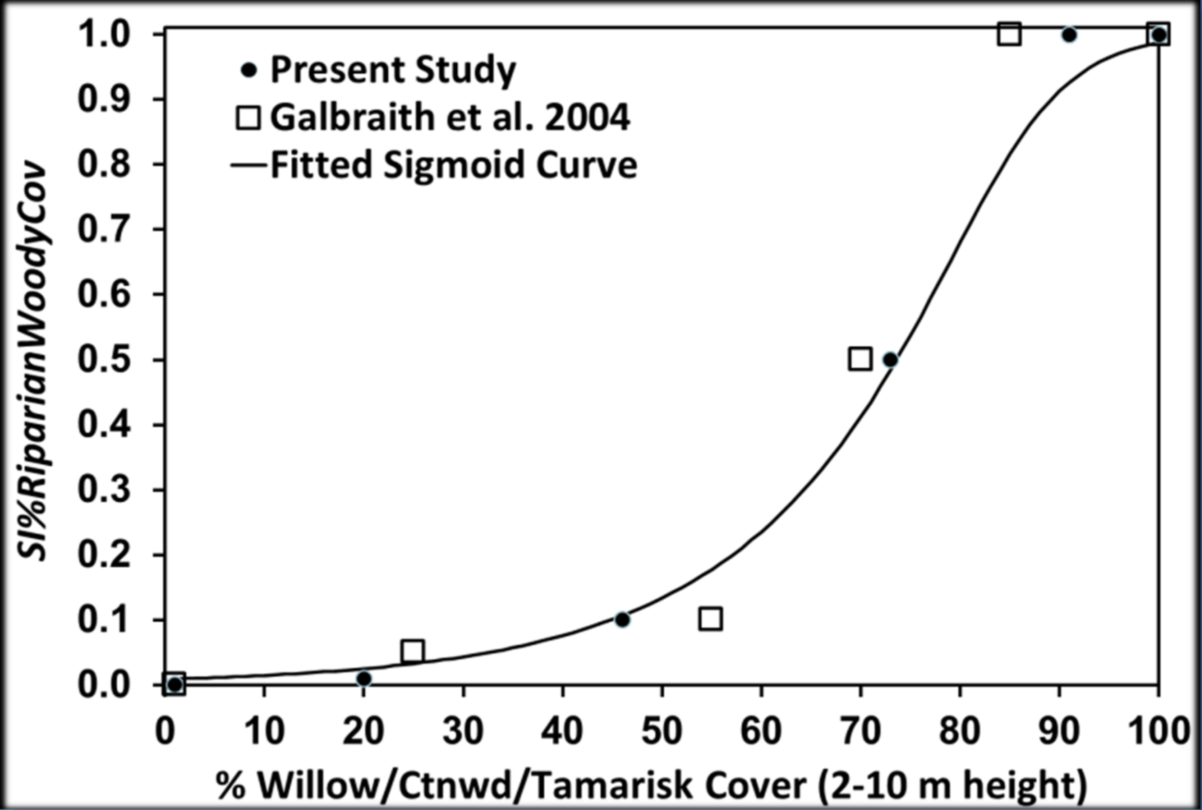


(Tracy *et al*. 2016)

Original HSI model-building steps

- Pull info on habitat suitability from field studies
- Identify factors
- Estimate their relative contributions
- Relationship between each variable value & habitat suitability

(Tracy *et al*. 2016)



Calculated total Habitat Suitability Index (HSI)

- Percent cover (*SI1*)
  - tamarisk
  - willow
  - cottonwood
- Vegetation height (*SI3*)
- Patch area (*SI2*)
- Distance to water (*SI4*)
- Tree defoliation (*SI5*) susceptibility

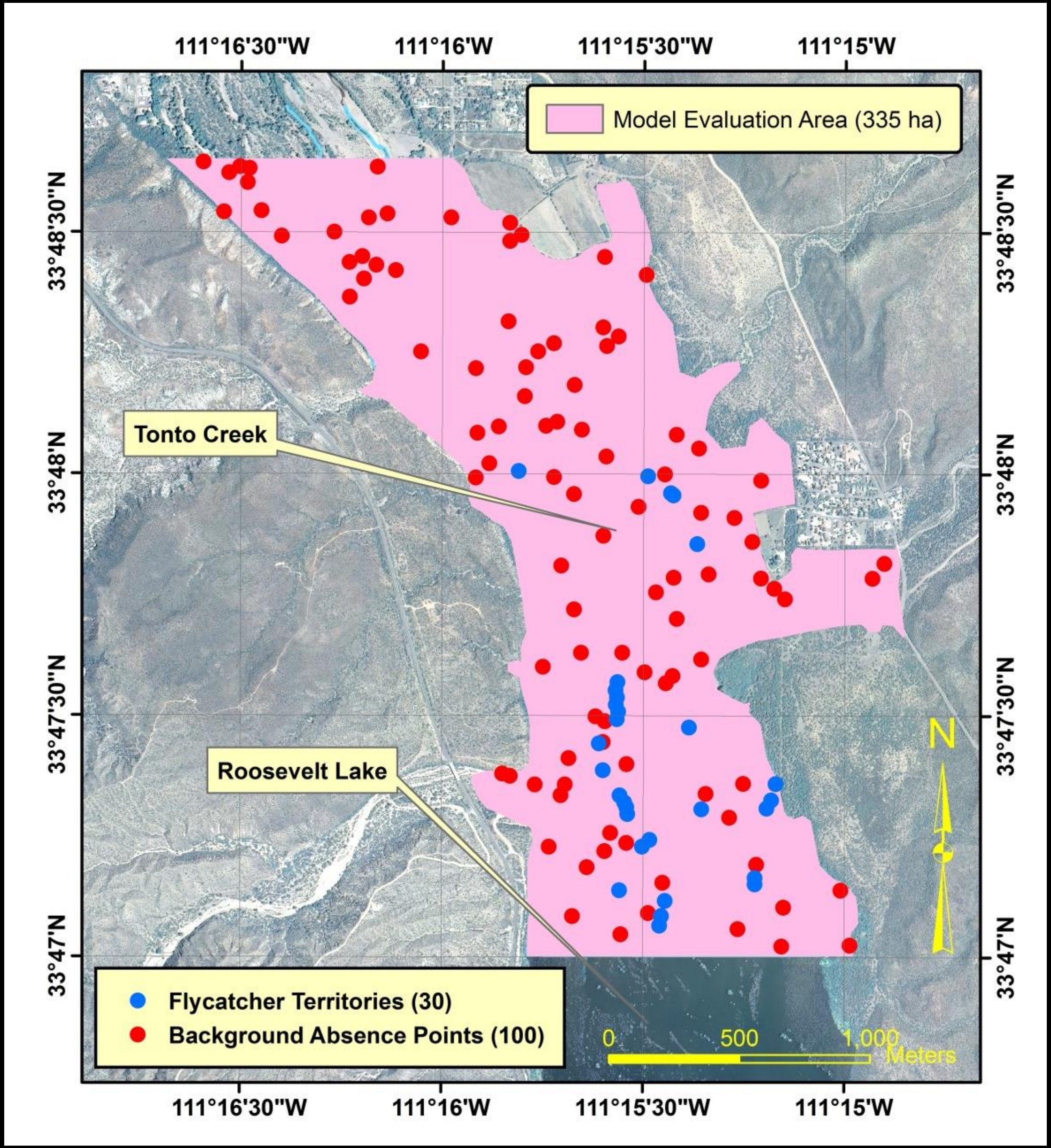
(based on % nests in tamarisk)

Flycatcher HSI calculation

$$HSI = SI1 \text{ x } SI5 \text{ x } \sqrt[3]{SI2 \text{x } SI3 \text{x } SI4}$$

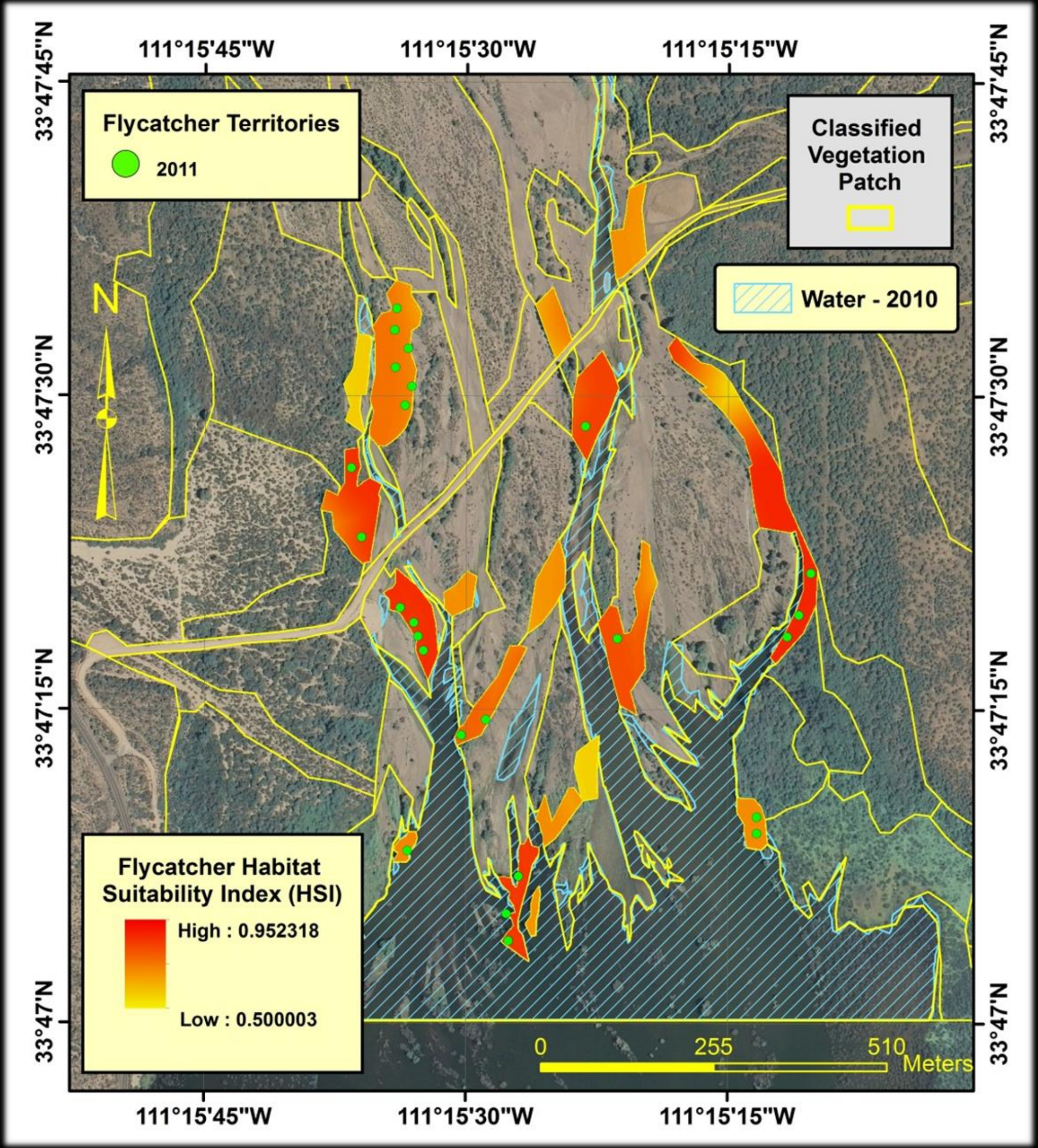
(Tracy *et al*. 2016)

Test model predictions verses SWFL field data



(Tracy *et al*. 2016)

Correctly predicted SWFL nesting



(Tracy *et al*. 2016)

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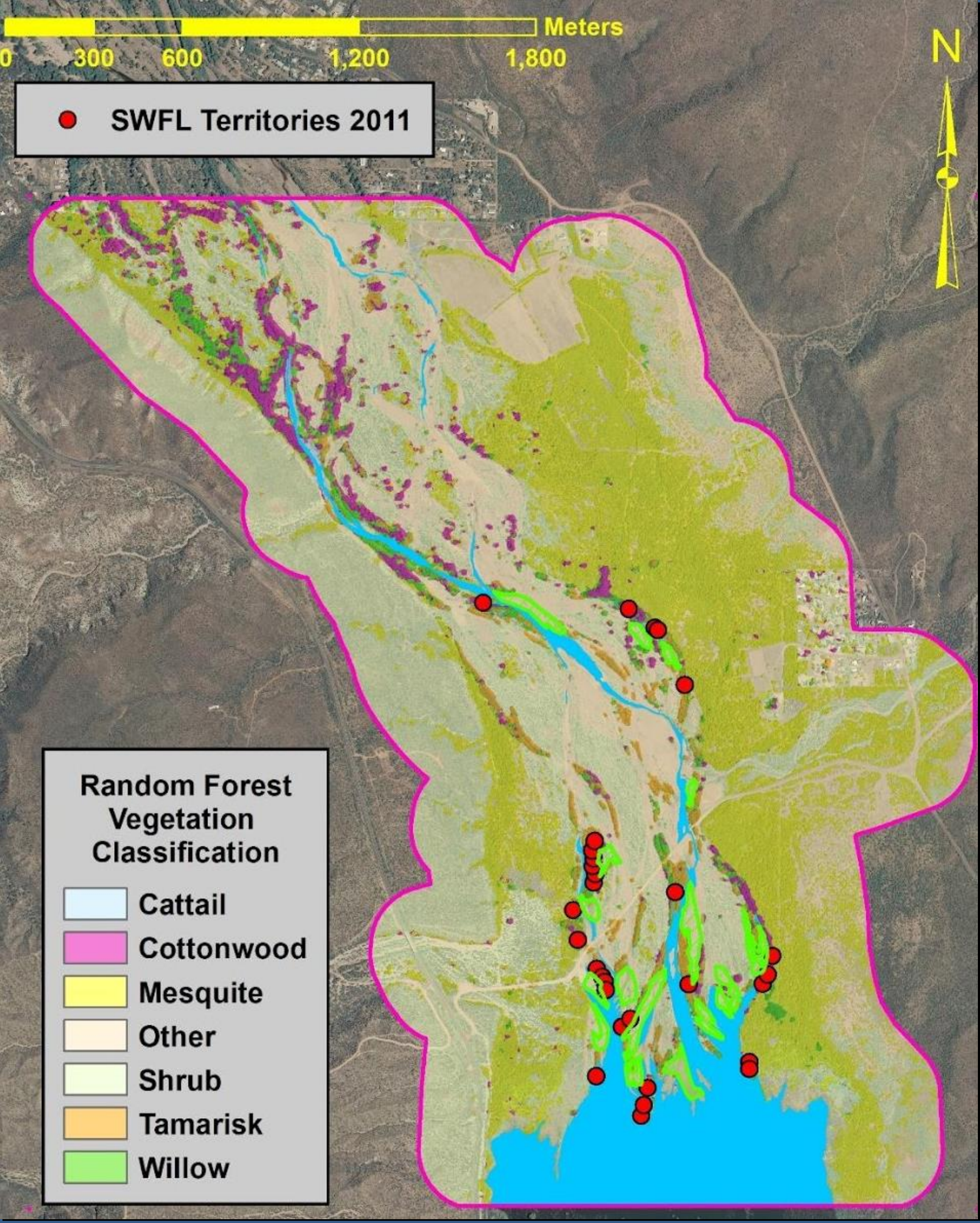
Added to Original Fine-Scale GIS Model

*Current results demo minor work over 2 months.
More to come!

We hope you'll ask for what is needed to support restoration projects!



Selected restoration patches near water

1) Plant installation & SWFL preferences.
2) 2011 water lines used for demo.
3) Future scenarios: sites identified for restoration & hydrological predictions.

Identified plant palette, planting type & plant spacing

Riparian restoration plantings of 2' deep pots at 3-meter spacings for Tonto Creek A-Cross site, AZ.

Species	Number Plantings	Percent Total
Goodding's Willow	8,952	98.9%
Fremont Cottonwood	100	1.1%
Total	9,052	100%

- 3 m apart
- 2' potted plantings

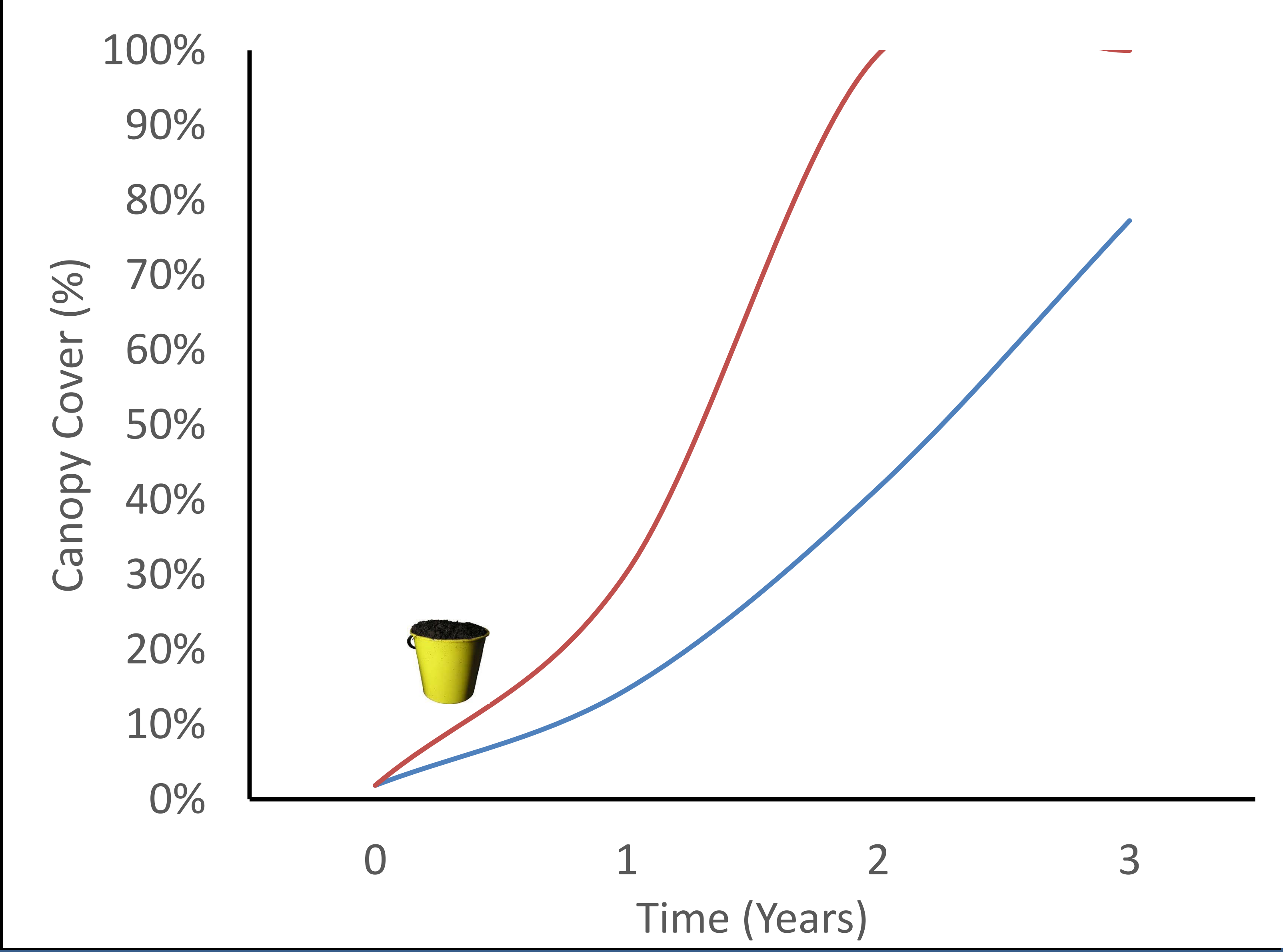
Added survival & growth by species & planting type

Reference	Location	Plant Spp.	Planting Type	Spacing	Duration	Survival
Laub et al. 2019	San Rafael River, Utah, U.S.A.	Fremont cottonwood	2-m-tall trees in 3.8 L pots	no info	1.25 years	35%
Amanda Clements, 2008 - 2010, Presentation	Western CO, Gunnison River	Cottonwood	poles	no info	1 growing season	0%
Amanda Clements, 2008 - 2010, Presentation	Western CO, Gunnison River	Cottonwood	poles	no info	1 growing season	12% yr 1, 0-6% yr 2
McMaster and Chaudhry 2017	Grand Canyon National Park, Colorado River	Salix gooddingii (Gooding's willow)	poles	no info	10 months	40%

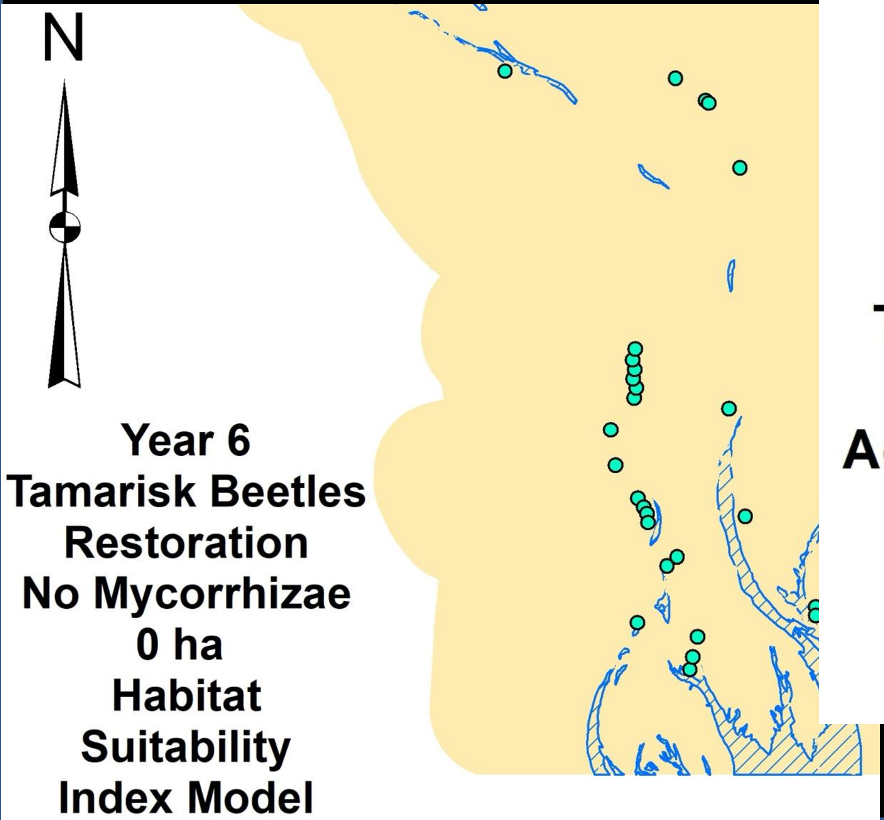
Added responses to appropriate mycorrhizal inoculation for each plant species

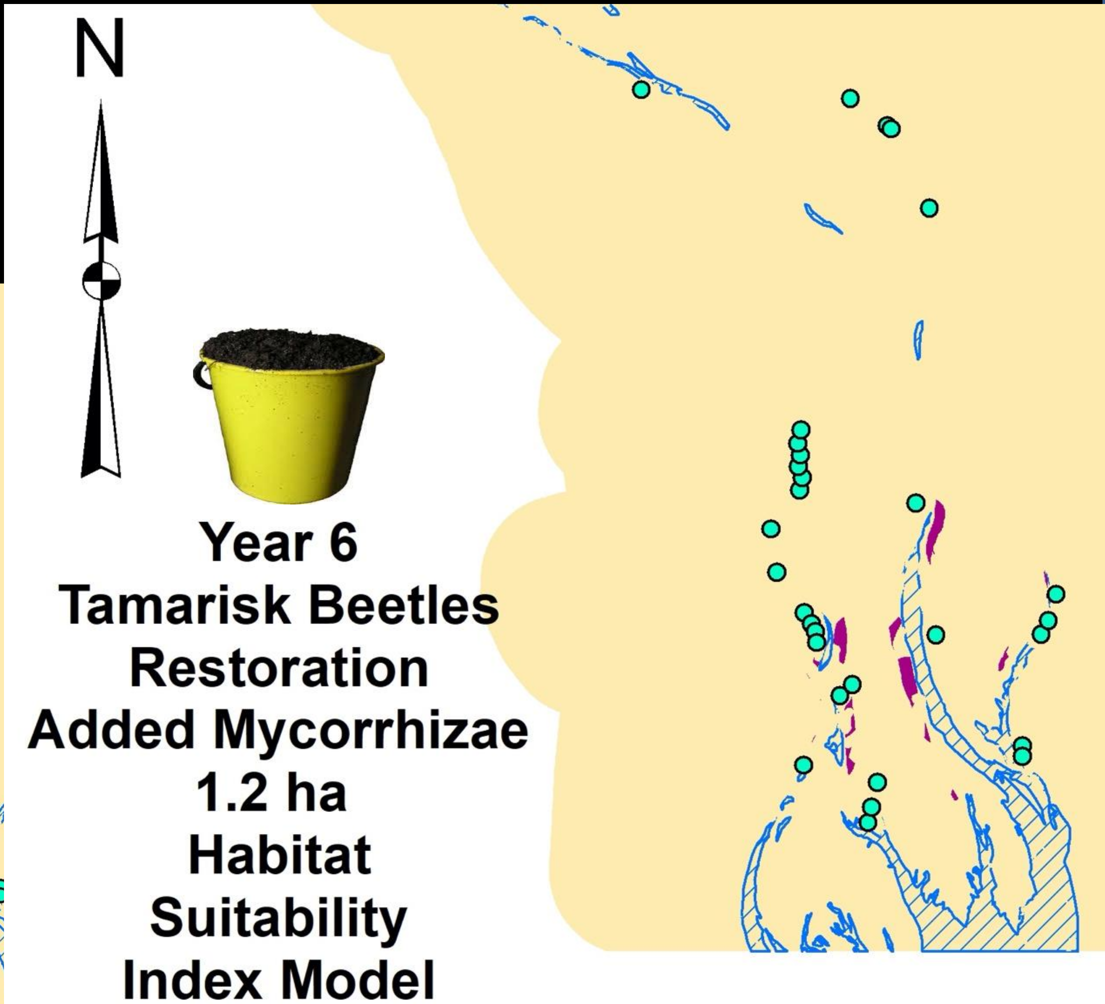
Reference	Effect	Percent Change	Direction	Time Interval	Context
Meinhardt & Gehring 2012	Cottonwood biomass	33%	+		Greenhouse + Field, biomass results from Greenhouse
Beauchamp et al. 2005	Tamarisk biomass	75%	-	1 growing season (7 mo)	Greenhouse
Gehring et al. 2014	Cottonwood biomass	100%	+	4 months	Greenhouse
Gehring et al. 2006					Field
Markovchick et al. in prep - Pulliam Year 1	15% to 19%	27%	+	1 growing season	Field

Inoculation increases canopy cover, and faster



Inoculation + restoration creates habitat with 50% suitability or higher within 6 yrs, despite defoliation

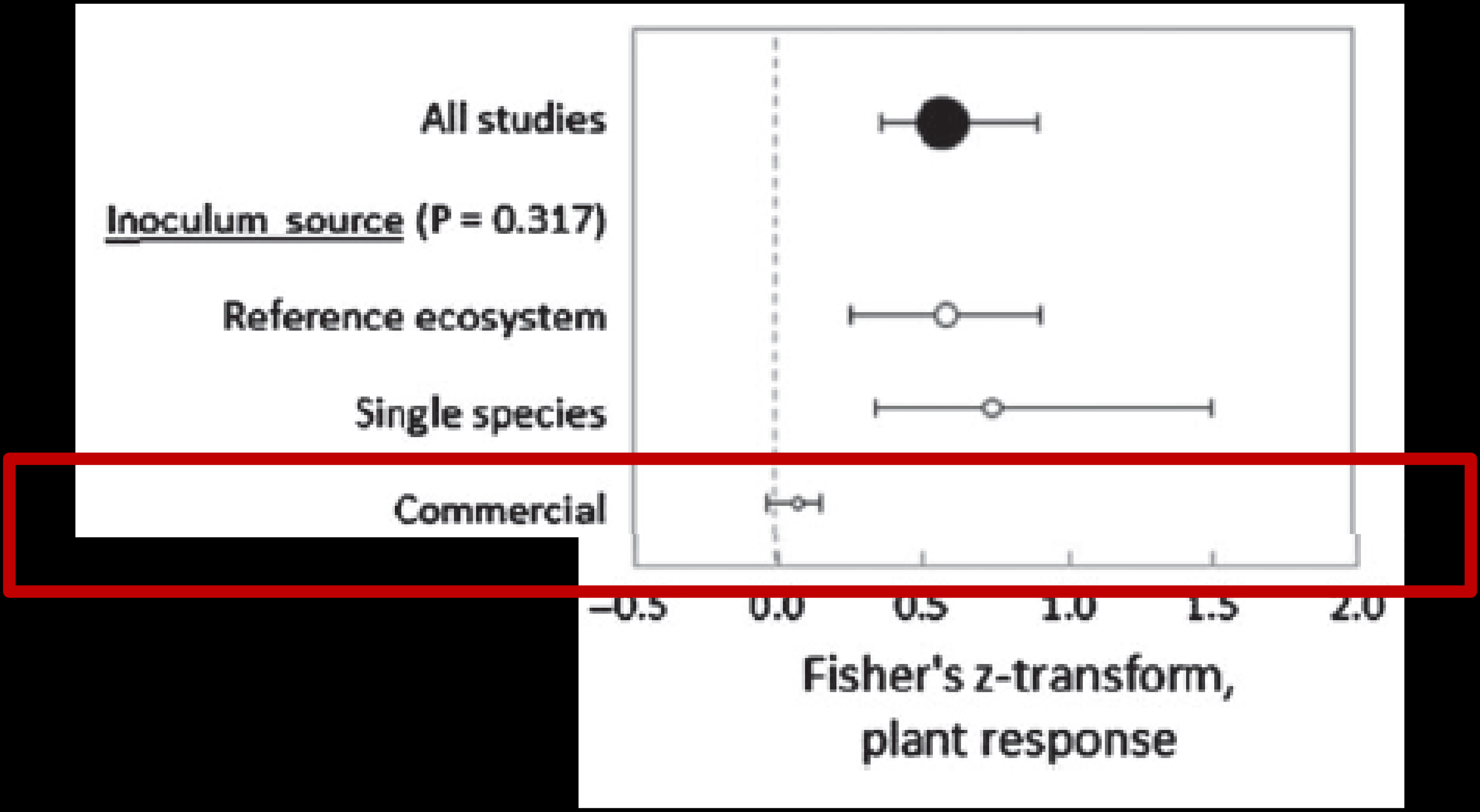




Discussion

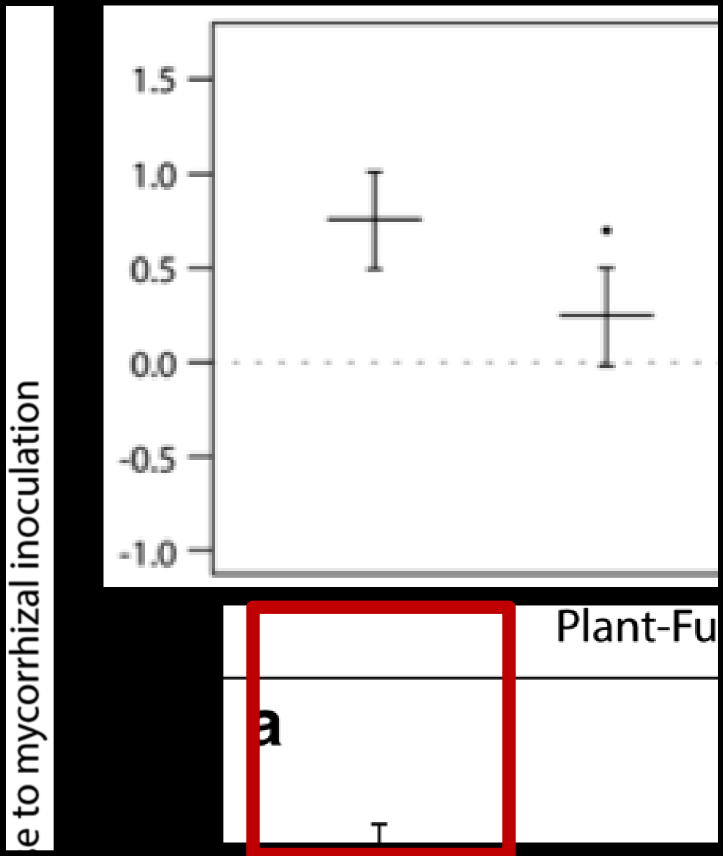
1) What is ”appropriate” mycorrhizal inoculation?

Please do not use commercial inoculum
Neutral to negative effects occur
with poor match between plants, soil & mycorrhizas



Maltz & Treseder, 2015

"…Importance of routinely considering the origin of plant, soil, and fungal components."



Rua et al. 2016

Other factors can affect inoculation outcomes

- Water availability
- Timing of inoculation
- Tamarisk status
- Other management actions that impact mycorrhizas (e.g. pesticides, fuel management…)

THURSDAY, FEBRUARY 6, 2020

OPTION 3

WORKSHOP | USING MYCORRHIZAL FUNGI IN RESTORATION PROJECTS OF THE SOUTHWESTERN U.S.
WITH NORTHERN ARIZONA UNIVERSITY

8:00 AM ~ 12:00 PM
$20, TRANSPORTATION PROVIDED
MEET IN THE WEST BALLROOM AT 8 AM

Nest Steps

1) Refine model specifics
   (e.g. each planting type modeled for comparisons).

2) Add sites under consideration for restoration.

3) Incorporate manager scenarios, to address key decisions.

4) Use model to weight SWFL outcomes vs. cost.

Thank you!

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Susan Mortenson, SWCA
Melissa McMaster,
Mariposa Ecological and Botanical Consulting
Ruth Valencia, SRP
Thomas G. Whitham
Emily Palmquist, USGS

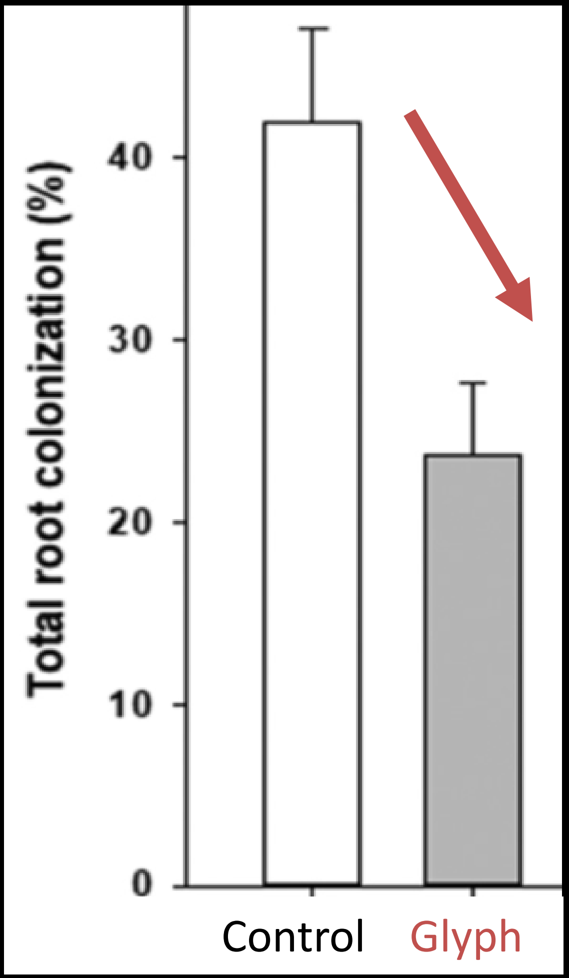
SWFL photo, 1st slide: S&D Maslowski, nps.gov

Identified Appropriate Mycorrhizal Inoculation Rate Increases: Willows

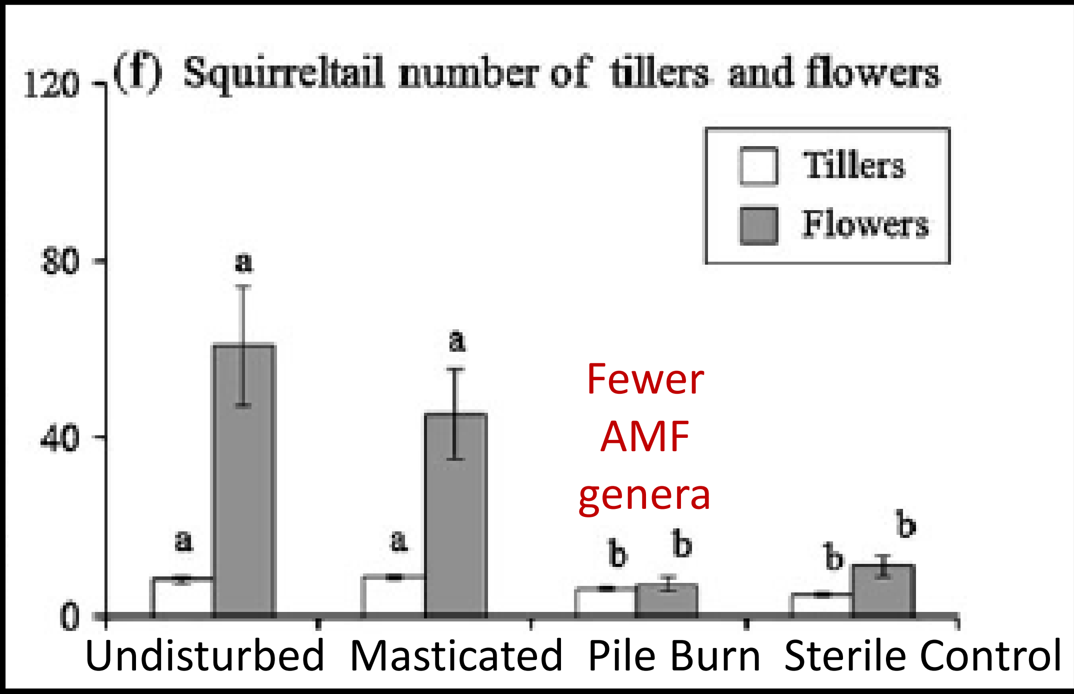
Reference	Effect	Percent Change	Direction	Time Interval	Context
Nara and Hogetsu 2004	Survival from 63% to 100%	60%	+	1 growing season	Field
Nara and Hogetsu 2004	Dry biomass 9.3 g to 25.5 g	174%	+	1 growing season	Field
Baum et al. 2006	109 g to 120 g, or 68 g to 93 g (stem + leaf dry weight)	10% or 68%, depending on soil/ inoculant	+	6 months	Greenhouse
Nara 2005	Mean survival 8/15 to 13, 14 or 15/15.	62% to 88%	+	4-5 months	GH / growth chamber
Nara 2005	Mean shoot dry weight 0.56 g -1.3 to ~2.49 g.	132% to 344%	+	4-5 months	Greenhouse / growth chamber
van der Heijden and Kuyper 2001	2.78 g to 2.88 up to 3.97 g depending on inoculant	3% to 42%	+	6.5 months	Greenhouse / growth chamber
van der Heijden 2001	Mean shoot dry weight 88.5 mg to 292-295, depending on inoculant.	229%	+	7.5 months	Greenhouse / growth chamber

Pesticides & Other Management Can Reduce

Glyphosate



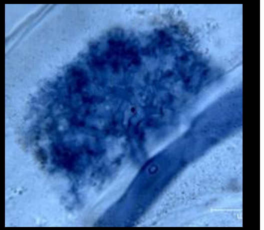
Helander *et al.* 2018



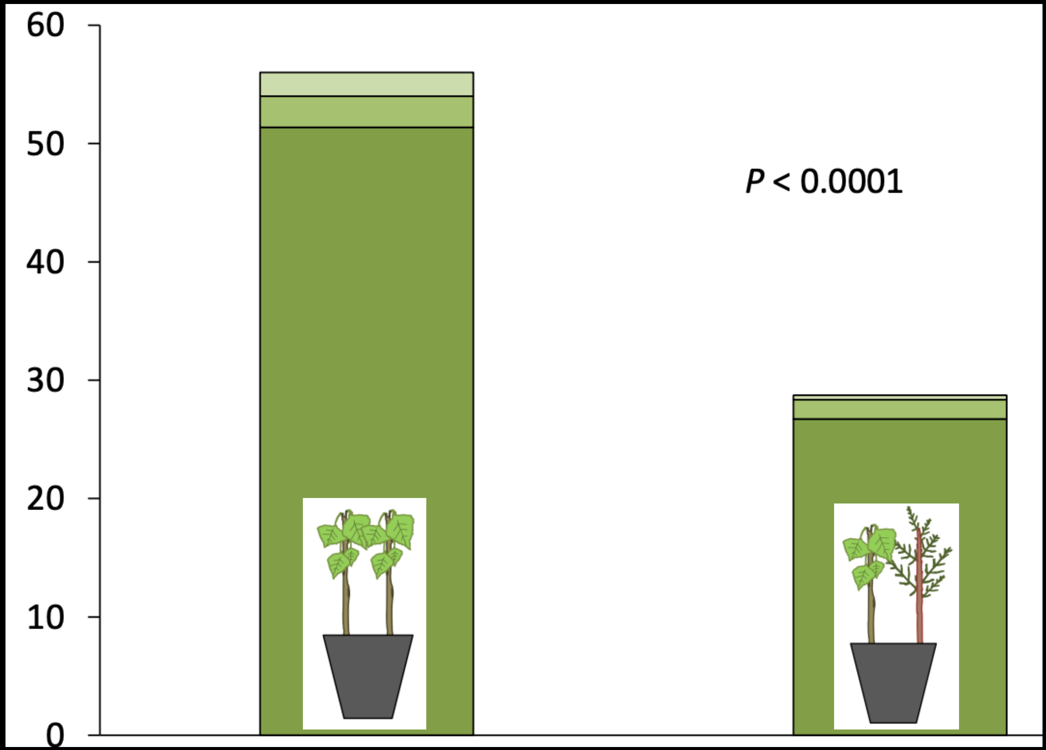
Undisturbed

Pile burn

Owen *et al*. 2013

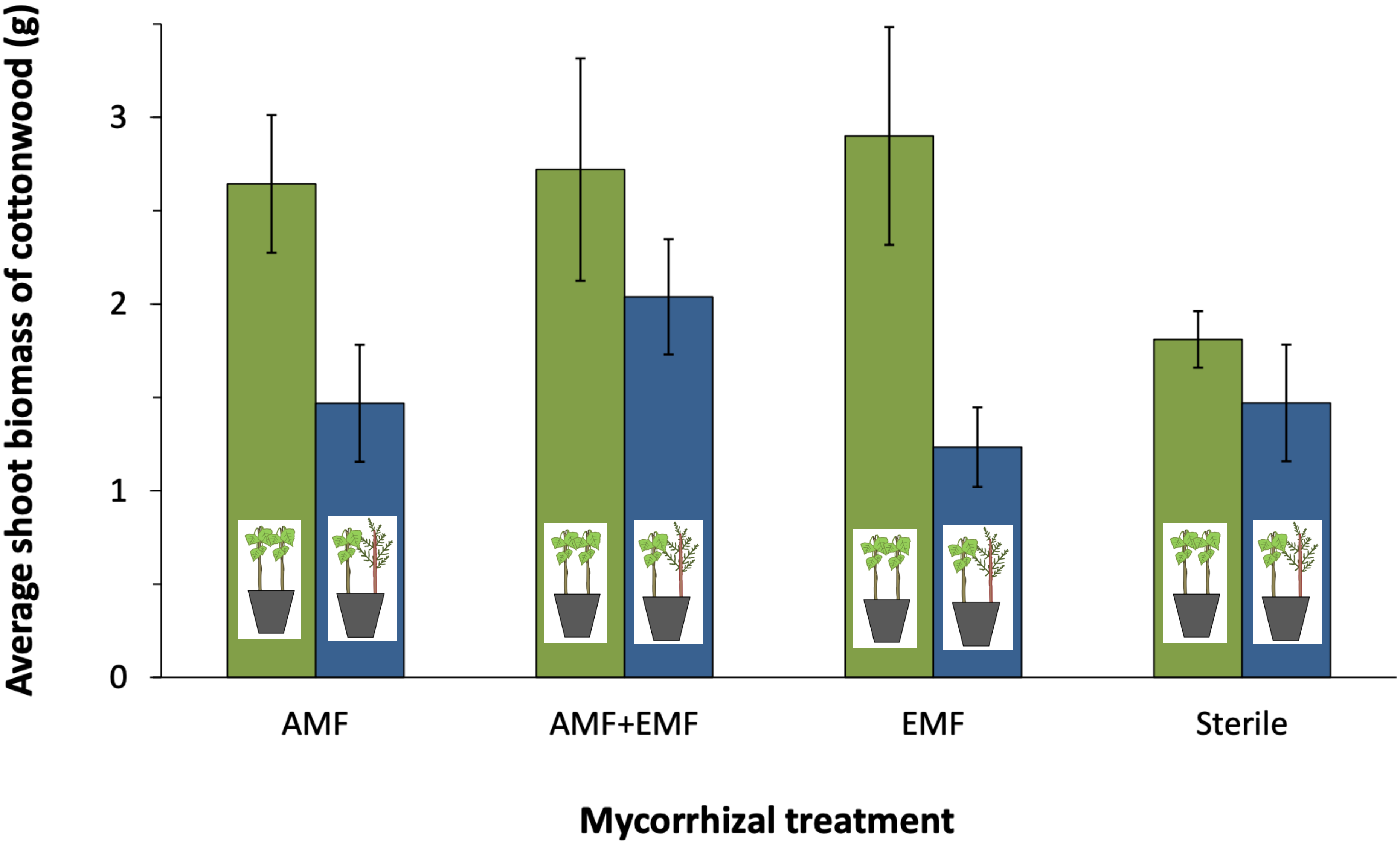


Tamarisk neighbors reduce mycorrhizal colonization



Meinhardt & Gehring, Ecological Applications, 2012

…AND reduce cottonwood shoot biomass



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