TEXAS A&M UNIVERSITY
AGRICULTURE & LIFE SCIENCES
DEPARTMENT OF ENTOMOLOGY

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KNOWLEDGE ENGINEERING LABORATORY

Southwestern Willow Flycatcher habitat suitability and connectivity under simulated conditions of tamarisk beetle herbivory and willow restoration.

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RG March
Texas A&M University

Tamarisk Coalition's 12th Annual Conference
Riparian Restoration in the Western US
18-20 February, 2014
Grand Junction, CO

Indirect Effects of Tamarisk Biocontrol

Tamarisk (*Tamarix* spp.)

Rapid & Gradual

Tamarisk defoliation(R)/ dieback (G)

Tamarisk beetle herbivory

Rapid

Tamarisk beetles (*Diorhabda* spp.)

Rapid & Gradual

Riparian woodland habitat loss

Gradual

Willow/ cottonwood recovery

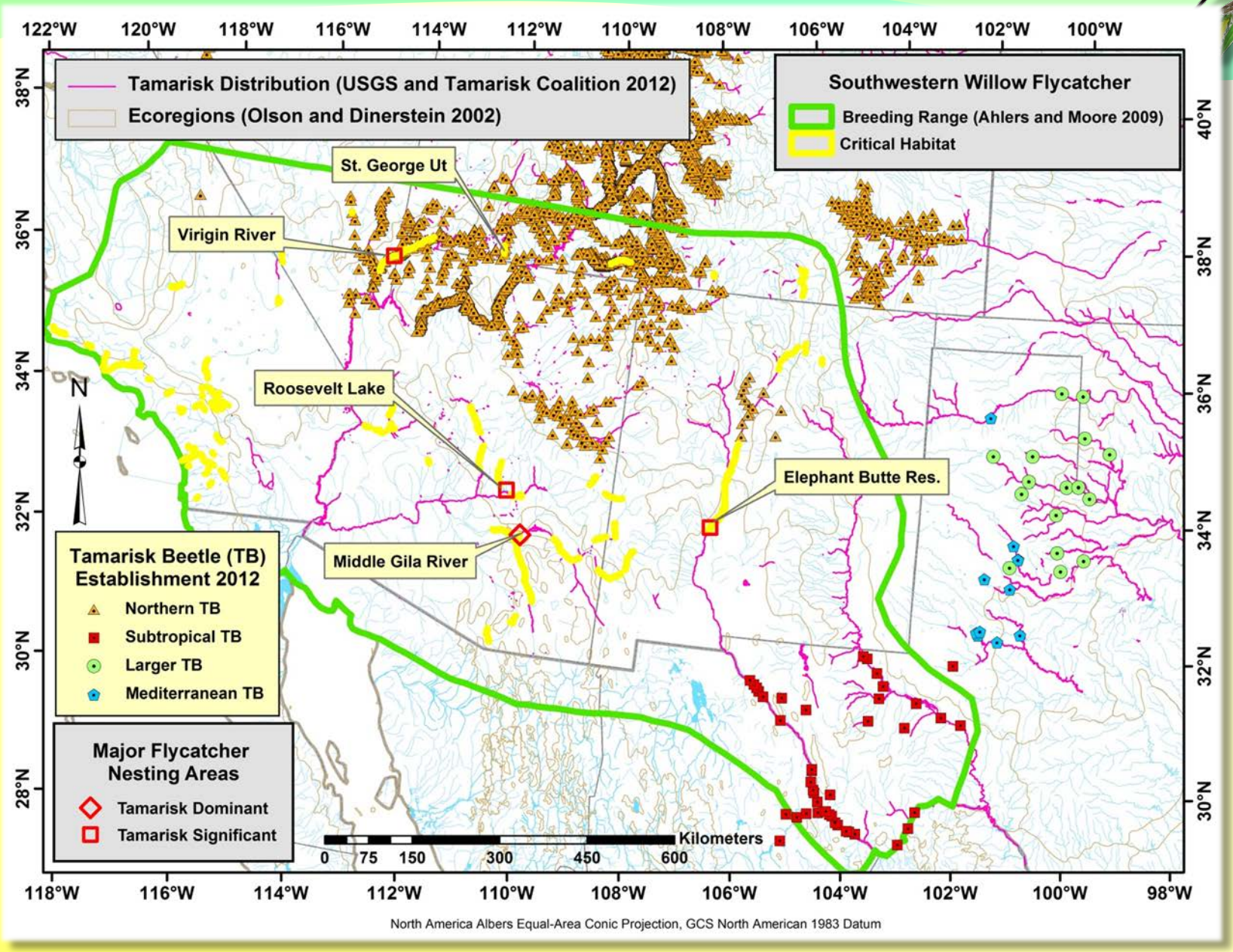
Federally endangered southwestern willow flycatcher (*Empidonax trailli extimus*)

Passive and active native riparian restoration

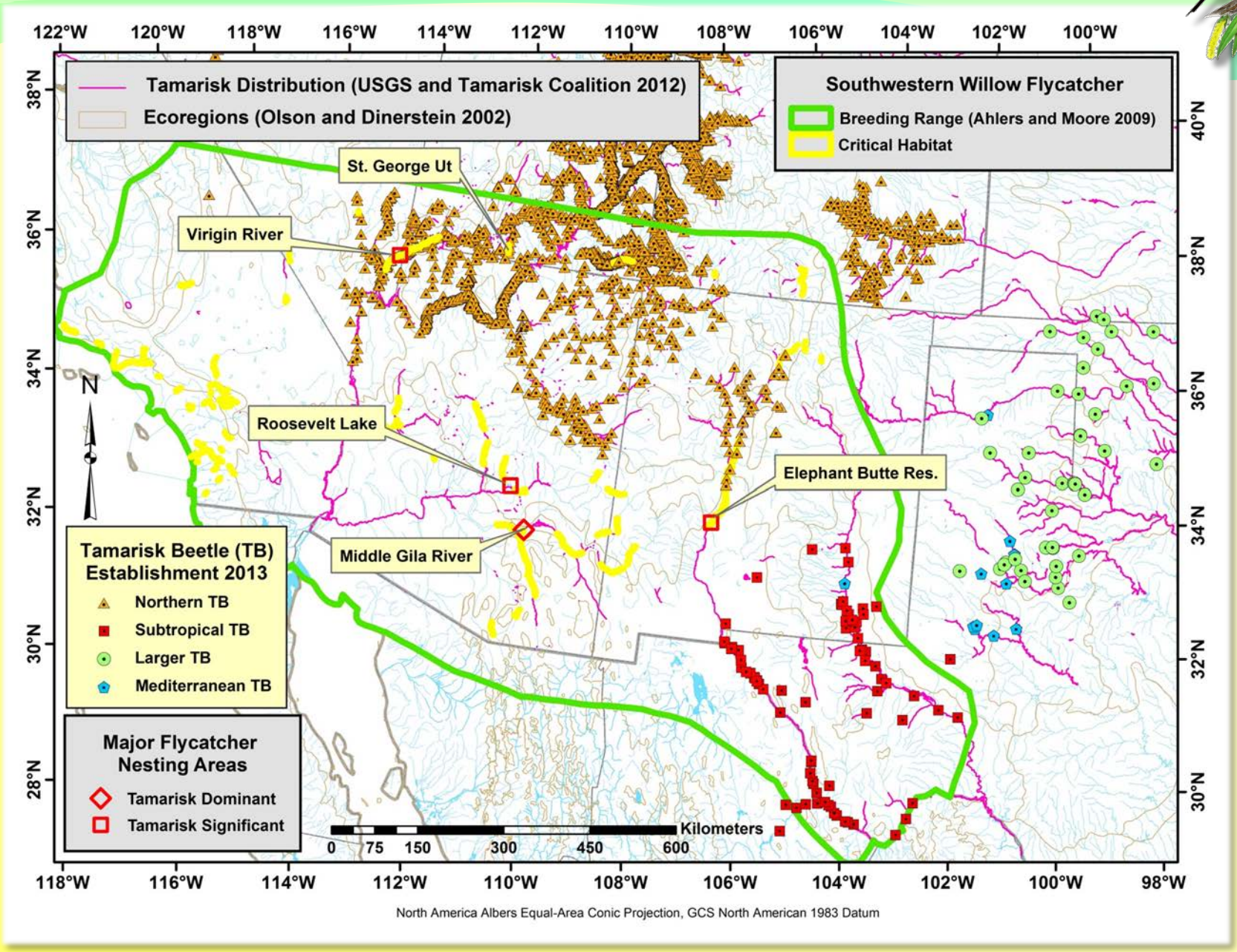
Riparian woodland habitat gain

Gradual

SW Willow Flycatcher and tamarisk beetle ranges- 2012

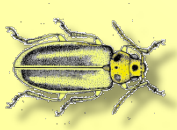


SW Willow Flycatcher and tamarisk beetle ranges- 2013



Effect of tamarisk beetle defoliation on federally endangered SW Willow Flycatcher, St. George, UT

- First year of complete defoliation -2009
  - Nest success of 13%; = 75% drop from typical 54% nest success
- Second year of complete defoliation - 2010
  - Nesting sites switched to primarily willows
  - Nest success of 30%

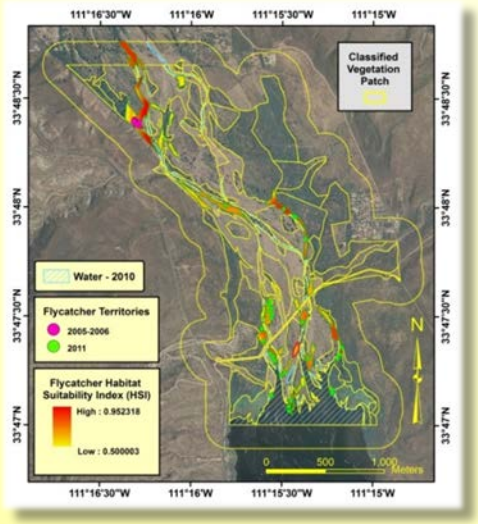


Rapid Tamarisk beetle defoliation

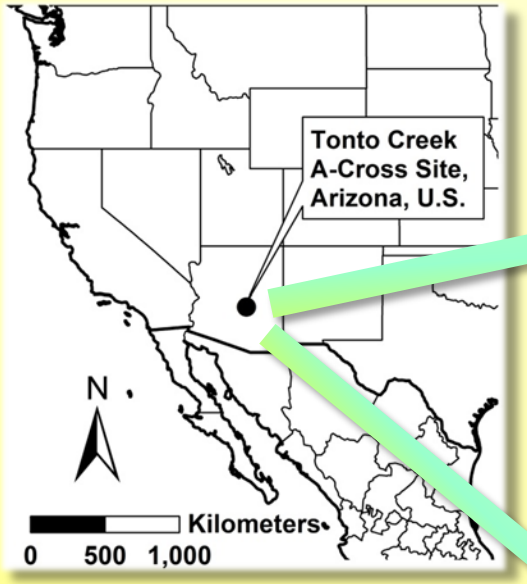
(McLeod 2011)

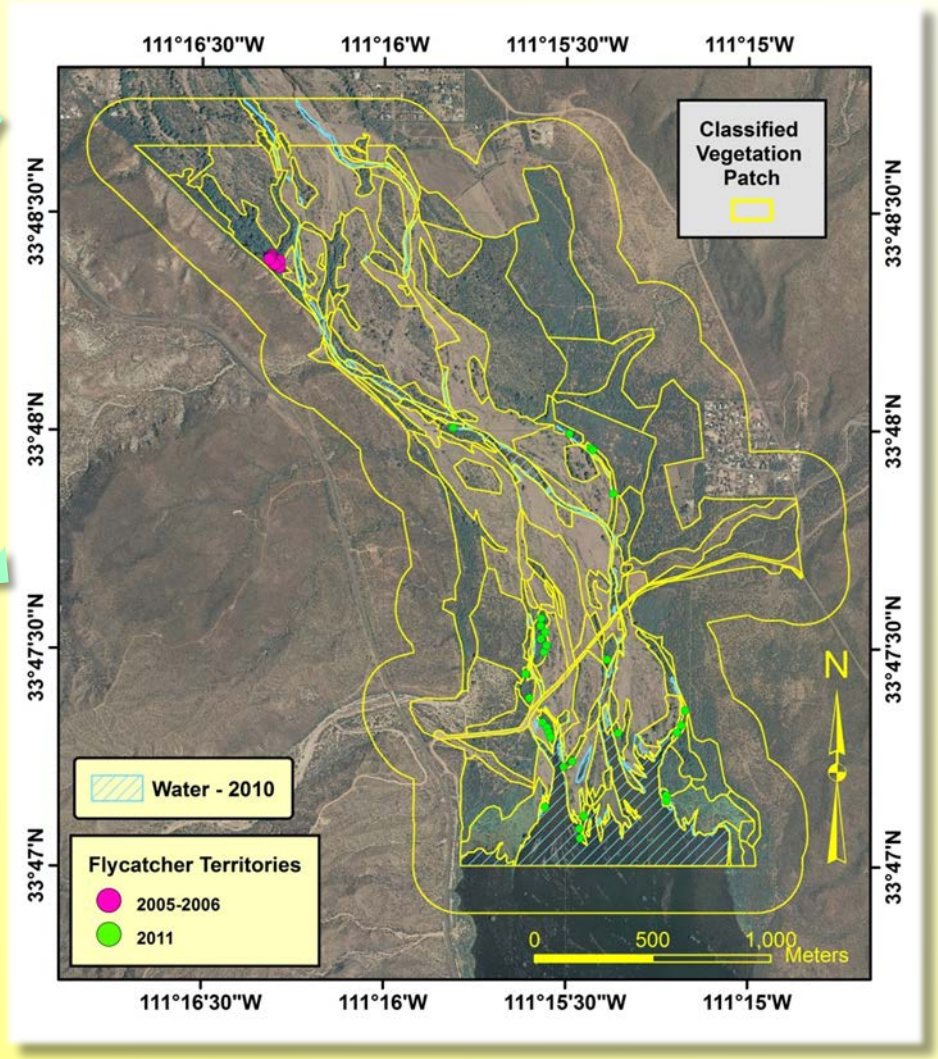
Objective: Project effects of tamarisk beetle and restoration on flycatcher habitat at patch-level

- Refine flycatcher HSI model of Galbraith et al. (2004) and compare with GLM suitability model
  - Redevelop habitat suitability index curves from literature data
  - Apply HSI (Arc GIS spatial analyst) and develop GLM model (R dismo pkg) at patch-level study site to define baseline habitat
  - Evaluate HSI and GLM models using 3-fold data partitioning for AUC and kappa (R dismo pkg)
- Simulate tamarisk beetle herbivory and restoration actions with HSI
  - Simulate 1st year beetle defoliation
  - Simulate 3rd year defoliation and dieback
  - Simulate 3rd year after restoration
- Simulate changes to connectivity of flycatcher HSI modeled habitat (FRAGSTATS)



Refine flycatcher Habitat Suitability Index Model and apply at Tonto Creek A-Cross Site, AZ



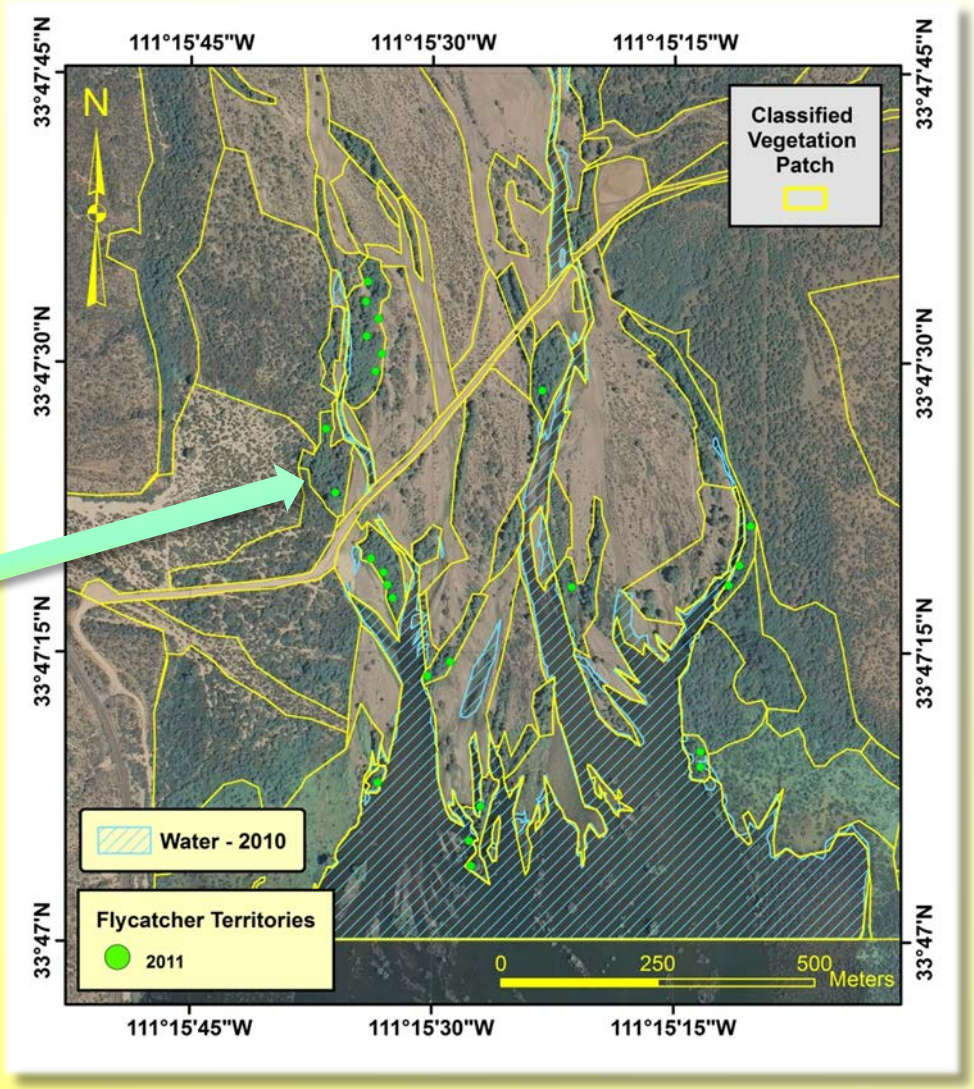


- 30 flycatcher territories in 2011; 100 random absence sites selected
- 335 ha, 3.5 km reach
- Tamarisk 10–90 % cover in woodland patches

Refine flycatcher Habitat Suitability Index Model for Tonto Creek A-Cross Site, AZ

- Tamarisk dominates 13 (43%) of 30 patches with flycatcher territories

Tamarisk in patch used by flycatchers at Tonto Creek, AZ in 2011



Refine flycatcher Habitat Suitability Index Model for Tonto Creek A-Cross Site, AZ

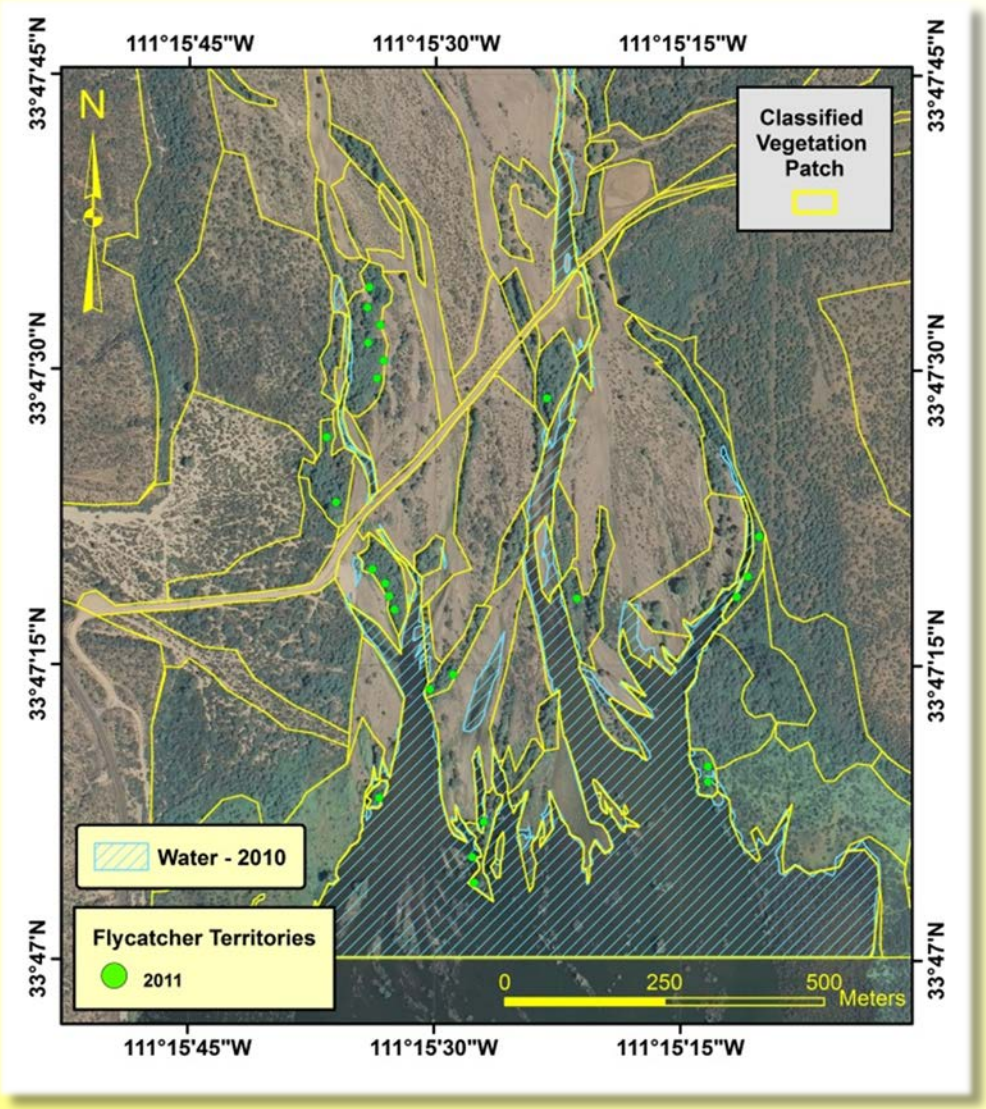
Five Habitat Suitability Index variables (1 m res)

- Percent cover tamarisk/ willow/cottonwood at 2–10 m height(*SI1*)
- Patch area (*SI2*)
- Vegetation height (*SI3*)
- Distance to water (*SI4*)
- Nest tree defoliation (*SI5*) susceptibility

Flycatcher HSI calculation

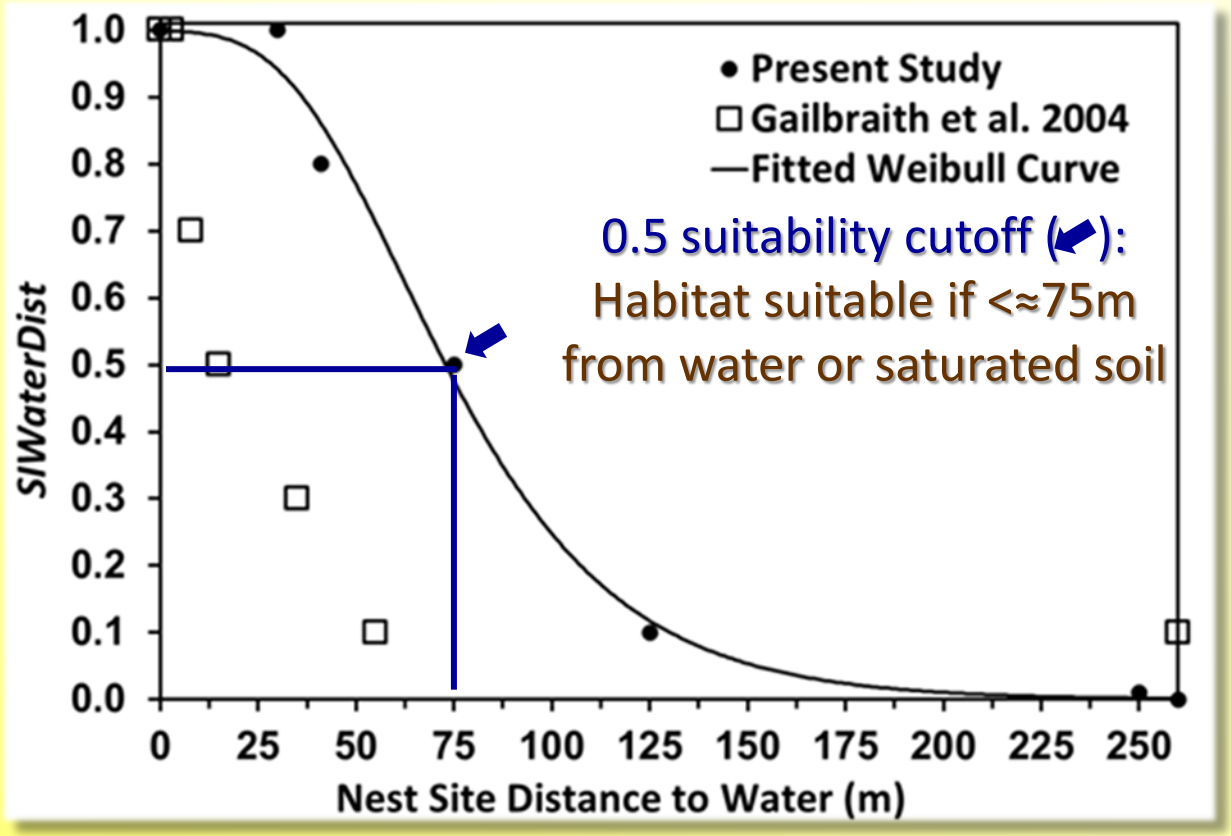
$$HSI = SI1 \times SI5 \times \sqrt[3]{SI2 \times SI3 \times SI4}$$

(Tracy et al. in prep.)



Flycatcher Habitat Suitability Index Model-
Estimating Suitability Index Curve of Distance to Water

- Step 1: Assemble univariate statistics from literature field data
- Step 2: Estimate suitability variables from field data statistics
- Step 3: Fit appropriate curve to estimated suitability variables

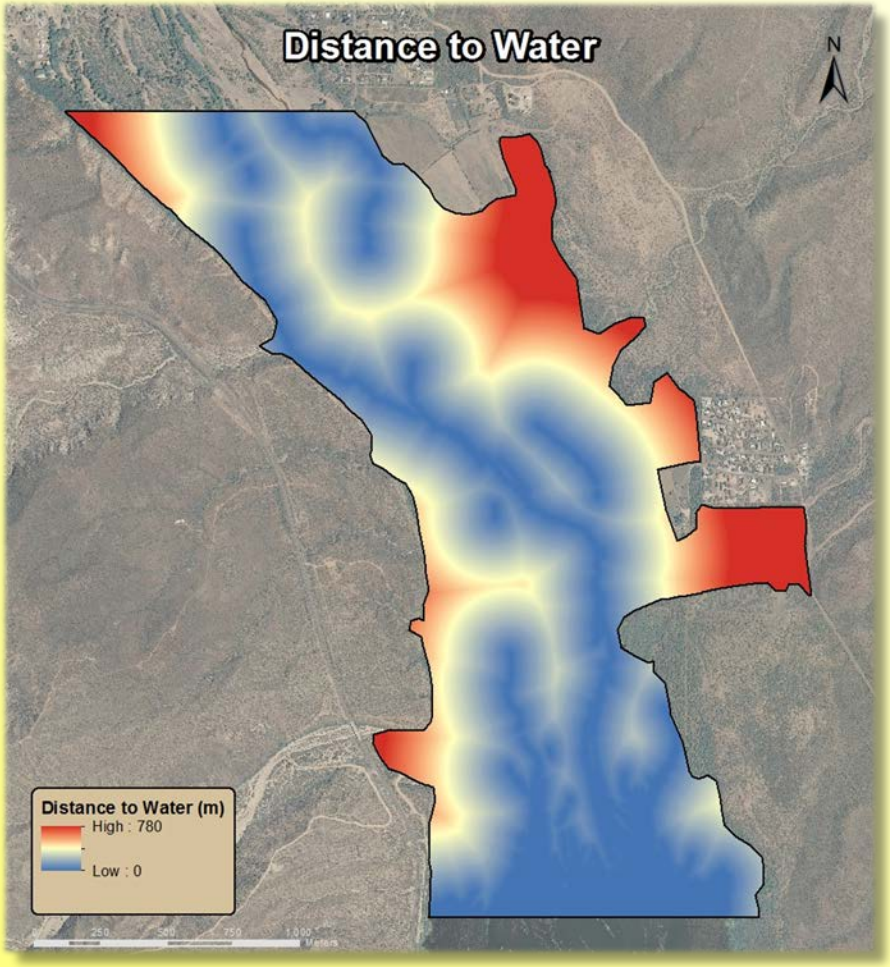


Fitted Weibull curve:

Suitability = 1 - e -1*((x+914501849.9222)/914501911.6335)**-30042543.2241

Flycatcher Habitat Suitability Index Model-
Estimating Suitability Index Curve of Distance to Water

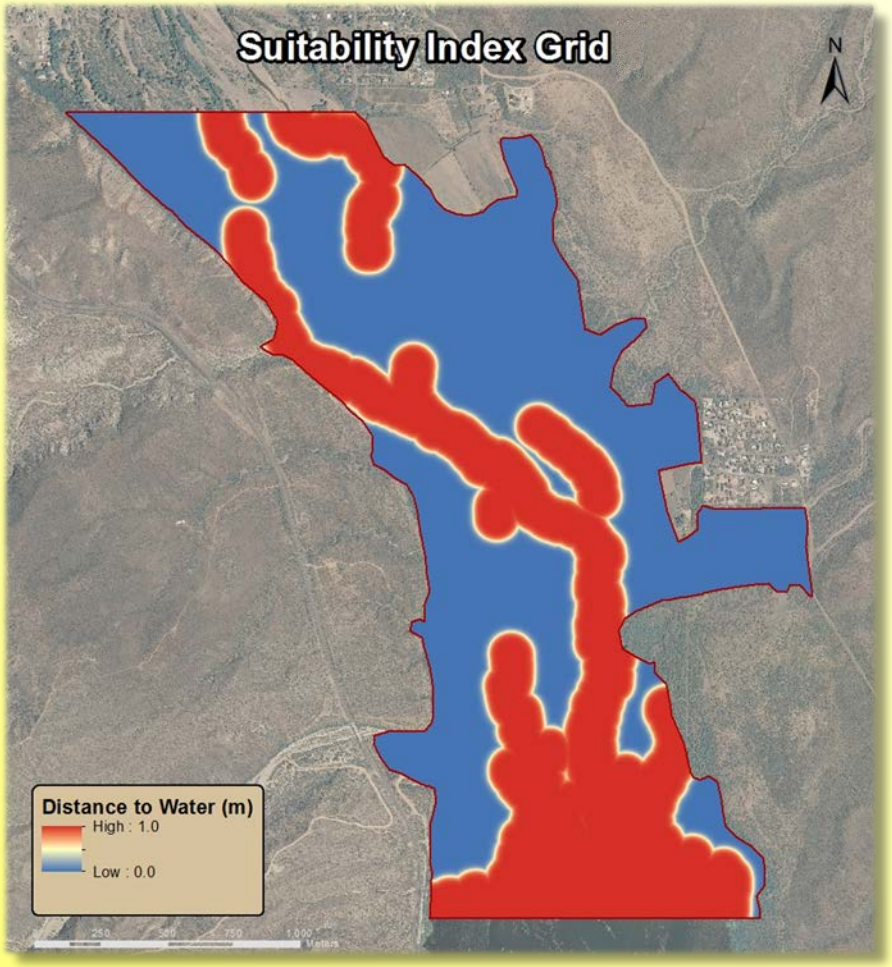
- Step 4: Calculate distance to water grid for study site (1 m res)



(Tracy et al. in prep.)

Flycatcher Habitat Suitability Index Model-
Estimating Suitability Index Curve of Distance to Water

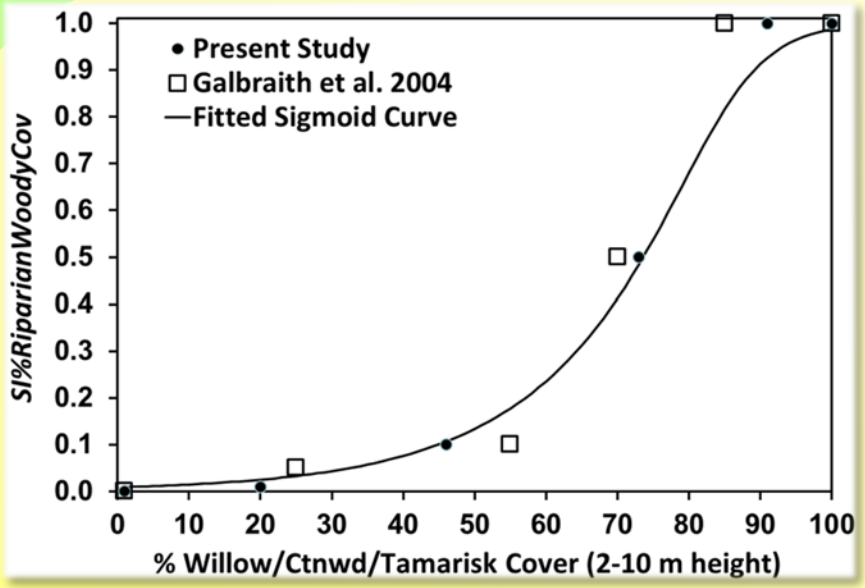
- Step 5: Apply suitability curve formula to distance to water grid and calculate suitability index grid *SI4*- distance to water



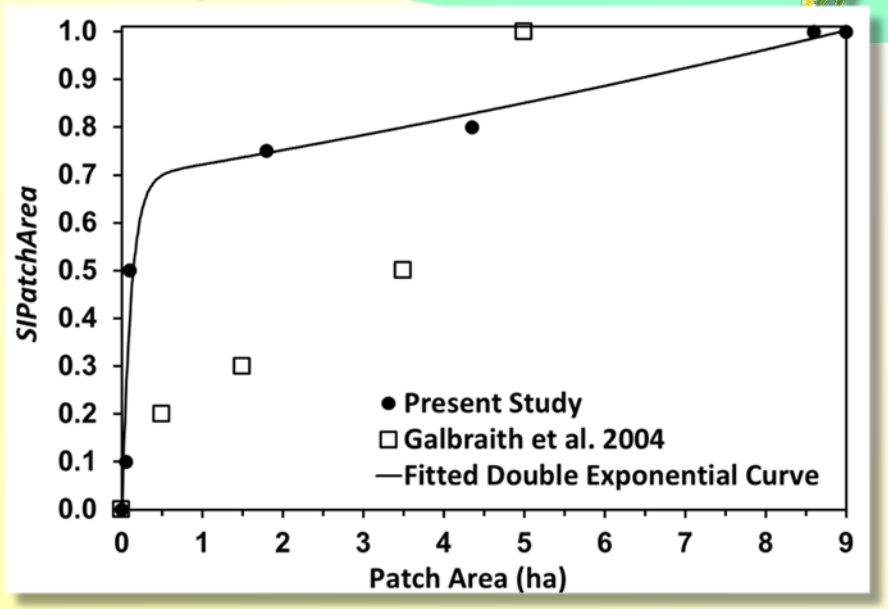
(Tracy et al. in prep.)

Flycatcher Habitat Suitability Index Model

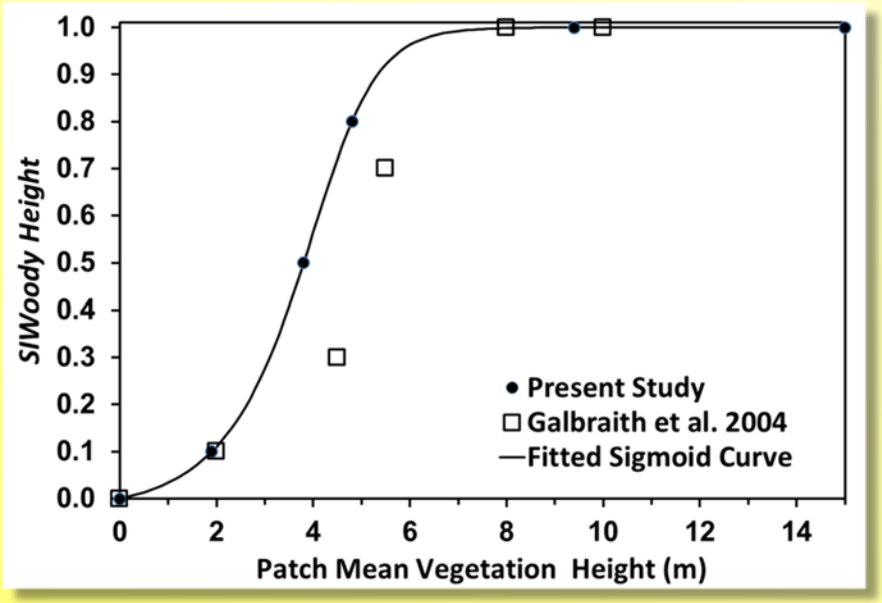
Patch-based Suitability Indices



% Cover Willow/ Cottonwood/Tamarisk at 2–10 m Height Index



Patch Area Index



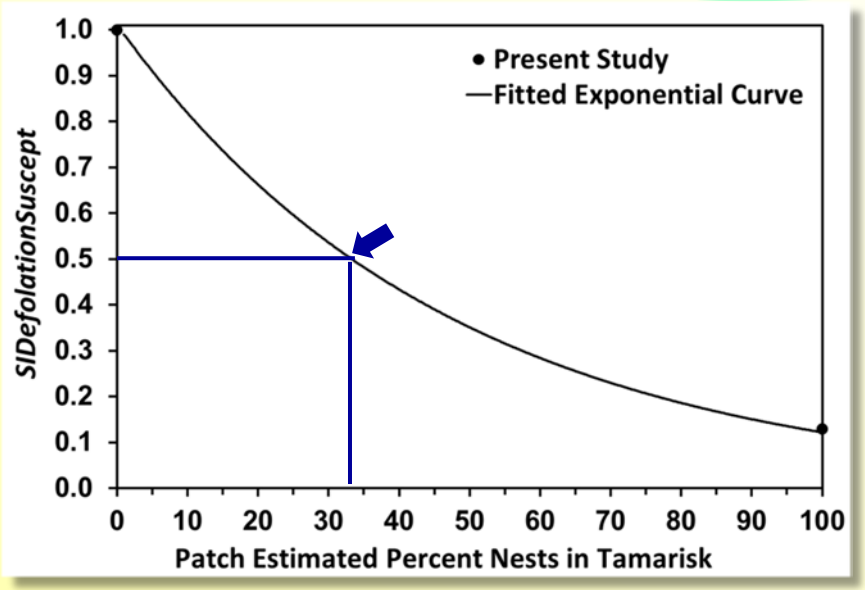
Patch Mean Vegetation Height Index

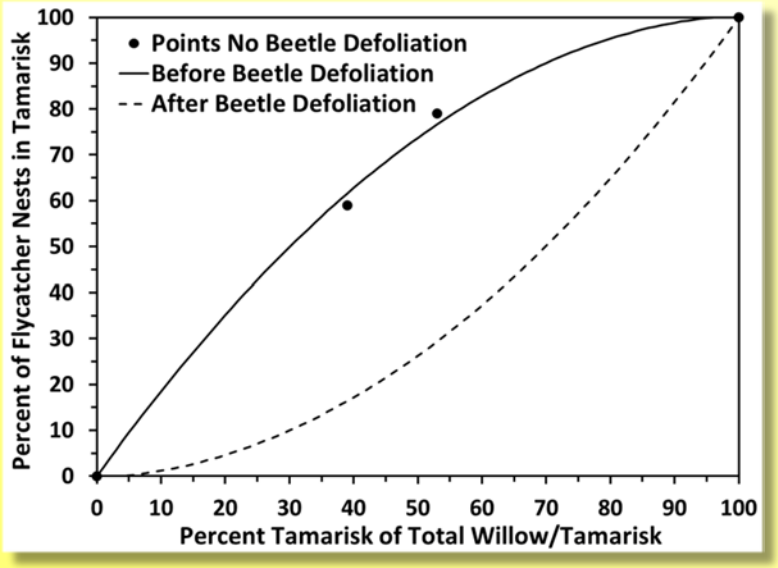
Flycatcher Habitat Suitability Index Model

Patch-based Suitability Indices

Nest Tree Defoliation Susceptibility Index

Habitat suitable if < ≈35% nests in tamarisk





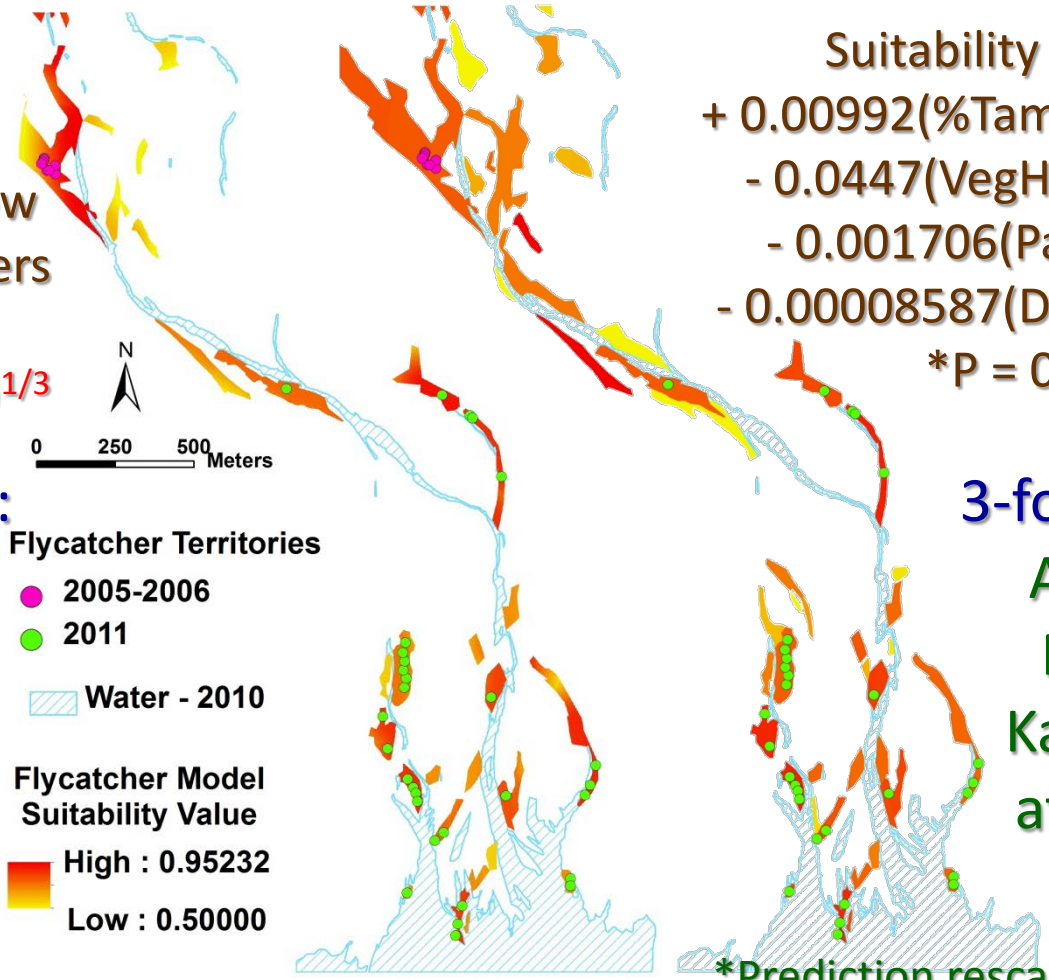
Estimated Percent Nests in Tamarisk based on % Tamarisk vs. Willow

Flycatcher Habitat Suitability Index Model and GLM Suitability Model

HSI

Suitability =
SI%Tamarisk/Willow
x (SIVegHeightMeters
x SIPatchAreaHa
x SIDistWatMeters)$^{1/3}$

3-fold validation:
AUC = 0.98;
Maximum
Kappa = 0.92
at threshold
0.72



GLM*

Suitability = 0.1091
+ 0.00992(%Tamarisk/Willow*)
- 0.0447(VegHeightMeters)
- 0.001706(PatchAreaHa)
- 0.00008587(DistWatMeters)
*P = 0.001

3-fold validation:
AUC = 0.98;
Maximum
Kappa = 0.90
at threshold
0.78

*Prediction rescaled to match HSI

Baseline suitability (Y0), Tonto Ck, AZ

HSI vs. GLM Flycatcher Suitability Model Comparison

Baseline flycatcher suitable habitat projected by HSI and GLM models for Tonto Creek A-Cross Site, AZ.

Model	Threshold	Total Quantity Suitable Habitat (ha)	Mean Quality Suitable Habitat
HSI	≥ 0.50	19.1	0.77
GLM	≥ 0.50	31.8	0.76
% Difference		66%	1%
HSI	≥ 0.71*	13.2	0.82
GLM	≥ 0.78*	19.7	0.82
% Difference		49%	0%

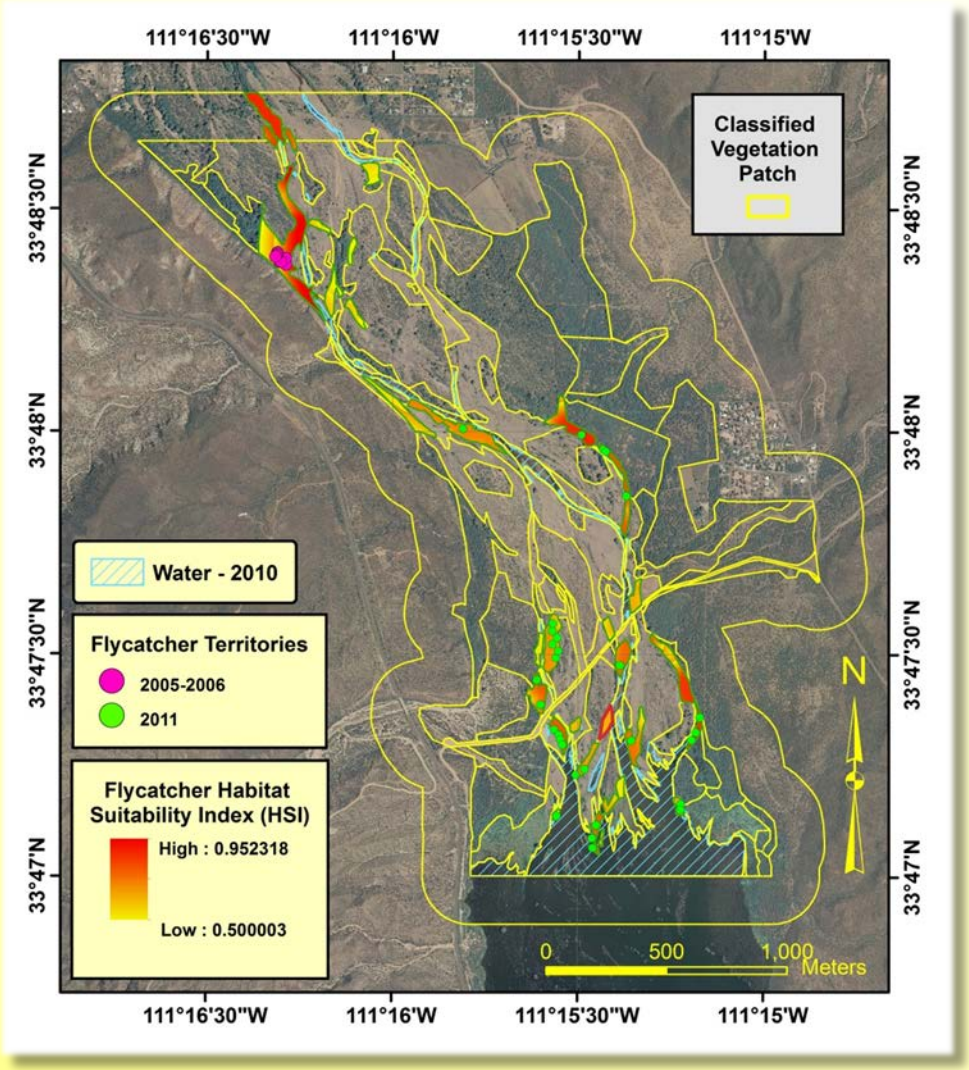
*Threshold maximizing kappa.

Flycatcher Habitat Suitability Index Model – *HSI*

Combine five suitability indices by weighted HSI formula to project baseline flycatcher habitat, Tonto Ck, AZ

Baseline HSI projections

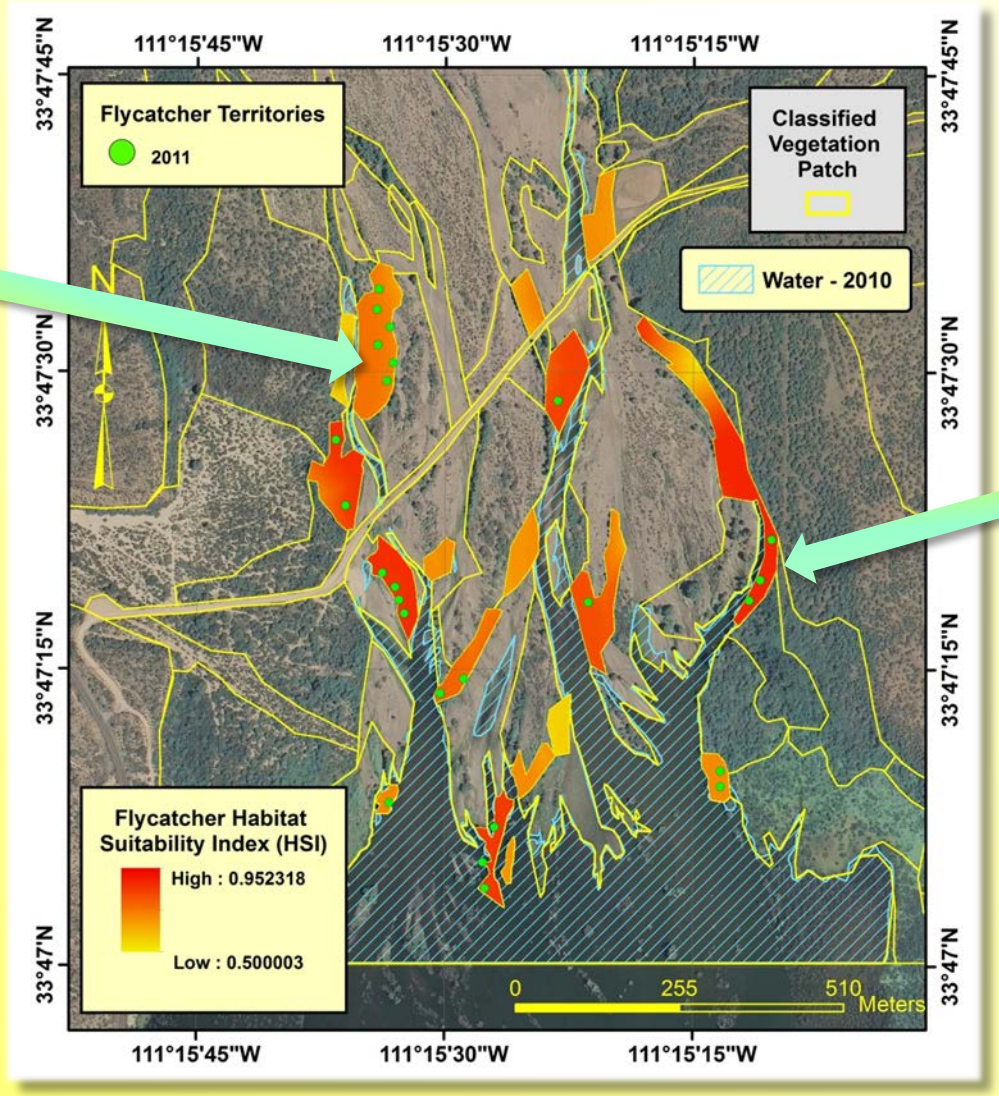
- Suitable flycatcher habitat (≥ 0.5 *HSI*) (yellow/orange/red) projected at 19.1 ha
- Suitable habitat quality projected at 0.77 out of 1.0



Flycatcher Habitat Suitability Index Model – *HSI*

Projected baseline flycatcher habitat, Tonto Ck, AZ

Correctly projected flycatcher occupied patch of 75% tamarisk 25% willow

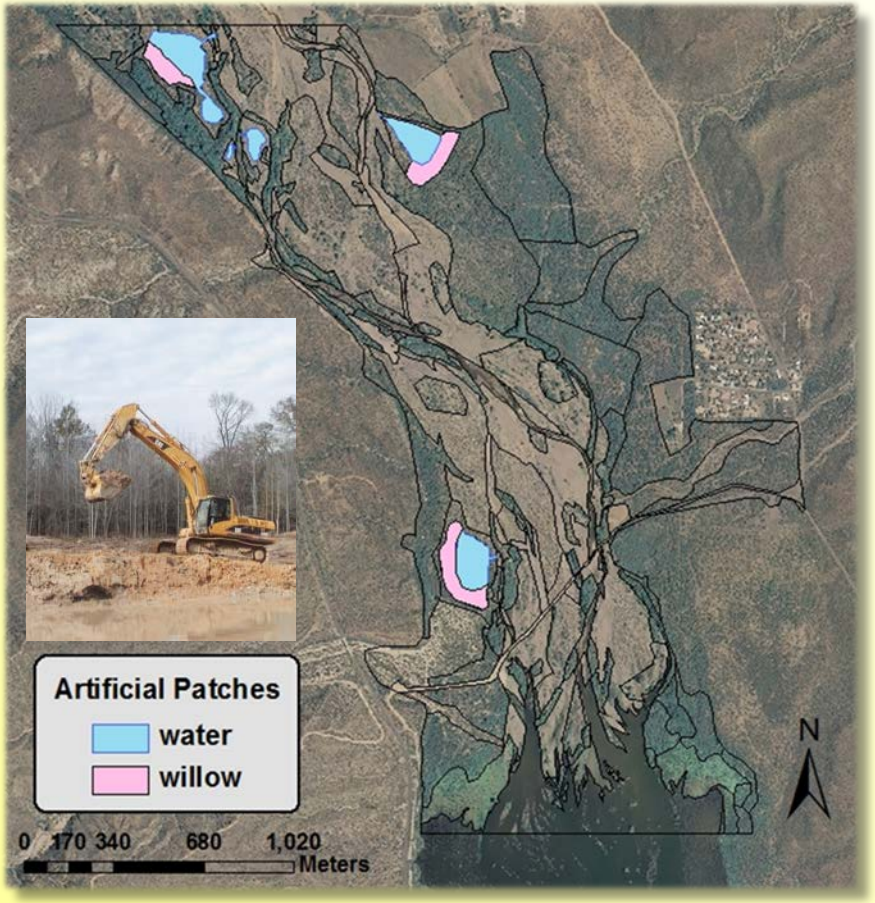


Correctly projected flycatcher occupied patch of 10% tamarisk 90% willow

Simulation flycatcher Habitat Suitability Index Model to assess beetle impact and restoration

Main assumptions for flycatcher HSI simulation models

- Tamarisk dieback due to beetles averages about 50% over a 3 yr period (based on data from Big Spring, Texas)
- Flycatchers switch nesting preference from tamarisk to willow after 1st yr defoliation
- Pole plantings of willows take three years to reach suitable heights for flycatcher nesting habitat

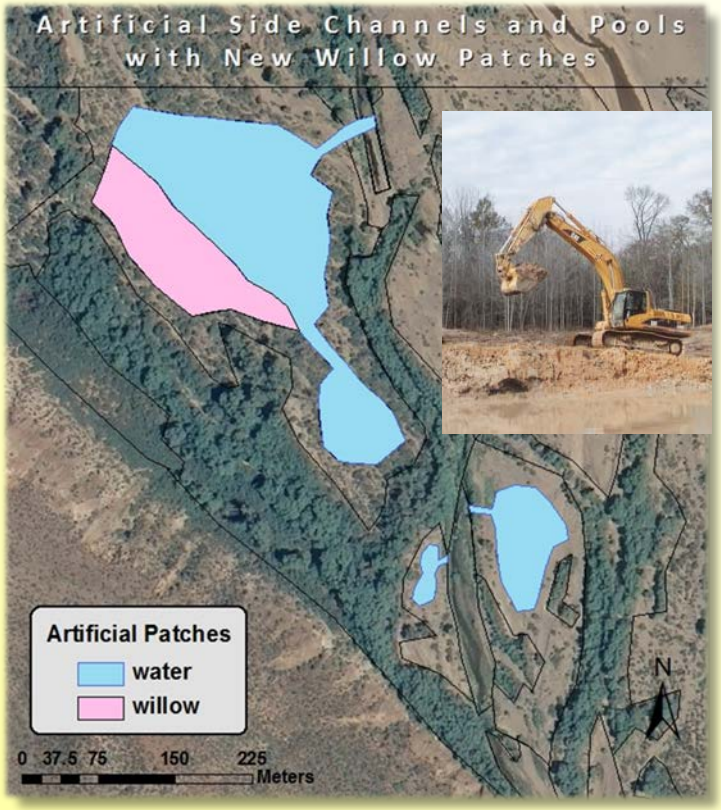


Year 3 simulated added artificial side channel pools and planted willow patches, Tonto Ck, AZ

Simulation flycatcher Habitat Suitability Index Model to assess beetle impact and restoration

Flycatcher HSI simulation model scenarios, Tonto Ck, AZ

- Year 0- baseline suitability
- Year 1- suitability with 100% beetle defoliation of tamarisk
- Year 3- suitability with beetle defoliation and 50% tamarisk dieback (including some willow regrowth)
- Year 3- suitability with beetle defoliation and dieback and 5 ha artificial willow patch creation and 8 ha pools

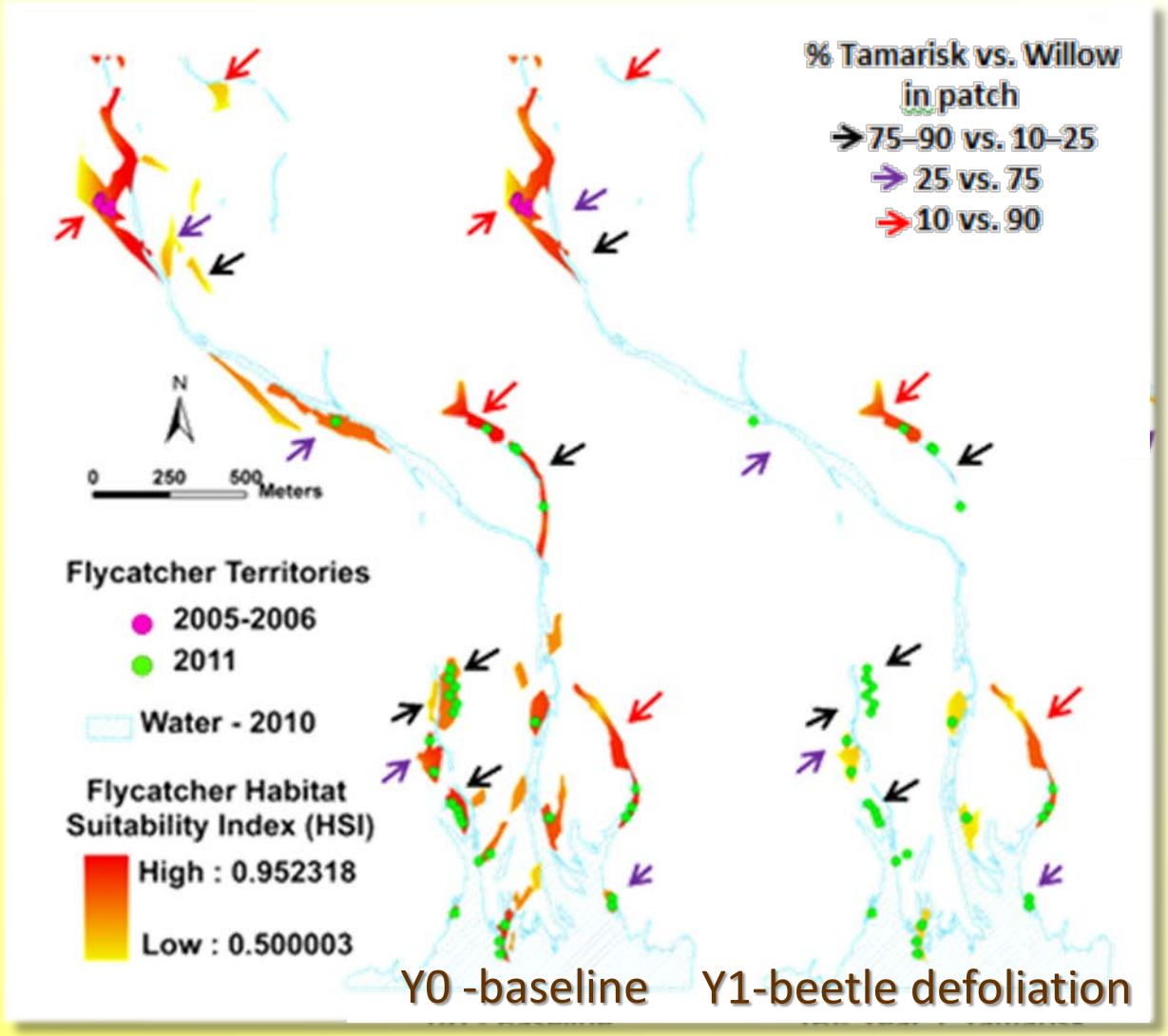


Year 3 simulated added artificial side channel pools and planted willow patches, Tonto Ck, AZ

Simulation flycatcher Habitat Suitability Index Model to assess beetle impact and restoration

Flycatcher HSI baseline (Y0) and Year 1 (Y1) simulation, Tonto Ck, AZ

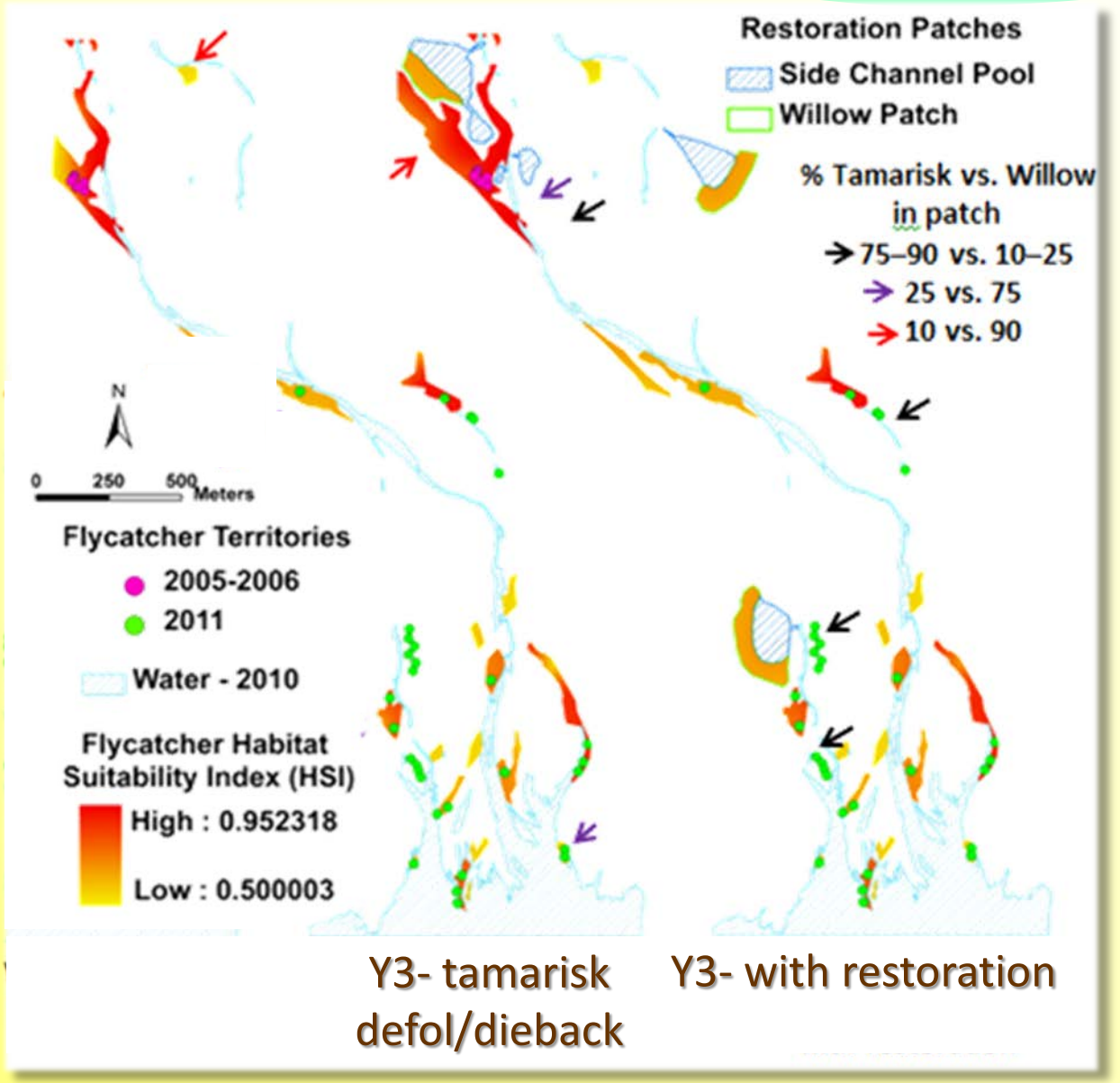
- In Year 1 of beetle defoliation, 56% loss of suitable flycatcher habitat, with a loss of 2/3 of suitable patches
- Most, but not all, patches lost are dominated by tamarisk



Simulation flycatcher Habitat Suitability Index Model to assess beetle impact and restoration

Year 3 simulations, Tonto Creek, AZ

- By Year 3 (Y3) of defoliation, only 25% of habitat is lost (not 56% as in Y1) due to flycatchers switching preference to willow.
- In Y3 with restoration of 5 ha willows, suitable habitat can be restored 22% above baseline Y0

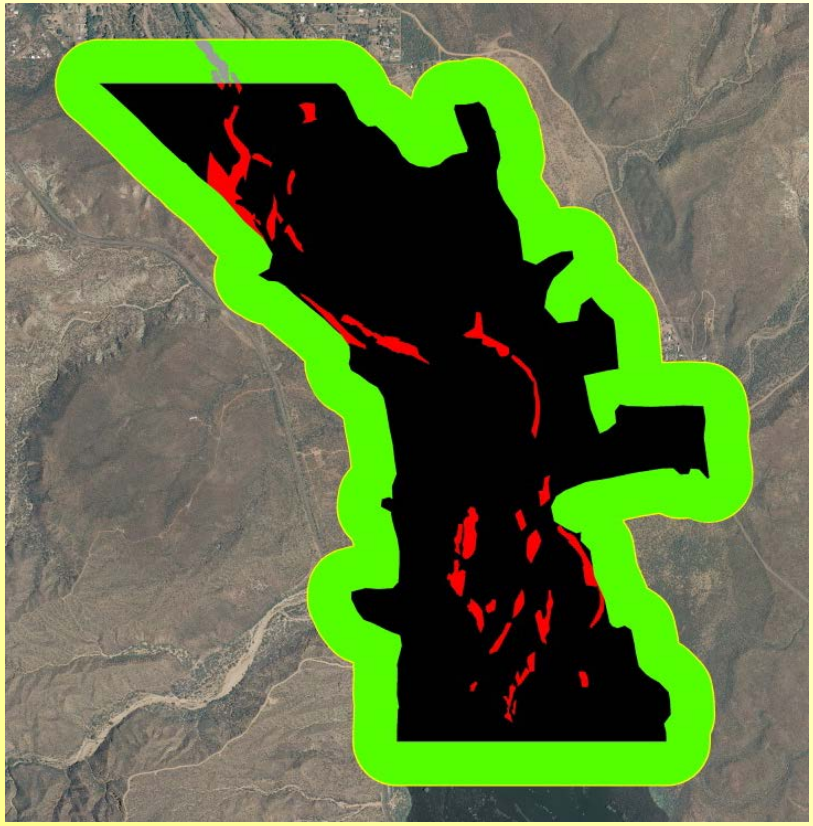


FRAGSTATS Connectivity metrics for flycatcher suitable habitat patches (HSI ≥ 0.5)

Patch Metrics

- Mean Patch Area (ha)
- Mean Proximity Index*
- Mean Euclidean Nearest Neighbor (m)*

1-m grid with 200 m buffer



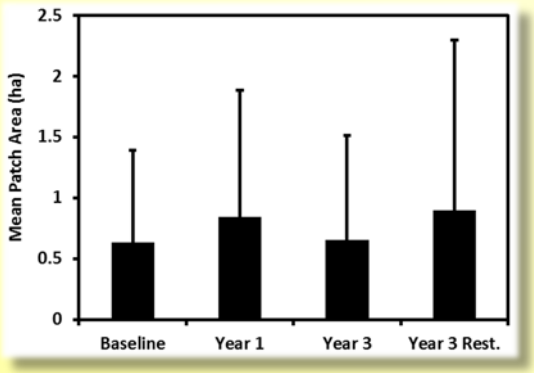
Class Metrics

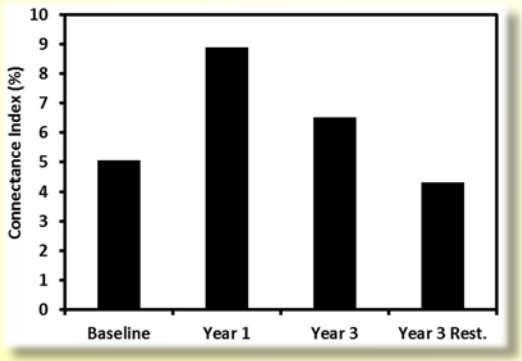
- Connectance Index (%)*
- Patch Cohesion Index
- Correlation Length

*Related to functional connectivity based on estimated 80 m radius flycatcher home range

Connectivity metrics for flycatcher suitable habitat patches (HSI ≥ 0.5): Baseline to Year 3 simulations

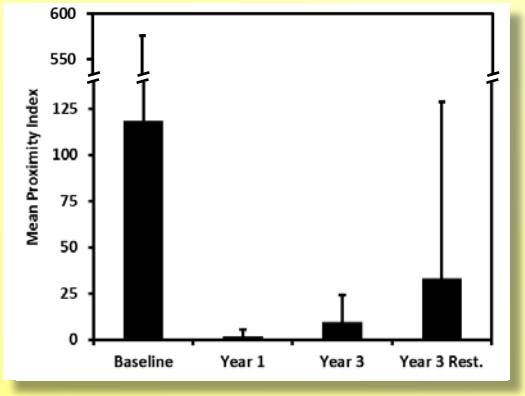
Mean Patch Area (ha)

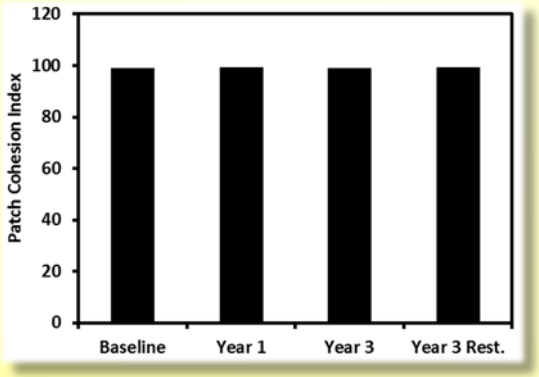




Connectance Index (%)

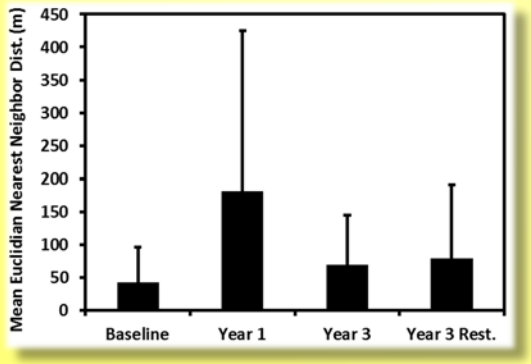
Mean Proximity Index

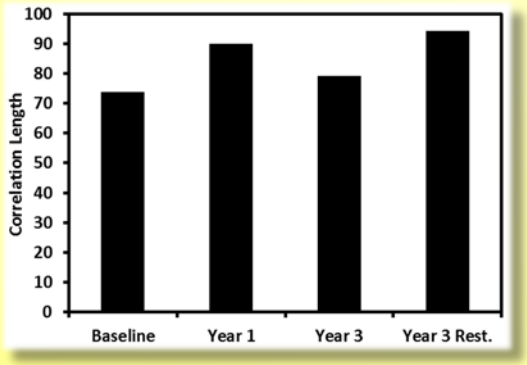




Patch Cohesion Index

Mean Euclidean Nearest Neighbor (m)





Correlation Length

Simulation flycatcher Habitat Suitability Index Model to assess beetle impact and restoration

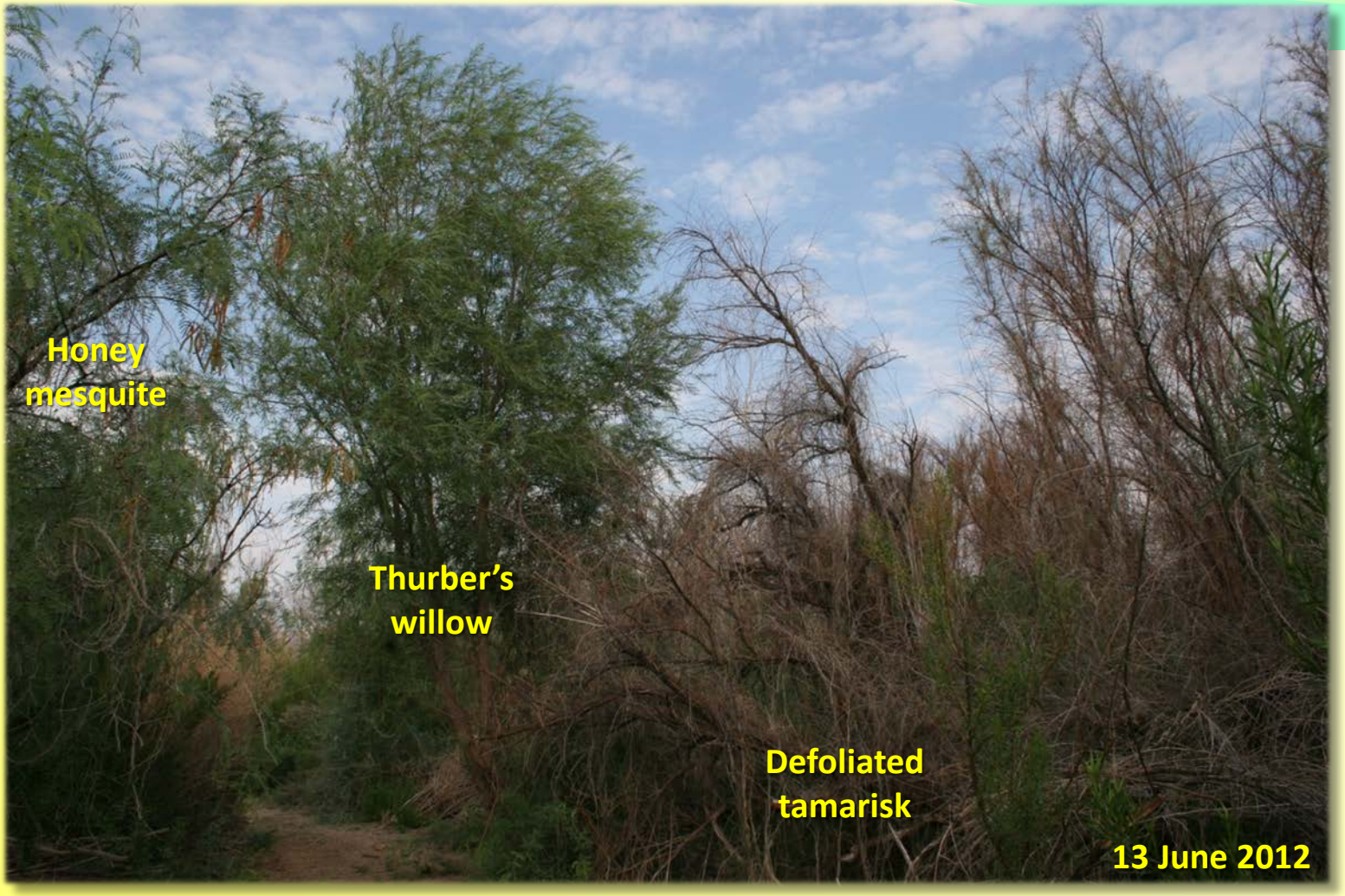
Projections from flycatcher HSI simulations

- Highest losses to flycatcher habitat may occur during the first year of tamarisk beetle defoliation
- Significant loss of flycatcher habitat suitability may occur in willow patches with as little as 10–25% tamarisk
- Addition of side channel pools with willow patches three years prior to arrival of beetles can potentially mitigate flycatcher habitat loss to tamarisk beetles
- Addition of pools next to existing willow stands can improve their suitability to flycatchers
- HSI simulations can guide timing, placement, and amount of pool/willow patches for habitat restoration

Acknowledgements

- Amy Ann Madara-Yagla, Forest Protection Officer, USDA Forest Service, Tonto National Forest, Tonto Basin Ranger District, Roosevelt, Arizona

Questions?



Forgotten River Reach, Rio Grande, Candelaria, TX