Tamarisk beetles, endangered flycatchers, and riparian restoration

Texas A&M AgriLife Research | Extension

James L. Tracy
Robert N. Coulson
Knowledge Engineering Lab.
Department of Entomology
Texas A&M University

Texas A&M University
Agriculture & Life Sciences
Department of Entomology

KEL
KNOWLEDGE ENGINEERING LABORATORY

Texas Riparian Association
October 26 2012,
McKinney Roughs Nature Park, Texas

Restoration and Tamarisk Biocontrol

Tamarisk (Saltcedar; *Tamarix* spp.)

Tamarisk beetles (*Diorhabda* spp.)

Native Riparian Restoration

Southwestern willow flycatcher (*Empidonax trailli extimus*)

Tamarisk (Saltcedar)

- Old World *Tamarix* spp. ornamentals 1800s
- Naturalized SW riparian areas 1920's-1930's

Asian *T. ramosissima/T.chinensis*

Mediterranean *T. gallica/T. canariensis*

Tamarisk Invasion

- Extensive monocultures in arid and semi-arid riparian habitats
- Now dominant western riparian tree

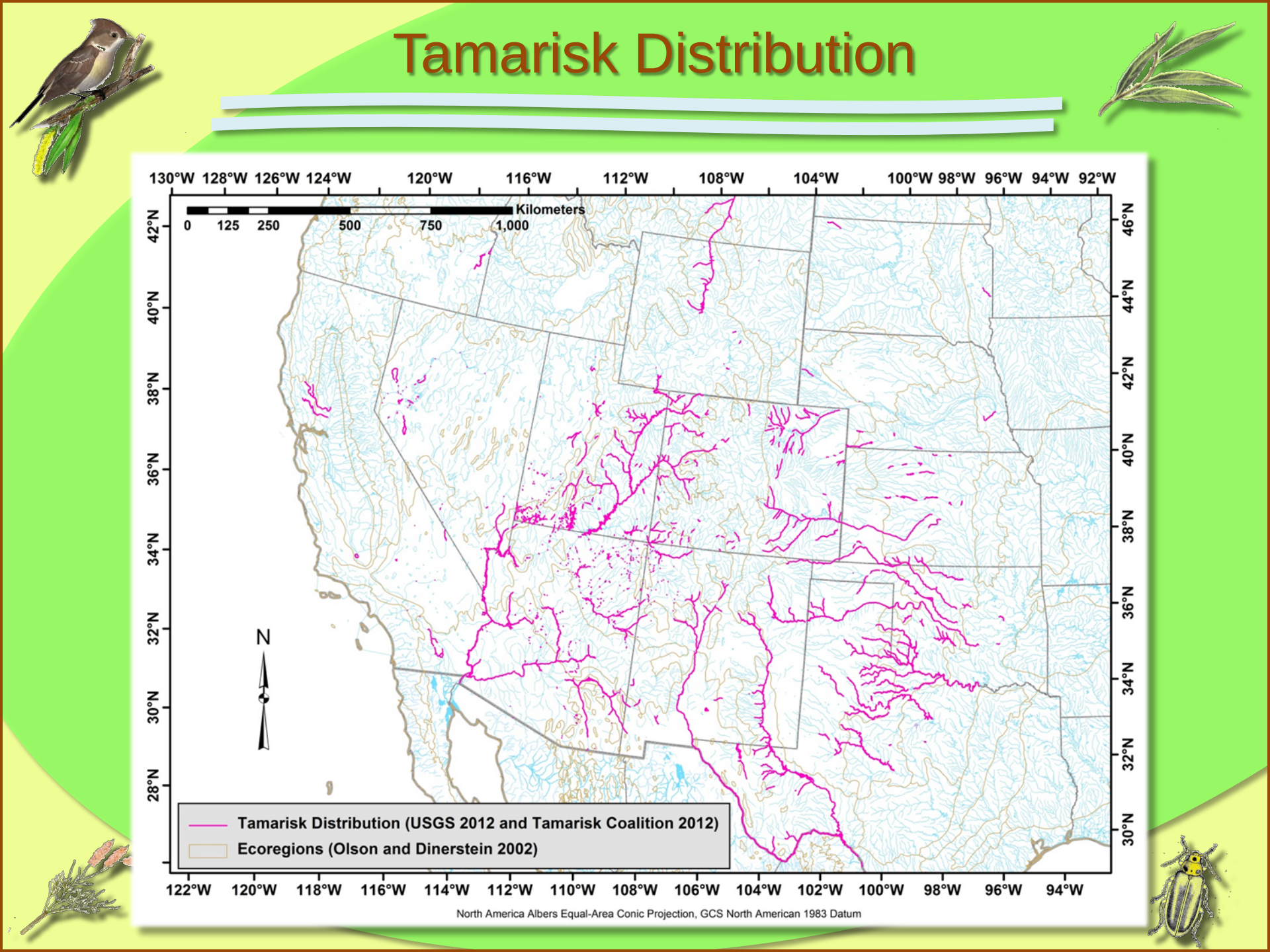
Rio Grande at Candelaria ,TX, 15 April 2008 (Jim Everitt, USDA)

Tamarisk Invasion

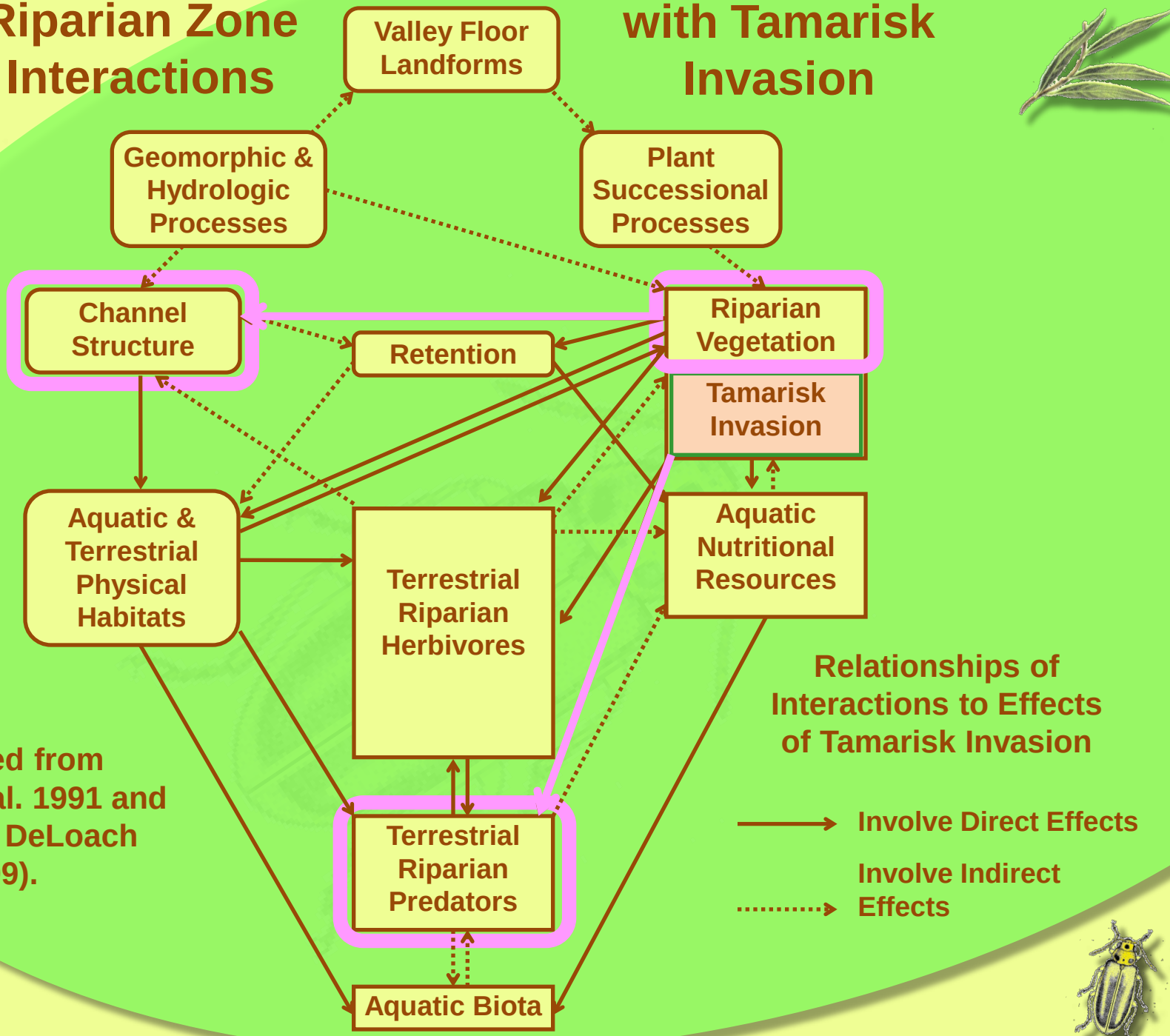
- Multimillion dollar control programs such as along Pecos River

Pecos River nr Iraan ,TX, 1971 (Jack DeLoach, USDA)

Tamarisk Distribution



Riparian Zone Interactions with Tamarisk Invasion



(modified from Gregory et al. 1991 and Tracy and DeLoach 1999).

Relationships of Interactions to Effects of Tamarisk Invasion

→ Involve Direct Effects

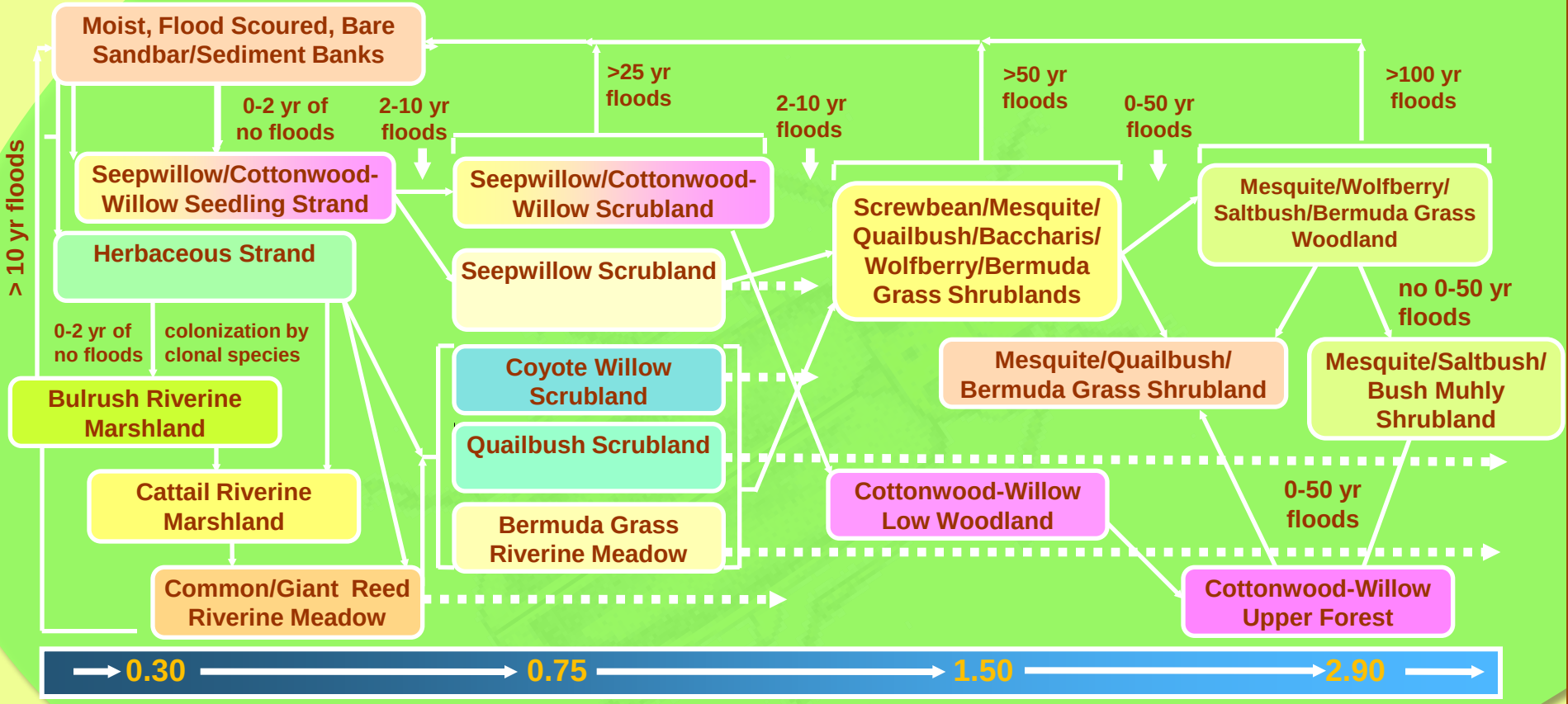
⇢ Involve Indirect Effects

Tamarisk Ecosystem Costs

- **Loss of riparian biodiversity**
  - Cottonwood/willow woodlands
  - Grasslands and shrublands
  - Marshes and unvegetated strands
- **Loss of complex lateral stream habitat**

Beals Creek, Big Spring ,TX, 16 Aug 2007 (Jack DeLoach, USDA)

Plant Successional Model of a Southwestern Riparian System



Increasing Depth to Water Table (m)

Tracy and Deloach (1999)

Tamarisk – Loss of Riparian Diversity

Moist, Flood Scoured, Bare Sandbar/Sediment Banks

tamarisk invasion

0-2 yr of no floods

Tamarisk Seedling Strand

2-10 yr floods

Tamarisk Scrubland

>25 yr floods

2-10 yr floods

Tamarisk Low Woodland

>50 yr floods

0-50 yr floods

Tamarisk Upper Woodland

>100 yr floods

Seepwillow/Cottonwood-Willow Seedling Strand

Herbaceous Strand

0-2 yr of no floods

colonization by clonal species

Bulrush Riverine Marshland

Cattail Riverine Marshland

Common/Giant Reed Riverine Meadow

Seepwillow/Cottonwood-Willow Scrubland

Seepwillow Scrubland

Coyote Willow Scrubland

Quailbush Scrubland

Bermuda Grass Riverine Meadow

Screwbean/Mesquite/Quailbush/Baccharis/Wolfberry/Bermuda Grass Shrublands

Mesquite/Wolfberry/Saltbush/Bermuda Grass Woodland

no 0-50 yr floods

Mesquite/Quailbush/Bermuda Grass Shrubland

Mesquite/Saltbush/Bush Muhly Shrubland

Cottonwood-Willow Low Woodland

0-50 yr floods

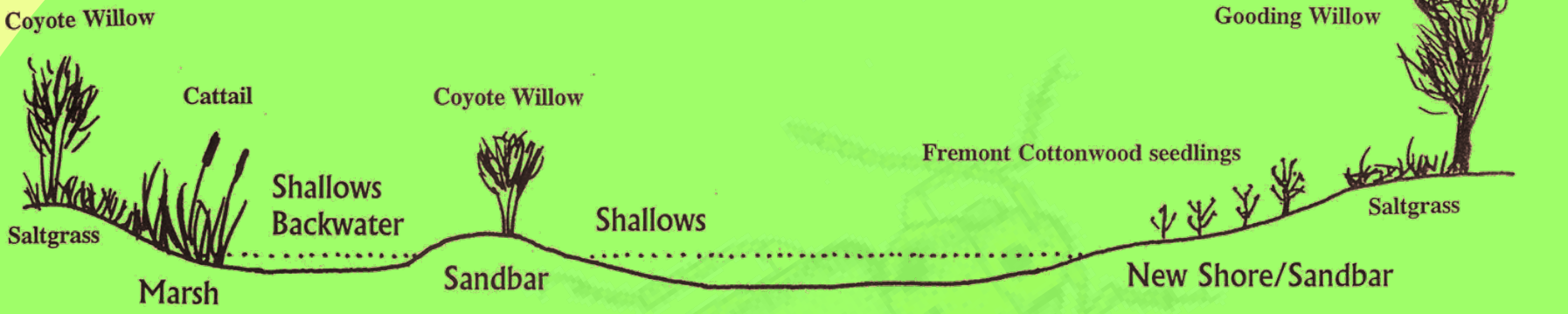
Cottonwood-Willow Upper Forest

0.30 → 0.75 → 1.50 → 2.90

Tamarisk – Loss Complex Lateral Habitats

Tamarix Induced Changes in Channel Structure and Associated Habitats

Historical Heterogenous Wide, Braided Channel Habitat



Above Channel Modified by *Tamarix* into a Homogenous, Narrow, Deep Run Habitat

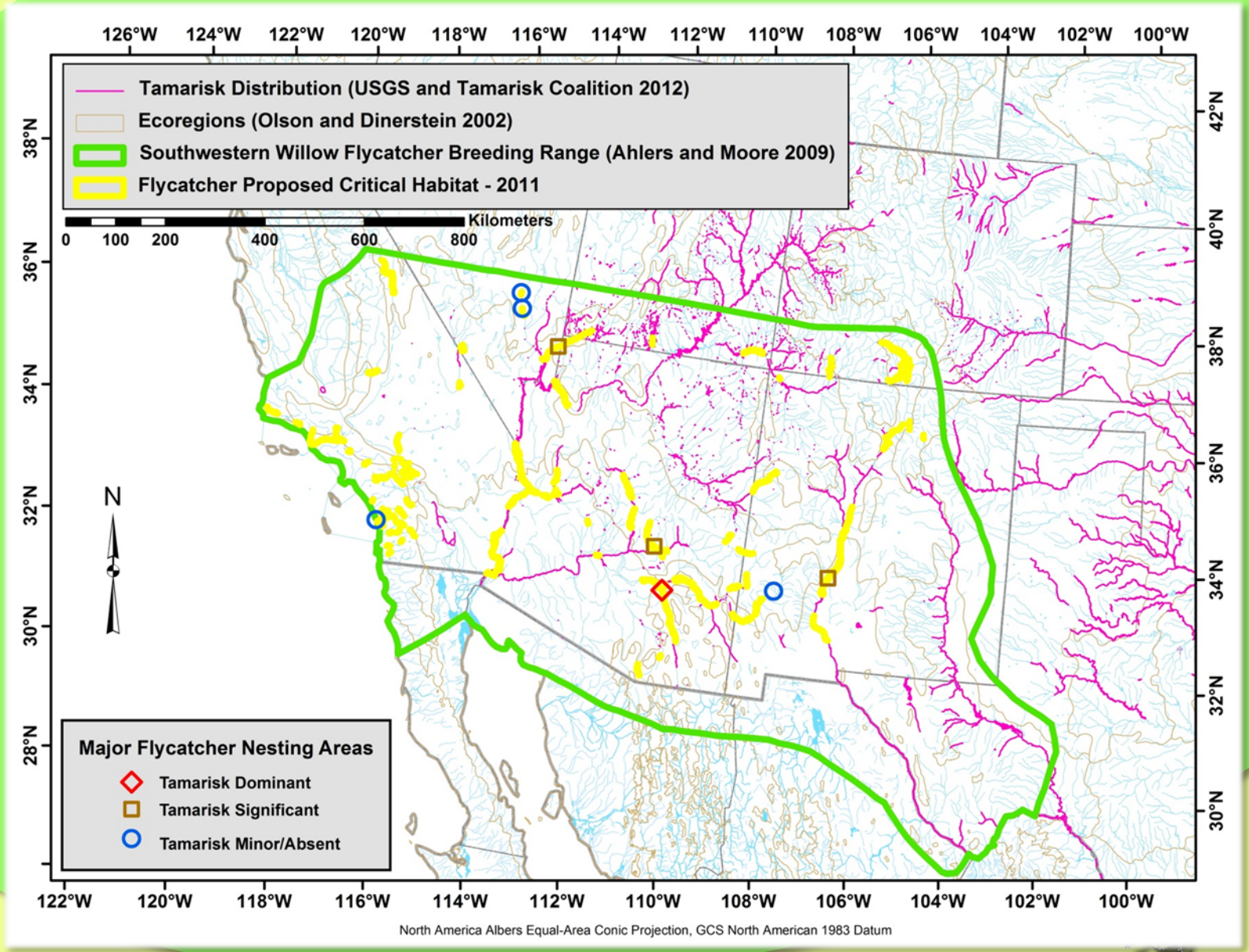
Tamarisk Ecosystem Services

- Bank stabilization/erosion control
- Riparian woodland bird habitat
- Pollen and nectar source for bees, insects
- Capillary draw down of salts in wet soils
- Phytoremediation of salts, nutrients, metals

Beals Creek, Big Spring ,TX, 16 Aug 2007 (Jack DeLoach, USDA)

SW Willow Flycatcher

Federally Listed Endangered 1995



SW Willow Flycatcher

Lower San Pedro River, AZ

Buttonbush-tamarisk-
Goodding's willow-velvet ash understory

Buttonbush understory/
Goodding's willow-
velvet ash overstory

(Sogge et al. 1997)

Introduced Tamarisk Beetle, *Diorhabda* spp., Biocontrol Agents

Eggs

Larva (3rd Instar)

Pupa

5 mm

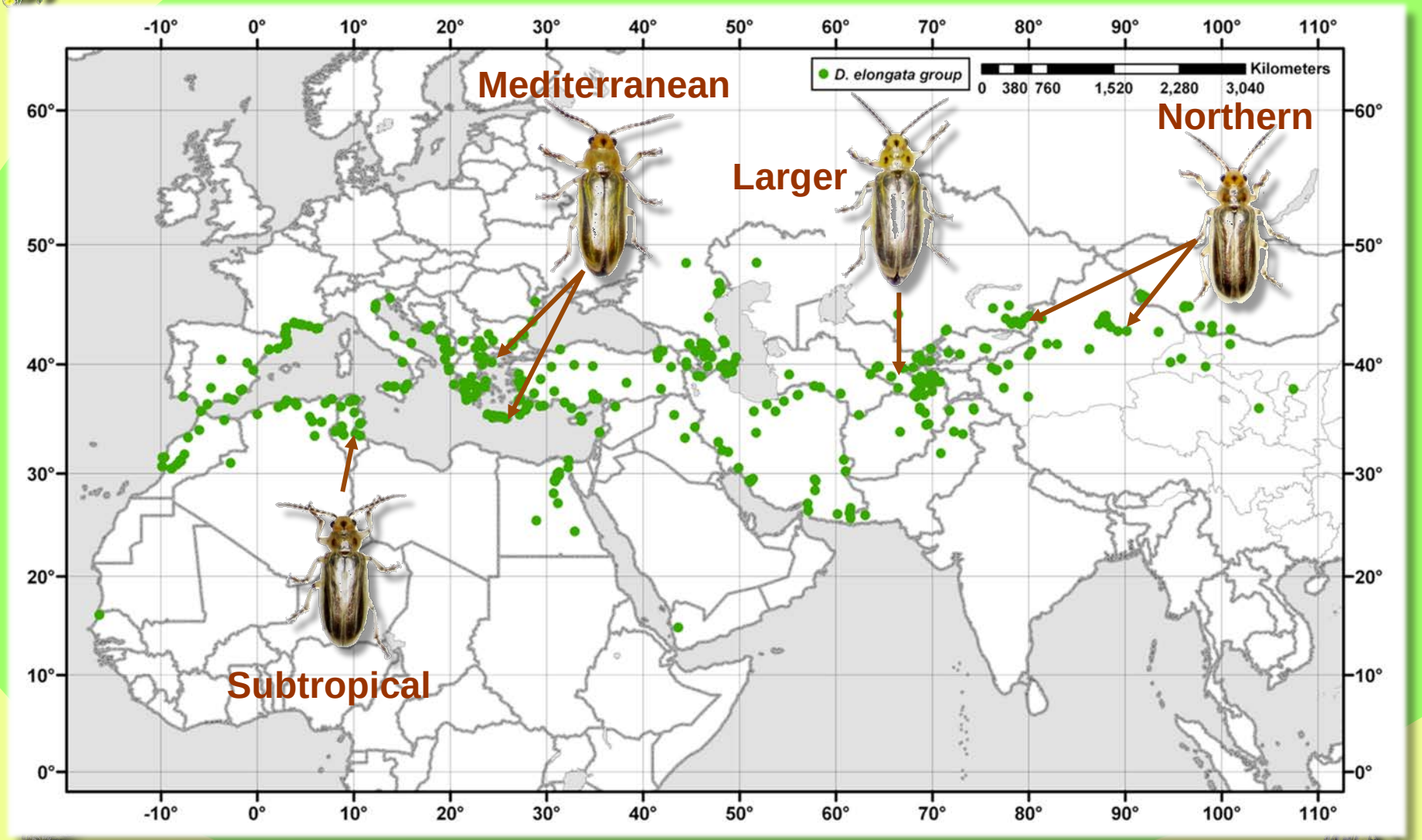
Northern
D. carinulata

Mediterranean
D. elongata

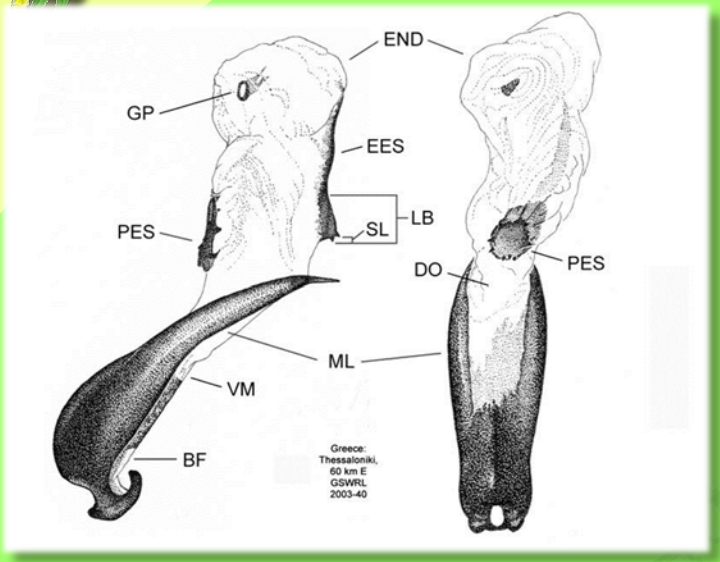
Larger
D. carinata

Subtropical
D. sublineata

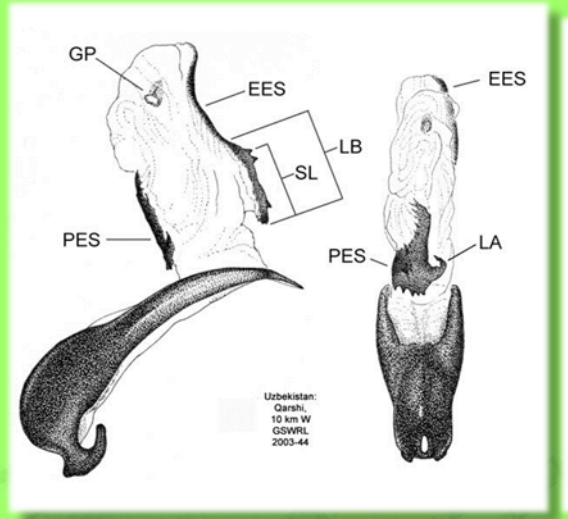
Tamarisk Beetle Old World Distribution



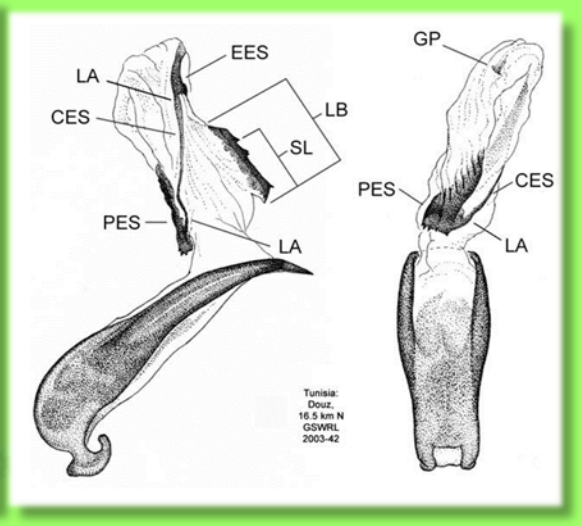
Tamarisk Beetle Male Genitalia



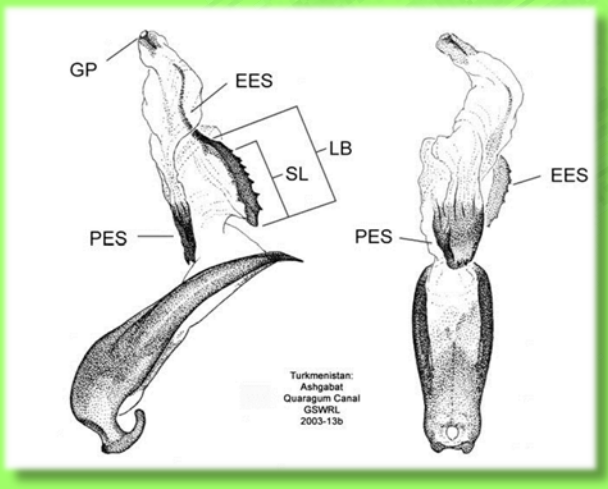
Mediterranean



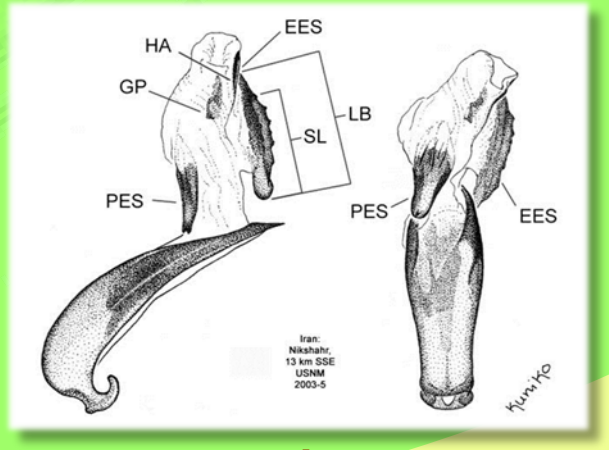
Larger



Subtropical

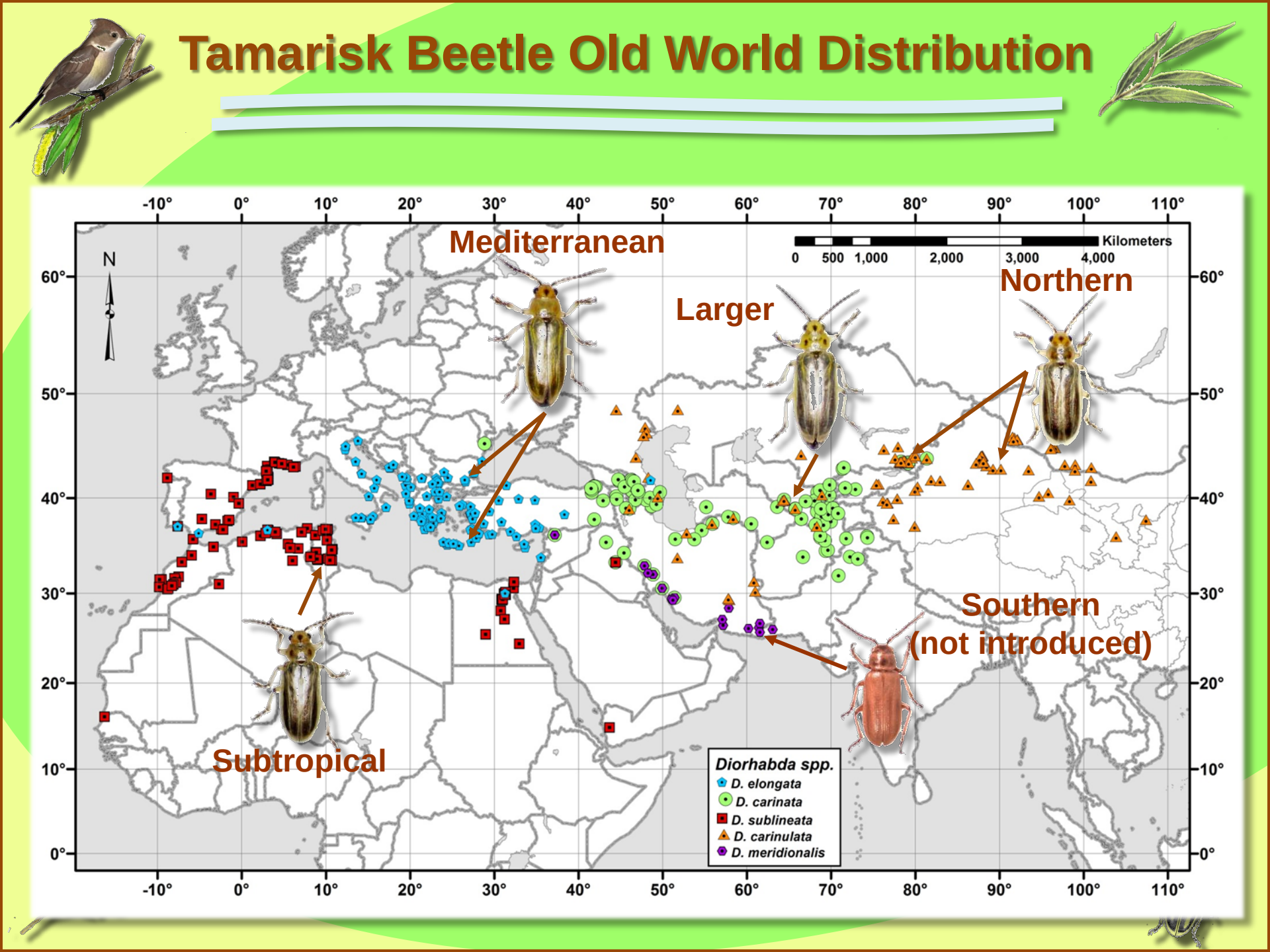


Northern



Southern

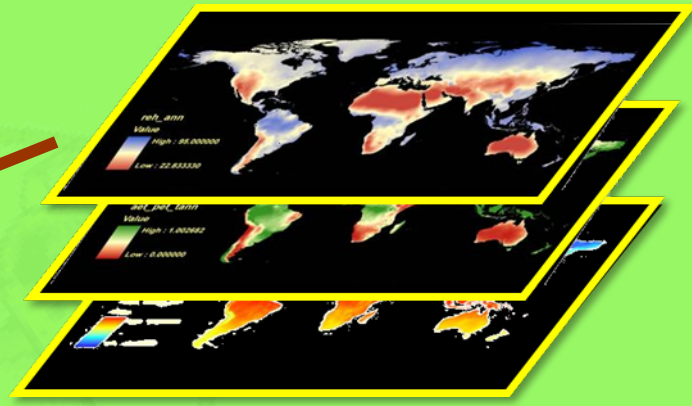
Tamarisk Beetle Old World Distribution



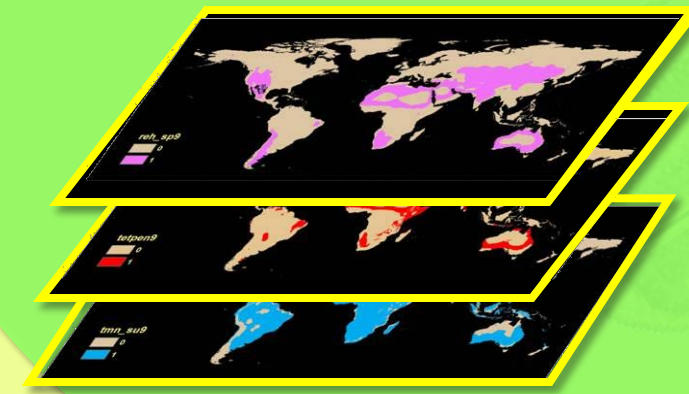
Species Distribution Model
- Environmental Score Index

Species Distribution Points

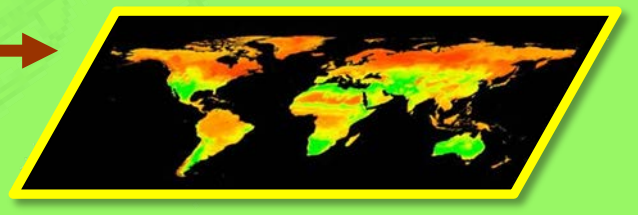
59 Environmental Layers



Environmental Ranges for Distribution

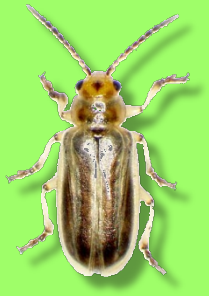


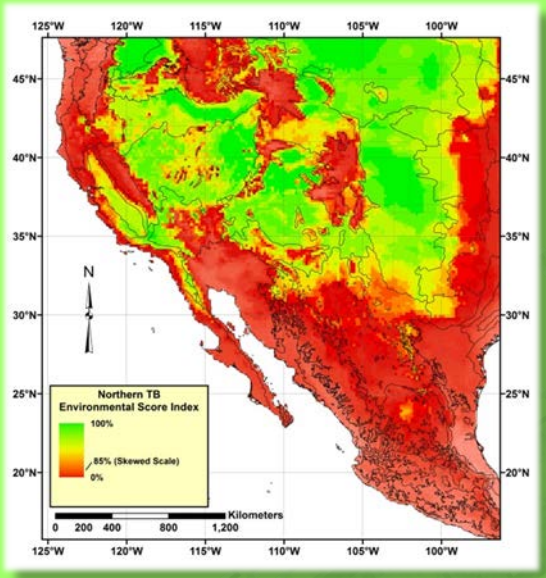
Projected Distribution



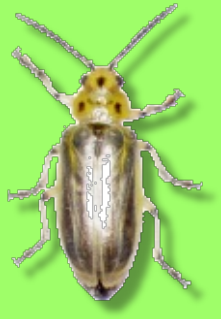
Tamarisk Beetle Distribution Models - Environmental Score Index

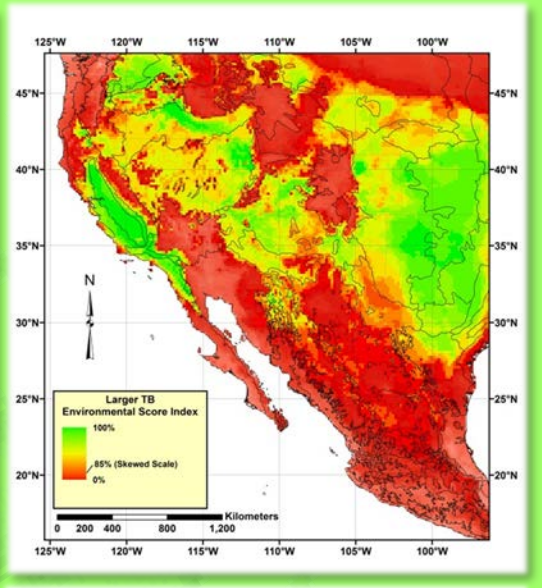
Northern TB



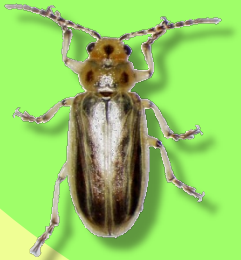


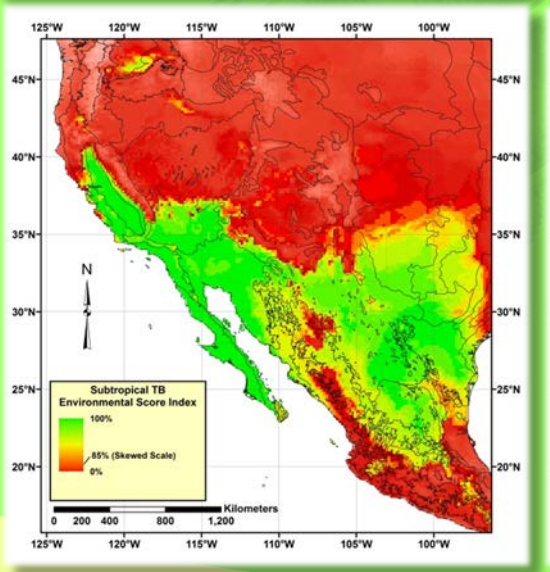
Larger TB



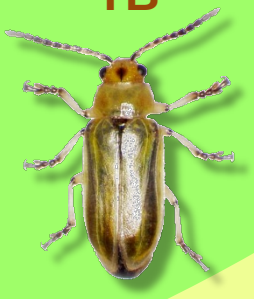


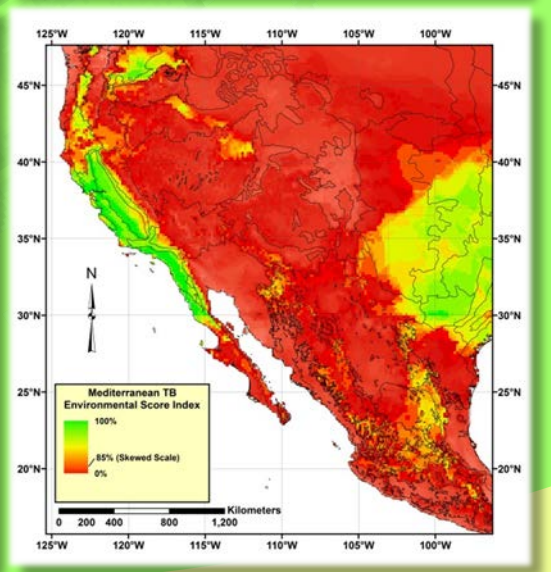
Subtropical TB



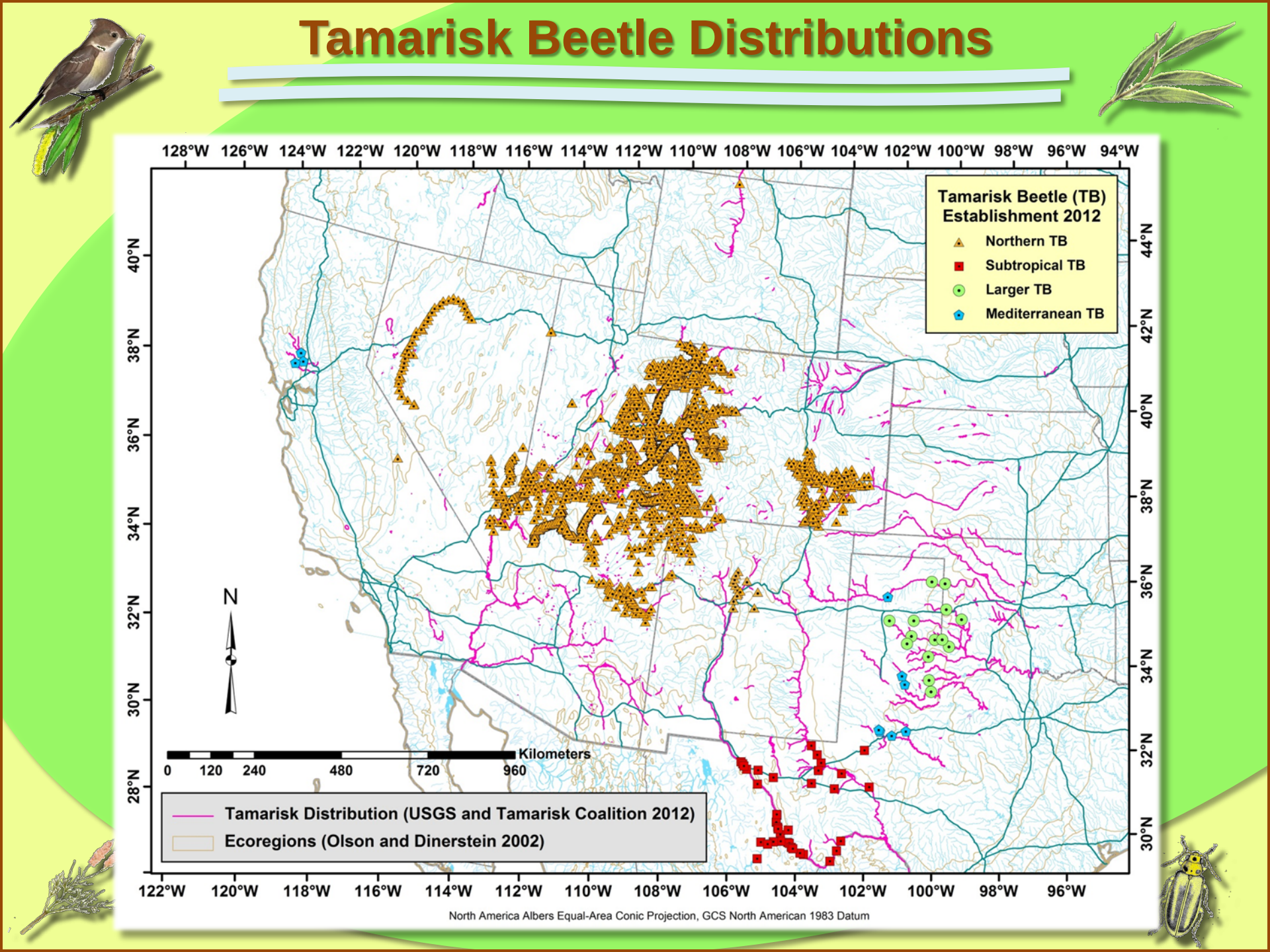


Mediterranean TB

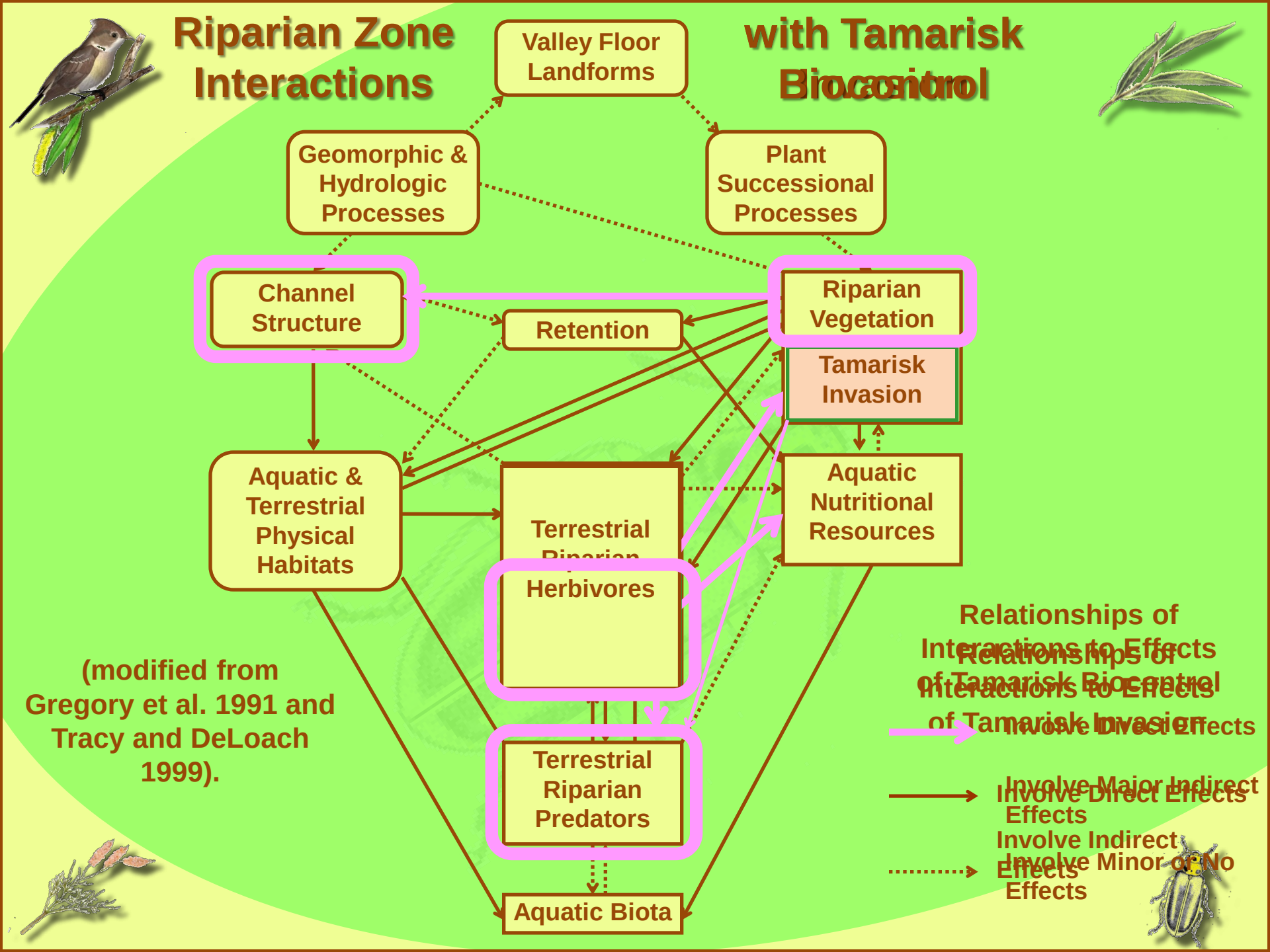




Tamarisk Beetle Distributions



Riparian Zone Interactions with Tamarisk Biocontrol



(modified from Gregory et al. 1991 and Tracy and DeLoach 1999).

Relationships of Interactions to Effects of Tamarisk Biocontrol

Relationships of Interactions to Effects of Tamarisk Invasion

Involve Direct Effects

Involve Major Indirect Effects

Involve Indirect Effects

Involve Minor or No Effects

Tamarisk Biocontrol and Biodiversity

Plant Successional Model of a Chihuahuan Rio Grande Riverine System

Moist, Flood Scoured, Bare Sandbar/Sediment Banks

tamarisk invasion

0-2 yr of no floods

2-10 yr floods

>25 yr floods

2-10 yr floods

>50 yr floods

0-50 yr floods

>100 yr floods

tamarisk herbivory

> 10 yr floods

Tamarisk Seedling Strand

Tamarisk Scrubland

Tamarisk Low Woodland

Tamarisk Upper Woodland

tamarisk beetle herbivory

tamarisk beetle herbivory

tamarisk beetle herbivory

tamarisk beetle herbivory

Moist, Flood Scoured, Bare Sandbar/Sediment Banks

Tamarisk/Cottonwood-Willow/ Seepwillow Scrubland

Tamarisk/Quailbush/ Screwbean/Mesquite Baccharis/ Wolfberry/ Bermuda Grass Shrublands

Tamarisk/Mesquite/ Wolfberry/Saltbush/ Bermuda Grass Woodland

0-2 yr of no floods

2-10 yr floods

>25 yr floods

2-10 yr floods

>50 yr floods

0-50 yr floods

>100 yr floods

tamarisk beetle herbivory

tamarisk beetle herbivory

tamarisk beetle herbivory

tamarisk beetle herbivory

Seepwillow/Cottonwood-Willow Seedling Strand

Seepwillow/Cottonwood-Willow Scrubland

Herbaceous Strand

Seepwillow Scrubland

Screwbean/Mesquite/ Quailbush/Baccharis/ Wolfberry/Bermuda Grass Shrublands

Mesquite/Wolfberry/ Saltbush/Bermuda Grass Woodland

no 0-50 yr floods

0-2 yr of no floods

colonization by clonal species

Coyote Willow Scrubland

Mesquite/Quailbush/ Bermuda Grass Shrubland

Mesquite/Saltbush/ Bush Muhly Shrubland

Bulrush Riverine Marshland

Quailbush Scrubland

Cattail Riverine Marshland

Cottonwood-Willow Low Woodland

0-50 yr floods

Bermuda Grass Riverine Meadow

Common/Giant Reed Riverine Meadow

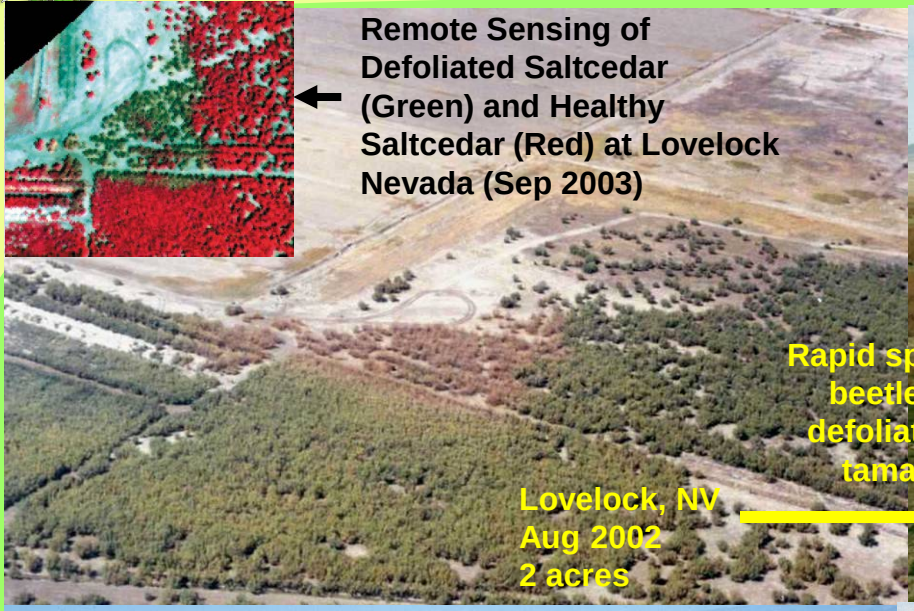
Cottonwood-Willow Upper Forest

0.30 → 0.75 → 1.50 → 2.90

Increasing Depth to Water Table (m)

Northern TB Defoliation - Nevada

Remote Sensing of Defoliated Saltcedar (Green) and Healthy Saltcedar (Red) at Lovelock Nevada (Sep 2003)



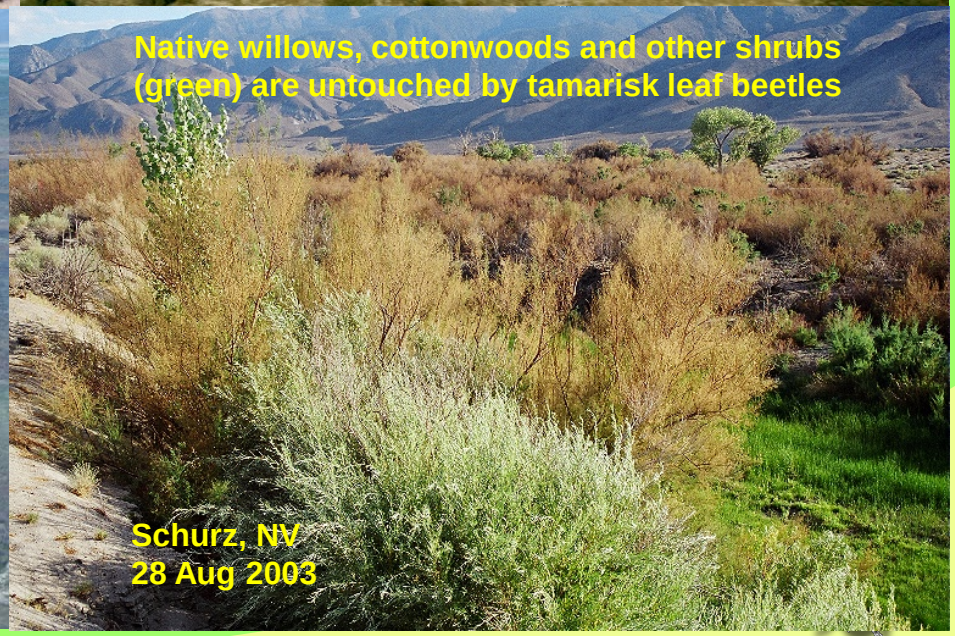
Lovelock, NV
Aug 2002
2 acres

Rapid spread of beetle and defoliation of tamarisk

Lovelock, NV
28 Aug 2003
500 acres

Lovelock, NV
Aug 2005
60,000 to 80,000 acres

Oct 2009 = 341 river miles defoliated in NV



Native willows, cottonwoods and other shrubs (green) are untouched by tamarisk leaf beetles

Schurz, NV
28 Aug 2003

Tamarisk Beetle Defoliation

Mediterranean TB, Big Spring, TX

- 2008

- 2009

Tamarisk Beetle Defoliation

Mediterranean TB, Big Spring, TX

Tamarisk Understory after Defoliation

Big Spring, TX

Tamarisk Understory after Defoliation

Big Spring, TX

15 Nov 2007

high percent bare ground

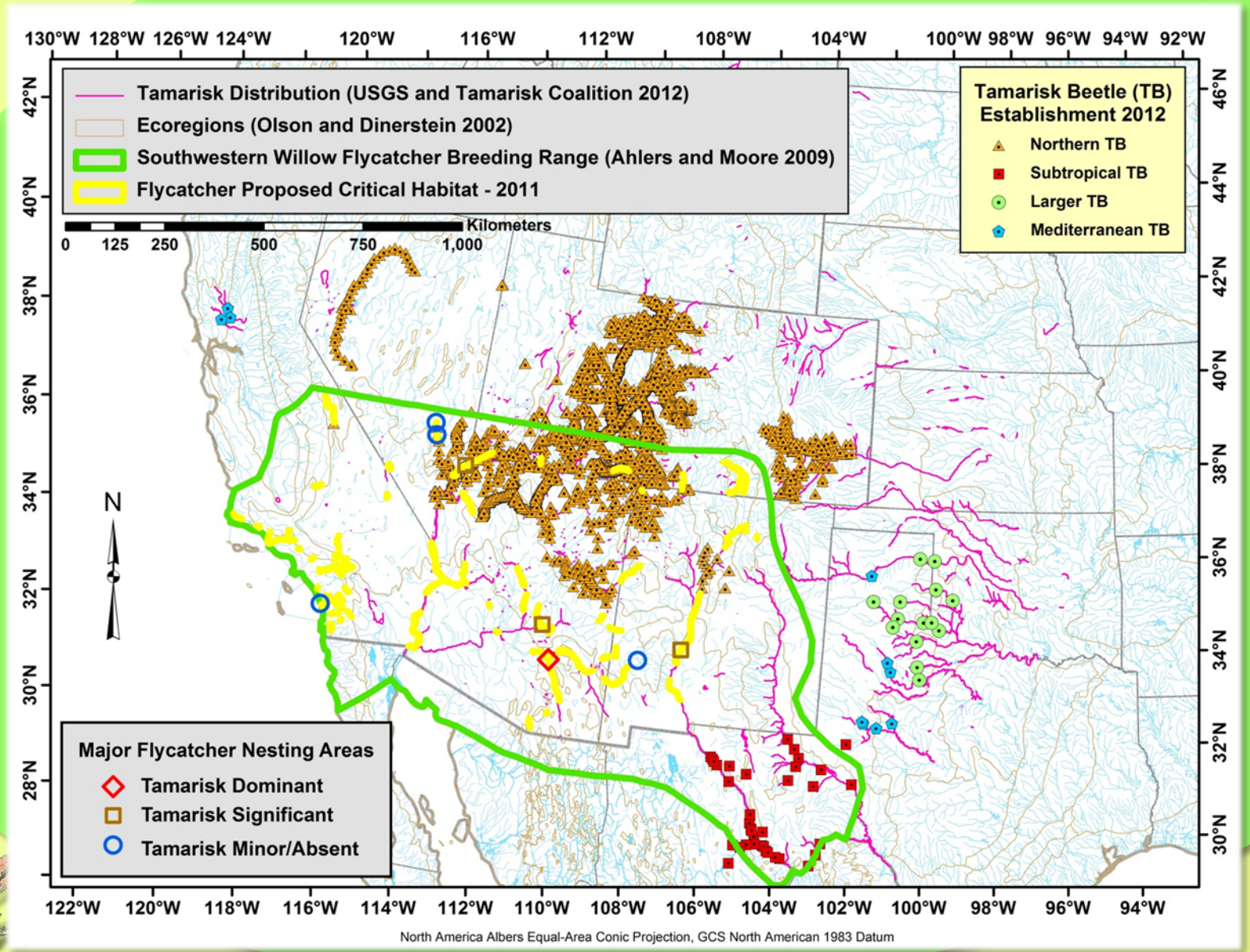
9 Oct 2008

76% Herbaceous:
48% vinemesquite, 17% Bermuda grass, 8% plains bristlegrass, 3% forbs (8 spp.)

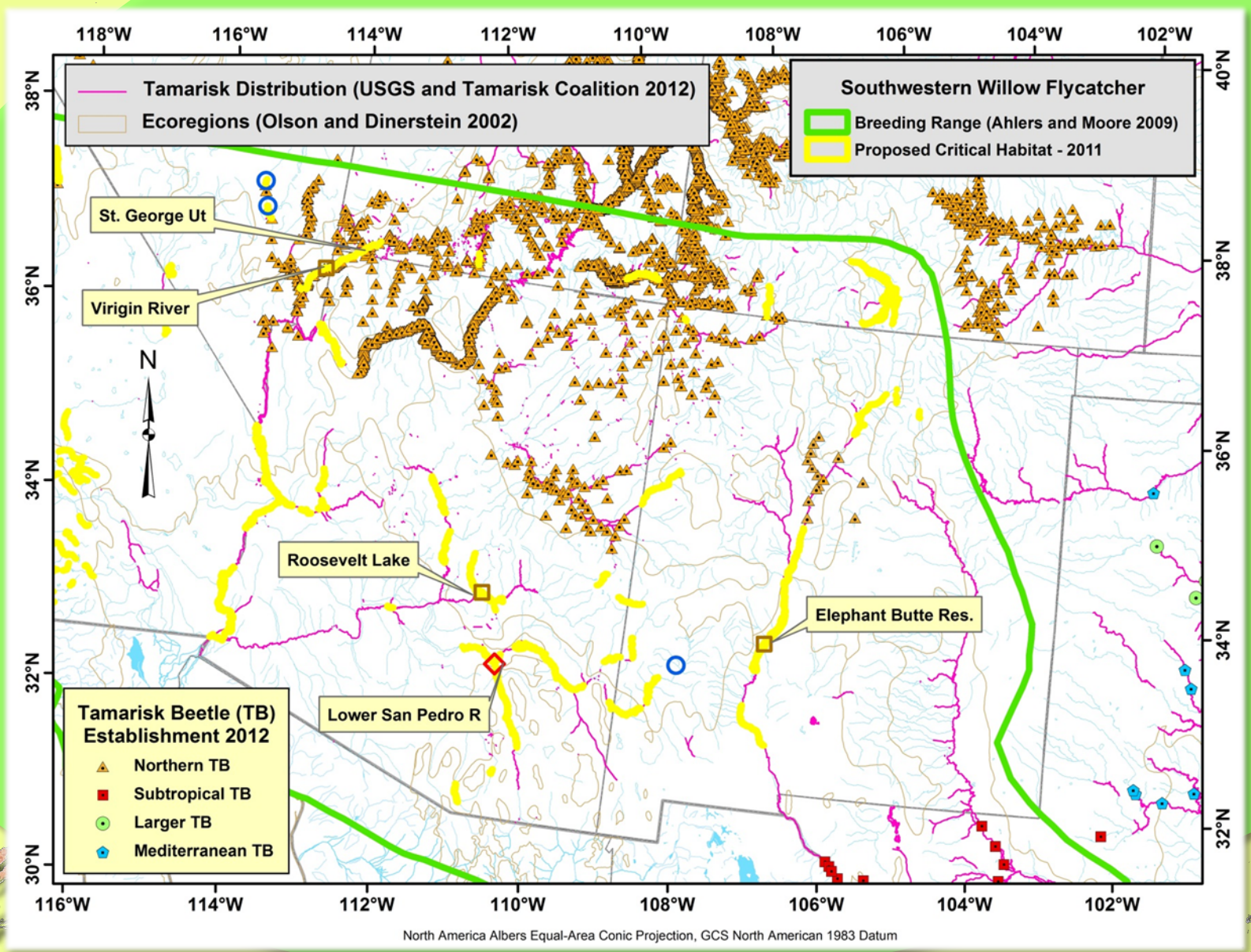
23 Sep 2009

73% Herbaceous:
37% vinemesquite, 12% jungle-rice, 10% Bermuda grass, 8% plains bristlegrass 6% forbs (6 spp.)

Flycatchers and Tamarisk Beetles



Flycatchers and Tamarisk Beetles



Tamarisk Beetle Impact on Flycatchers at St. George, Utah -Effects on Nest Success

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

(McLeod 2011)

Tamarisk Beetle Impact on Flycatchers

- **Tamarisk defoliation during nesting season**
  - Exposure to predators and brood parasitism
  - Lethal heat exposure for eggs
  - Heat stress for adults, attracting attention to nest
- **Tamarisk dieback following defoliation**
  - Lower % canopy cover reducing habitat suitability

Three Research Objectives

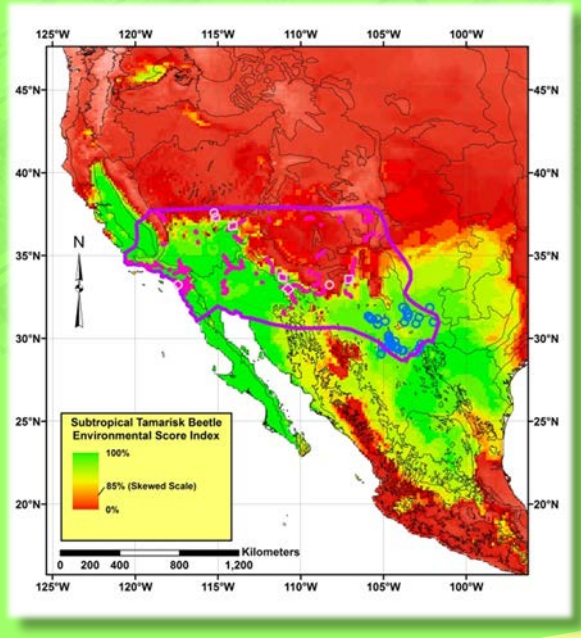
1 Project distribution/dispersal tamarisk beetles
- Continental Species Distribution Models (SDM's)
- Continental dispersal models

2 Project effects of tamarisk beetle & restoration on flycatcher habitat
- Flycatcher Habitat Suitability Index (HSI) model
- Flycatcher HSI model simulations

3 Plan restoration of riparian vegetation
- Patch-level plant HSI models
- Plant HSI model simulations

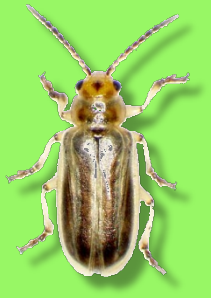
1 – Beetle Distribution/Dispersal

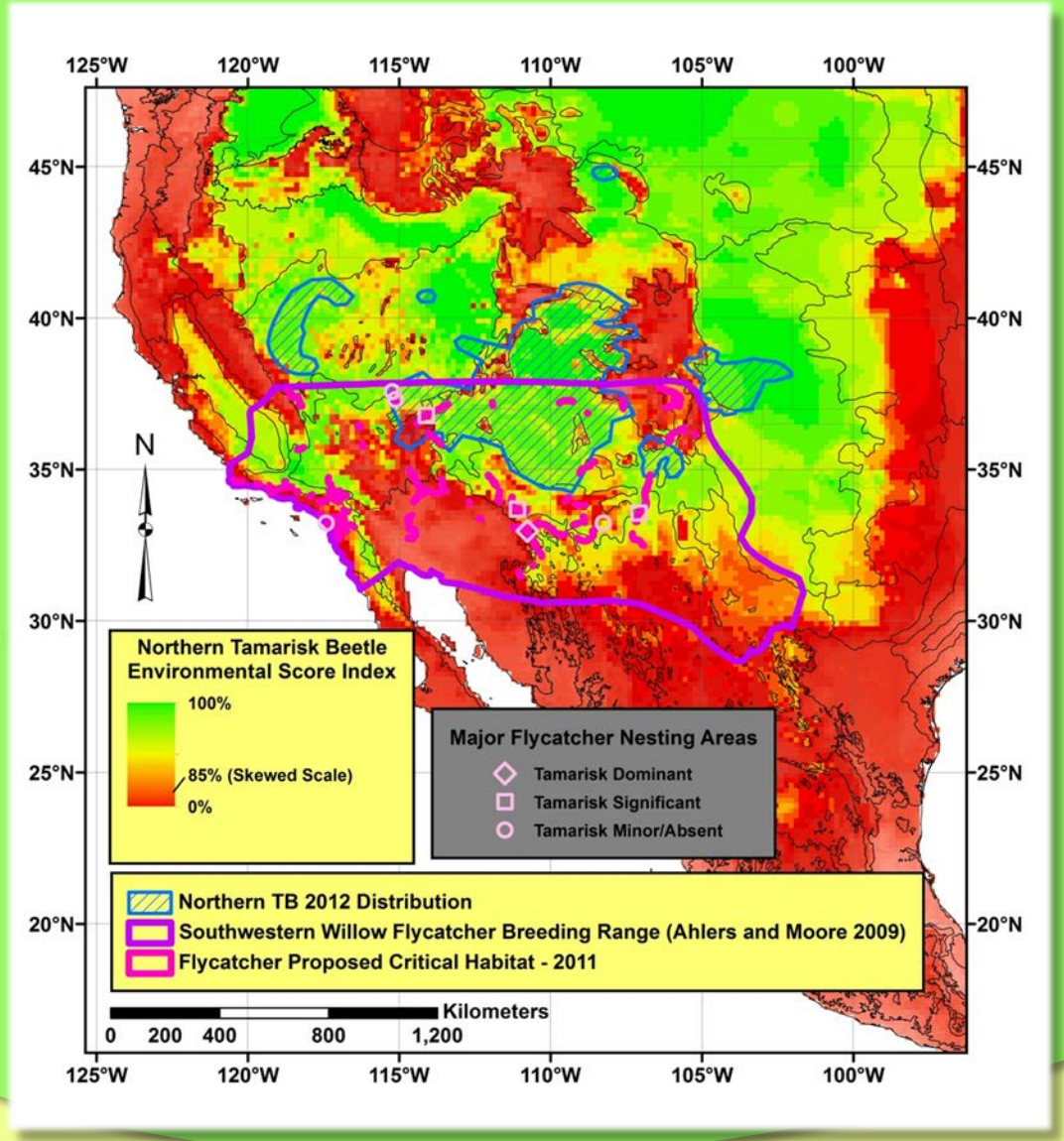
- **Develop Climatic Species Distribution Models**
  - Employ Old World and New World Data
  - Compare different models (Maxent, Env. Score)
  - Various climate data sets from 1 to 13 km resolution
- **Link with Cost-Distance Dispersal Model**
  - Project timing of beetle spread to flycatcher habitats



Northern Tamarisk Beetle Environmental Score Index Model

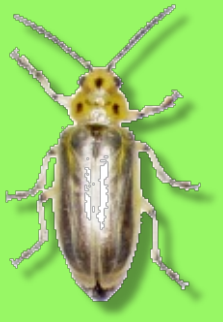
Northern TB

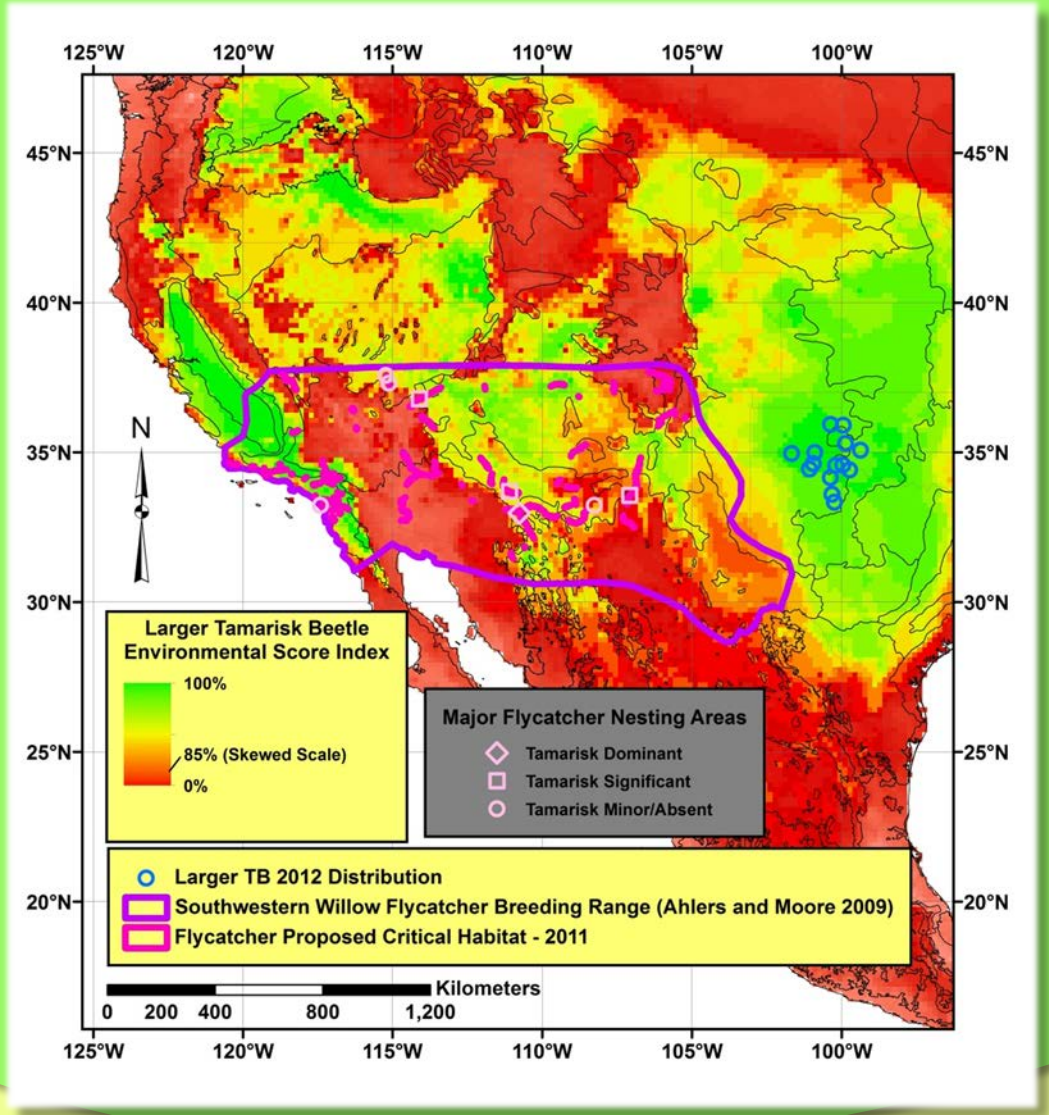




Larger Tamarisk Beetle Environmental Score Index Model

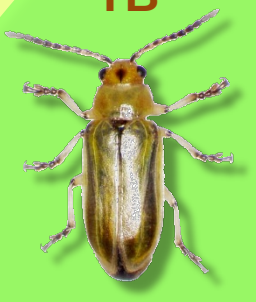
Larger TB

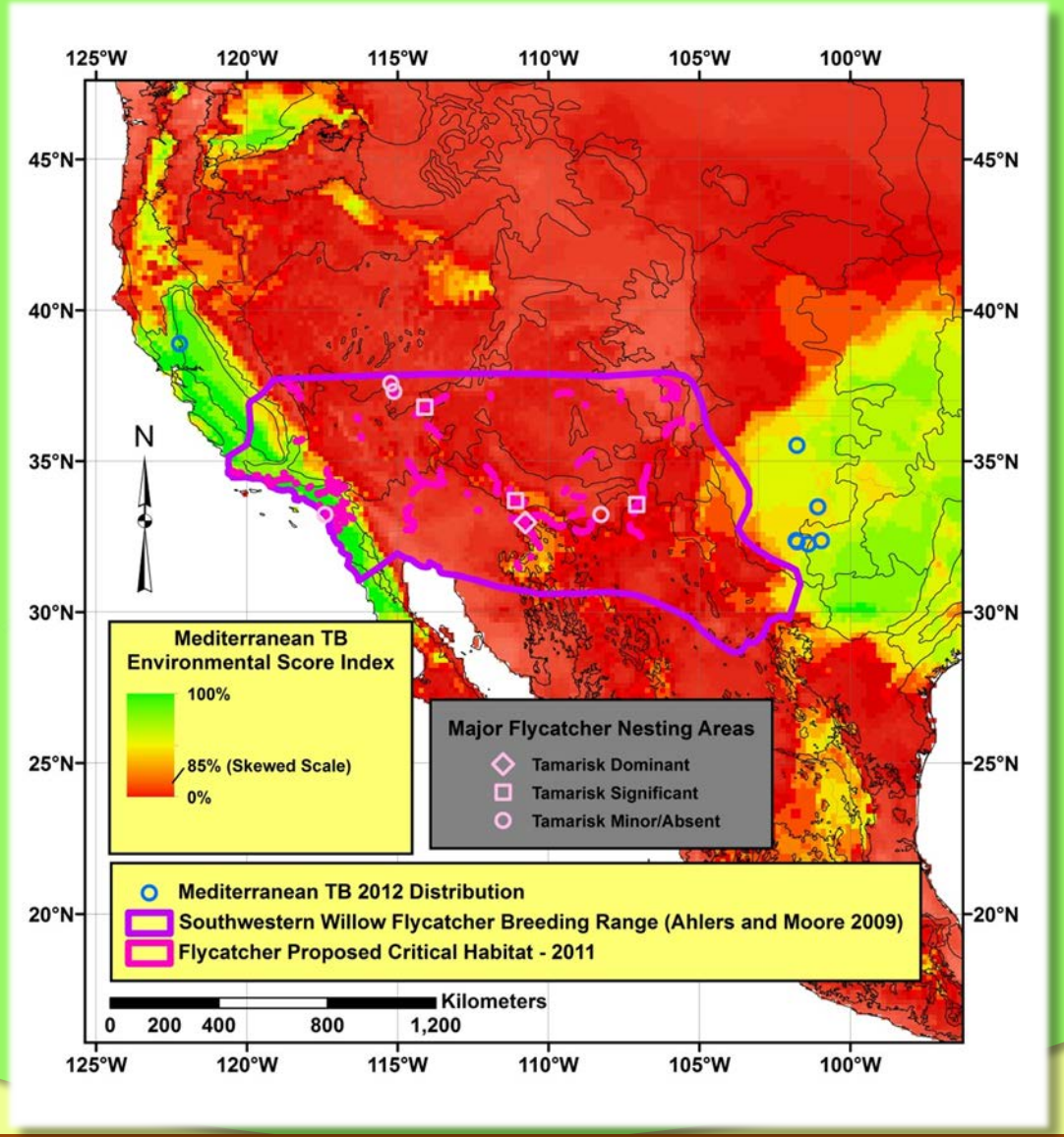




Mediterranean Tamarisk Beetle Environmental Score Index Model

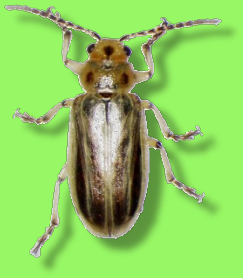
Mediterranean TB

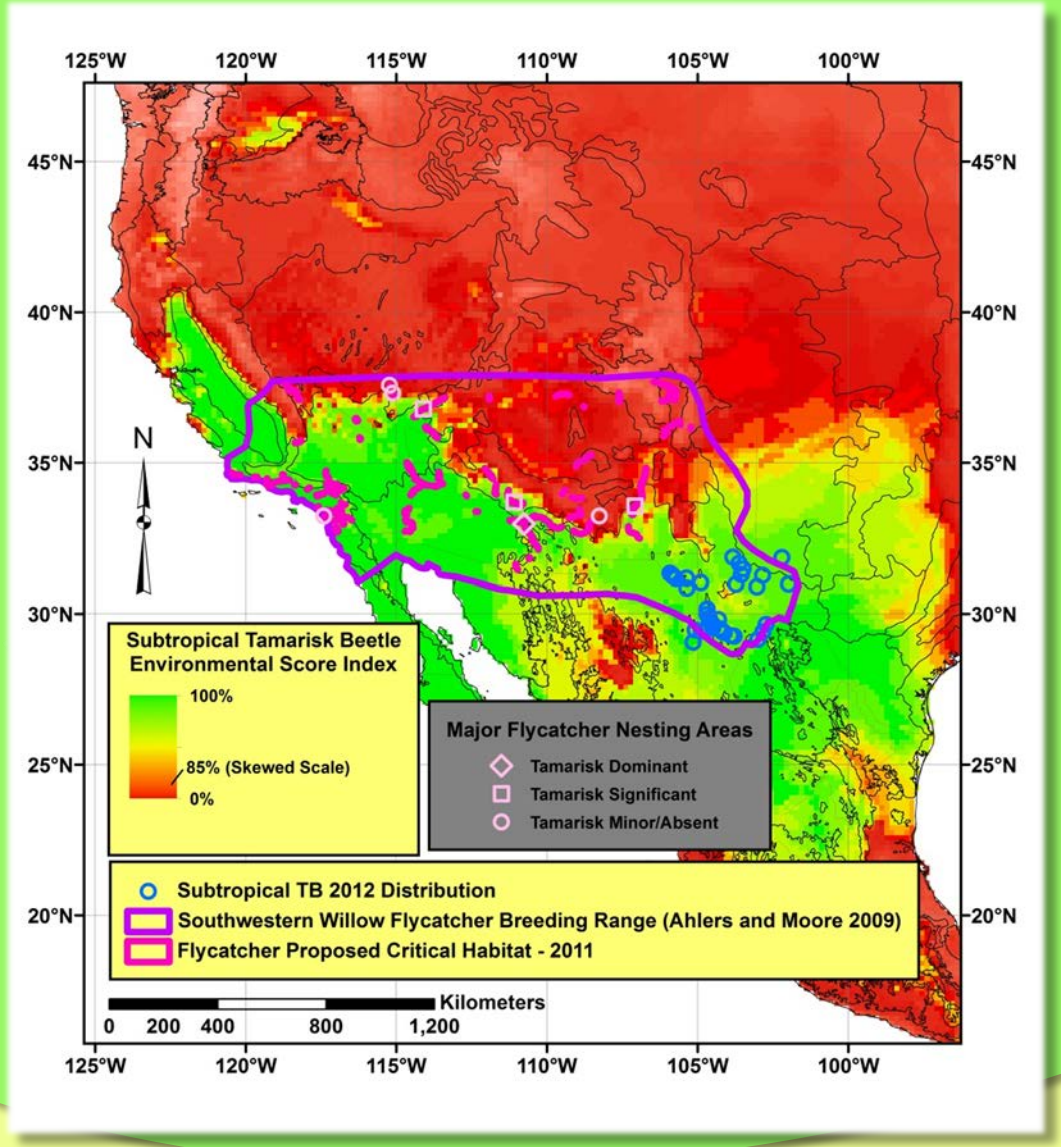




Subtropical Tamarisk Beetle Environmental Score Index Model

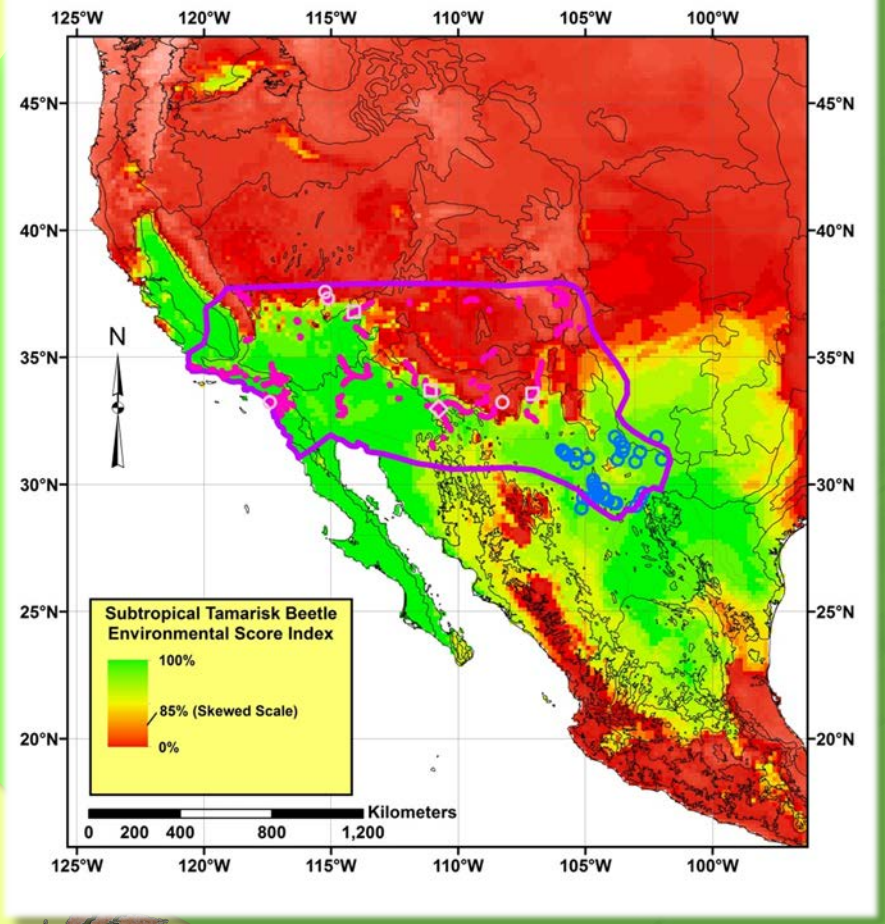
Subtropical TB



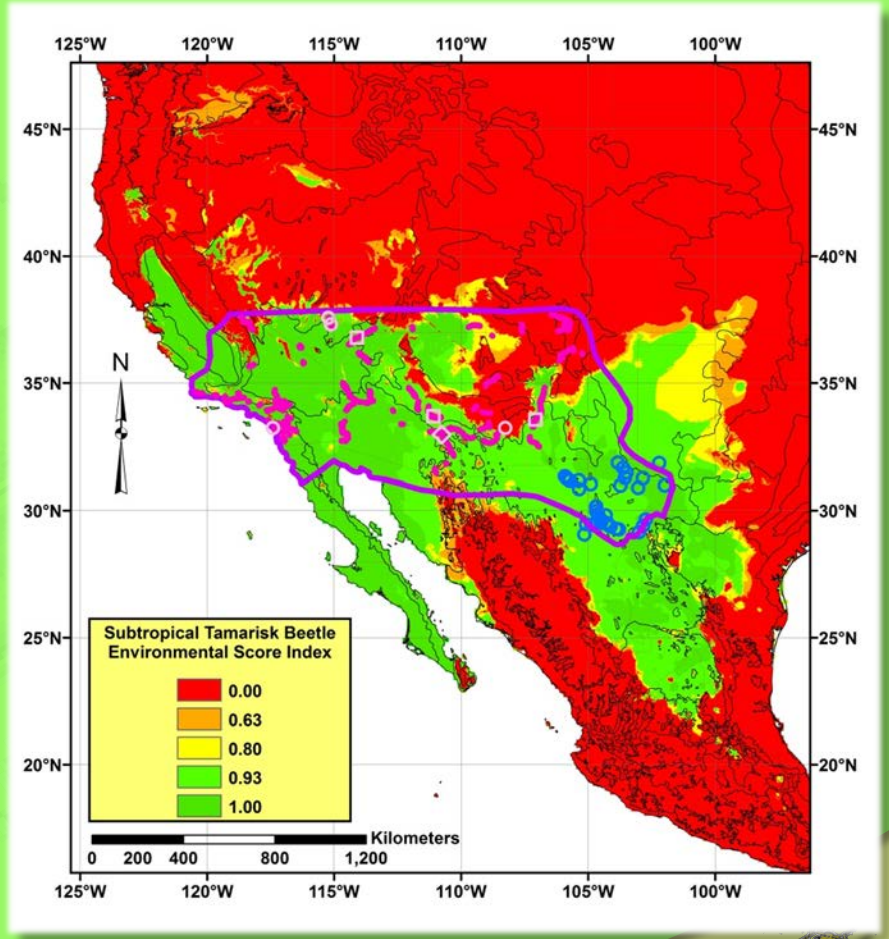


Subtropical Tamarisk Beetle Environmental Score Index Model

13 km Resolution- Climate Res. Unit

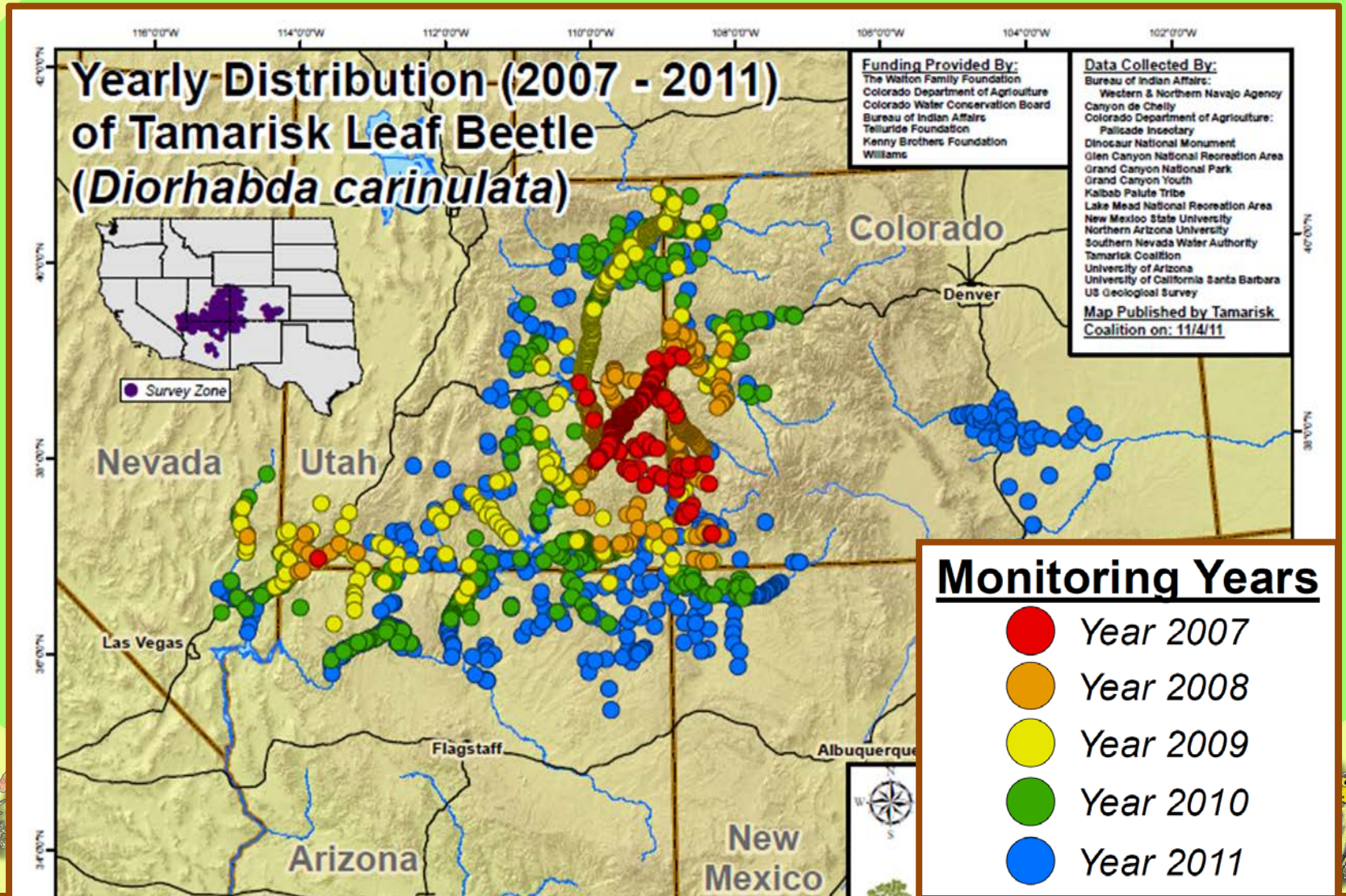


1 km Resolution- WorldClim



Tamarisk Coalition Monitoring

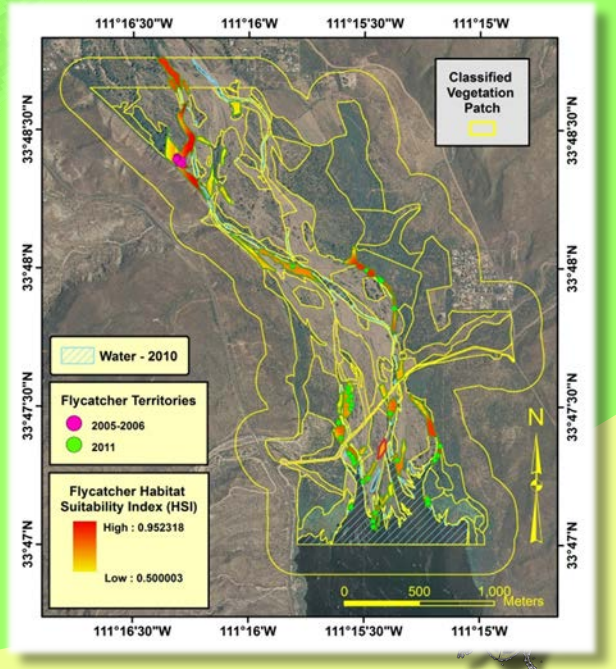
Northern Tamarisk Beetle



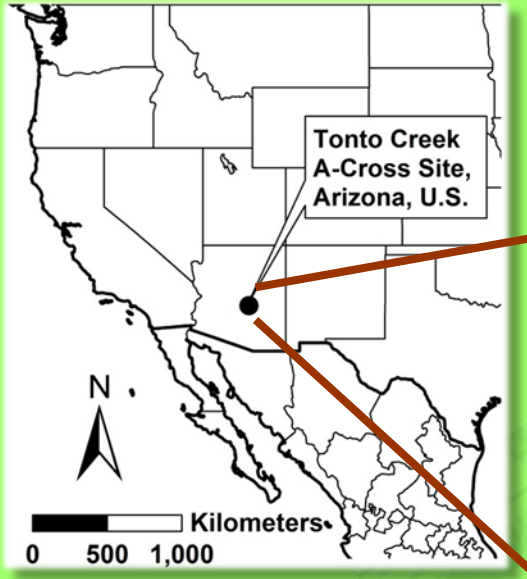
2 – Flycatcher Habitat Simulations

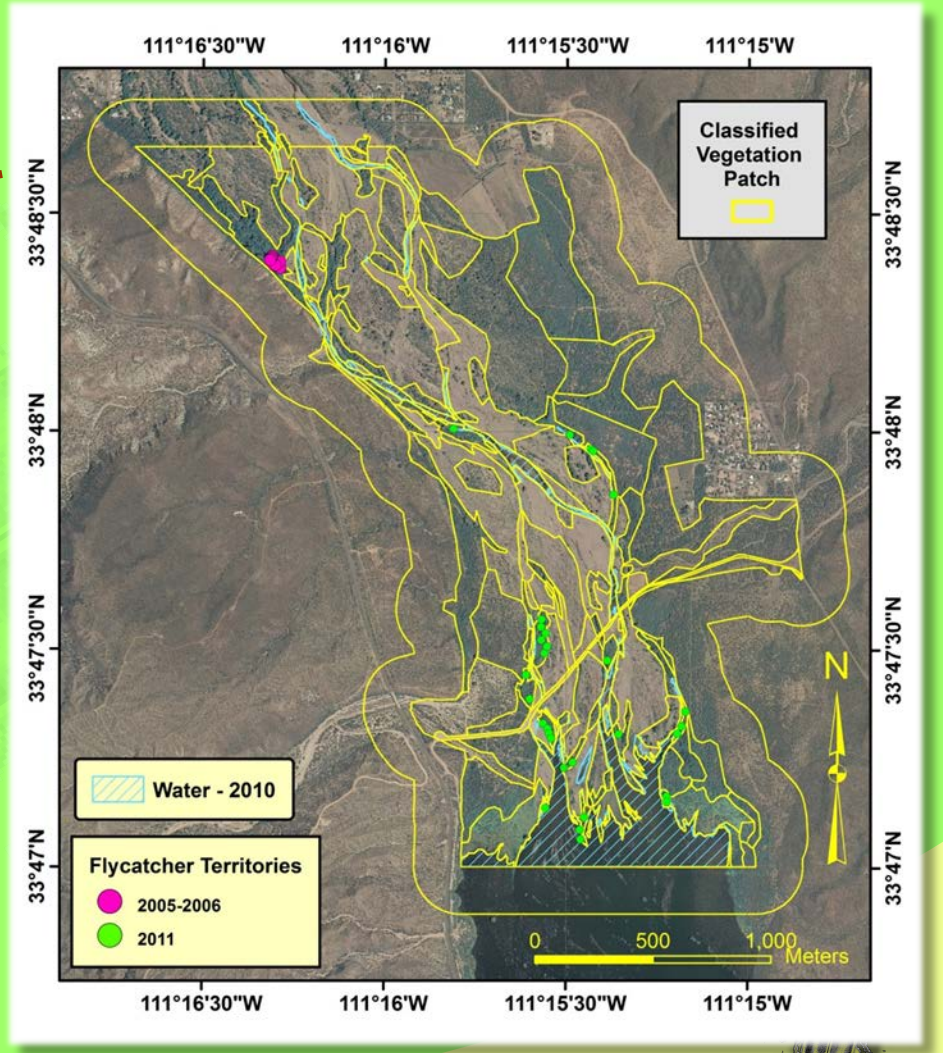
Habitat Suitability Index (HSI) models

- **Refine previous flycatcher HSI model**
  - Define baseline quantity/quality flycatcher habitat
- **Simulate tamarisk beetle herbivory with HSI**
  - Simulate first year of beetle defoliation
  - Simulate third year of beetle defoliation and dieback
- **Simulate restoration actions with HSI**
  - Simulate three years after adding willows and water with three years of beetle defoliation



Flycatcher Habitat Suitability Index Model for Tonto Creek A-Cross Site, Az



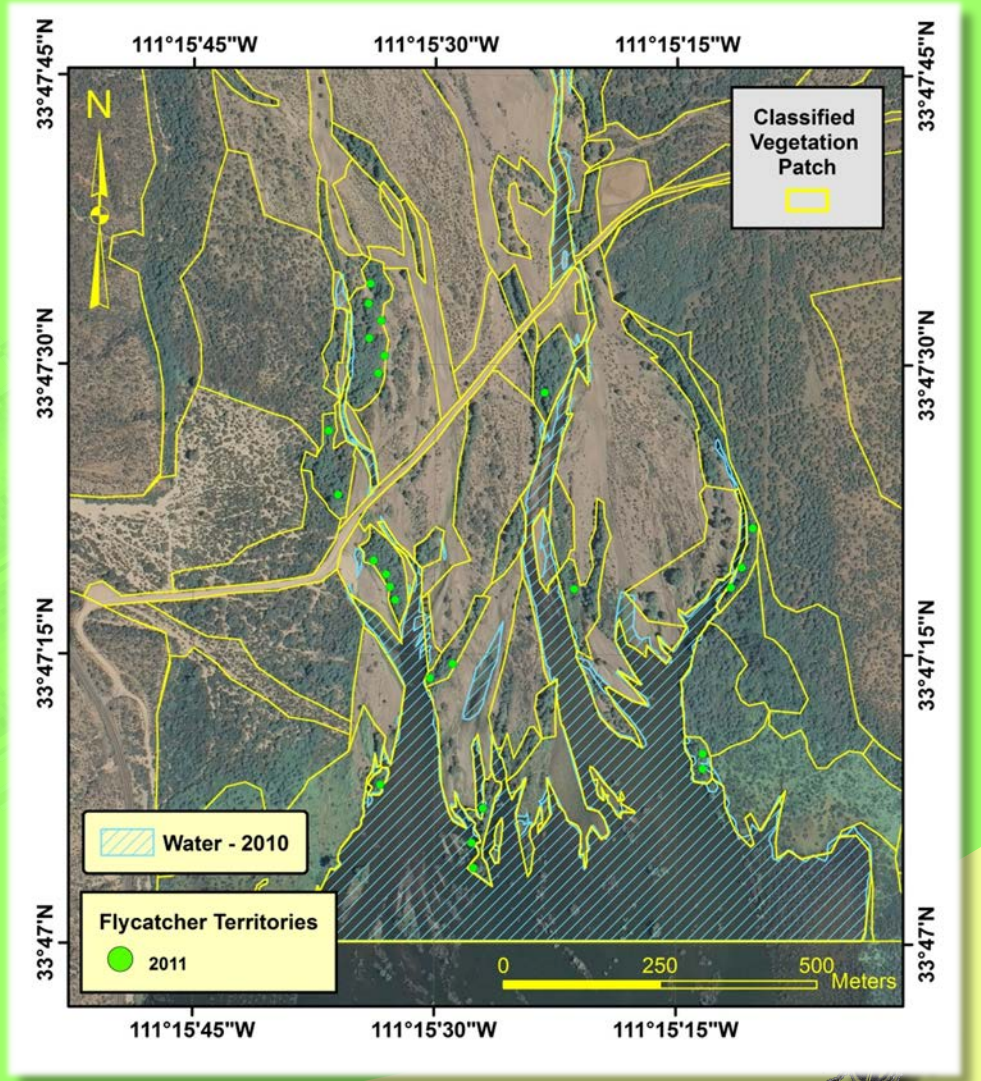


- 30 flycatcher terrirories in 2011
- 335 ha, 3.5 km reach
- Tamarisk 10–90 % cover in woodlands

Flycatcher Habitat Suitability Index Model for Tonto Creek A-Cross Site, Az

- **Tamarisk dominates 13 (43%) of flcyatcher territories at site**

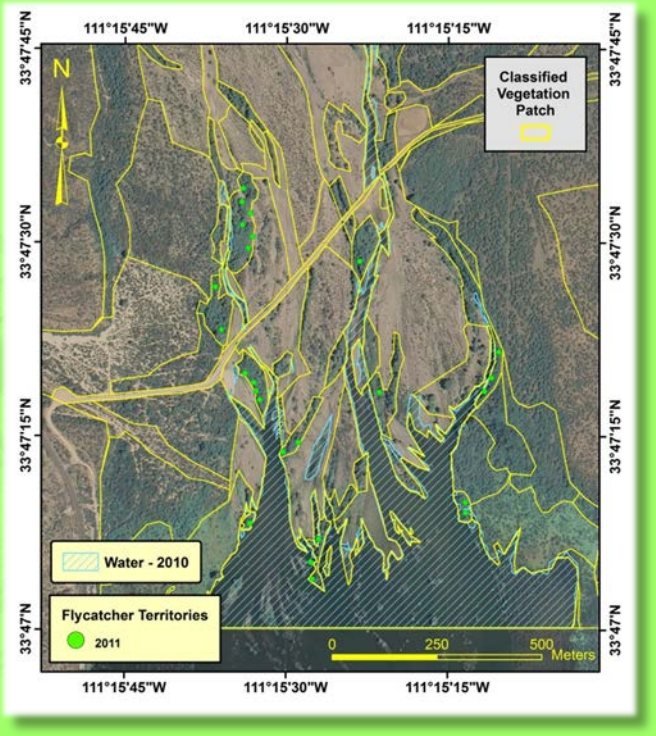
Tamarisk



Habitat Suitability Index Model

Five Habitat Suitability Indices (1 m res)

- Percent cover tamarisk/ willow/cottonwood
- Patch size
- Vegetation height
- Distance to water
- Nest tree defoliation susceptibility



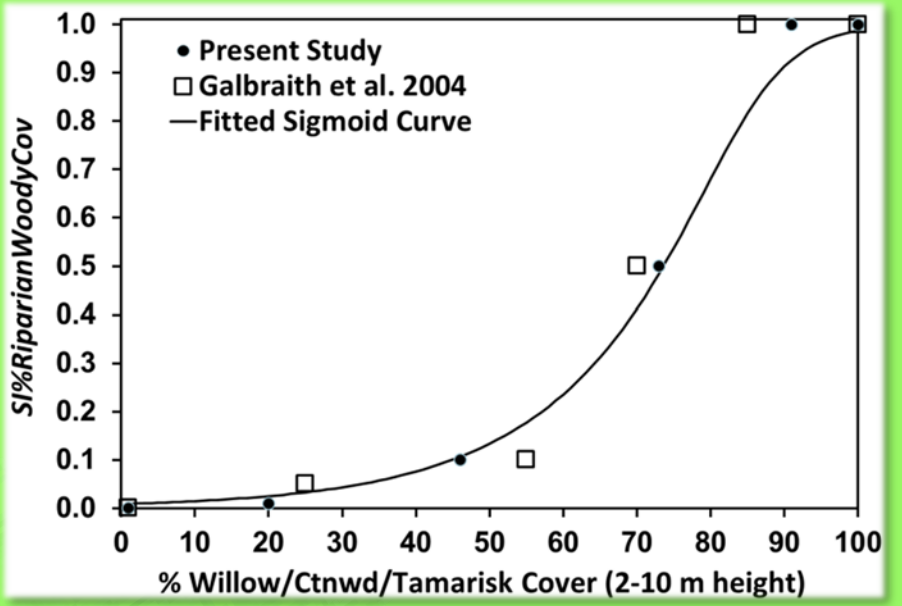
$$HSI = SI\%RiparianWoodyCov \times SIDefoliationSuscept \times \sqrt[3]{SIWoodyHeight \times SIPatchArea \times SIWaterDist}$$

SW Willow Flycatcher Habitat Suitability

- **Suitability Index of Percent Cover**

>75% Cover of Willow/Tamarisk at 2-10 m ht

(Tracy et al. in prep.)




Tonto Creek, AZ


Rio Grande atSan Marcial, NM

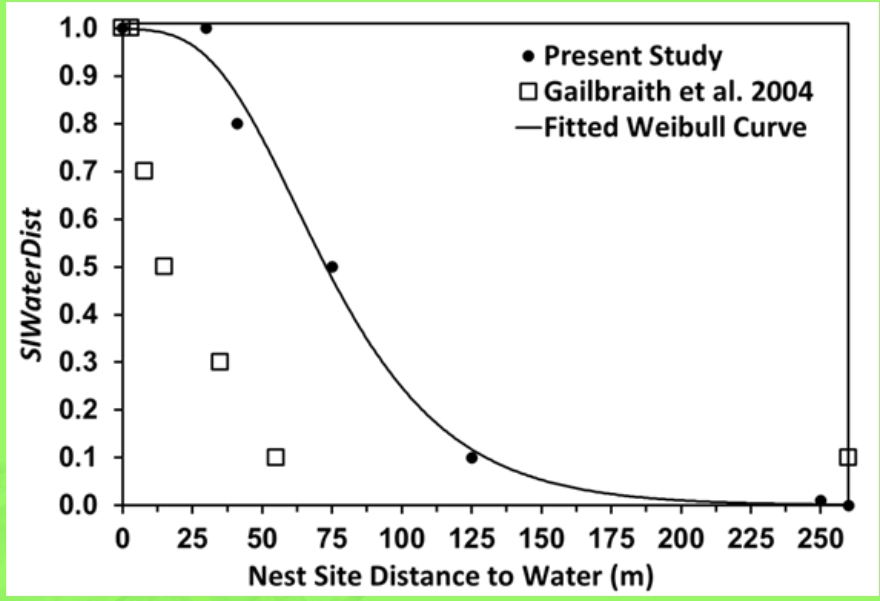
(Sogge et al. 1997)

SW Willow Flycatcher Habitat Suitability

- **Suitability Index of Nest Site Distance to Water**

<75m from water or saturated soil

(Tracy et al. in prep.)



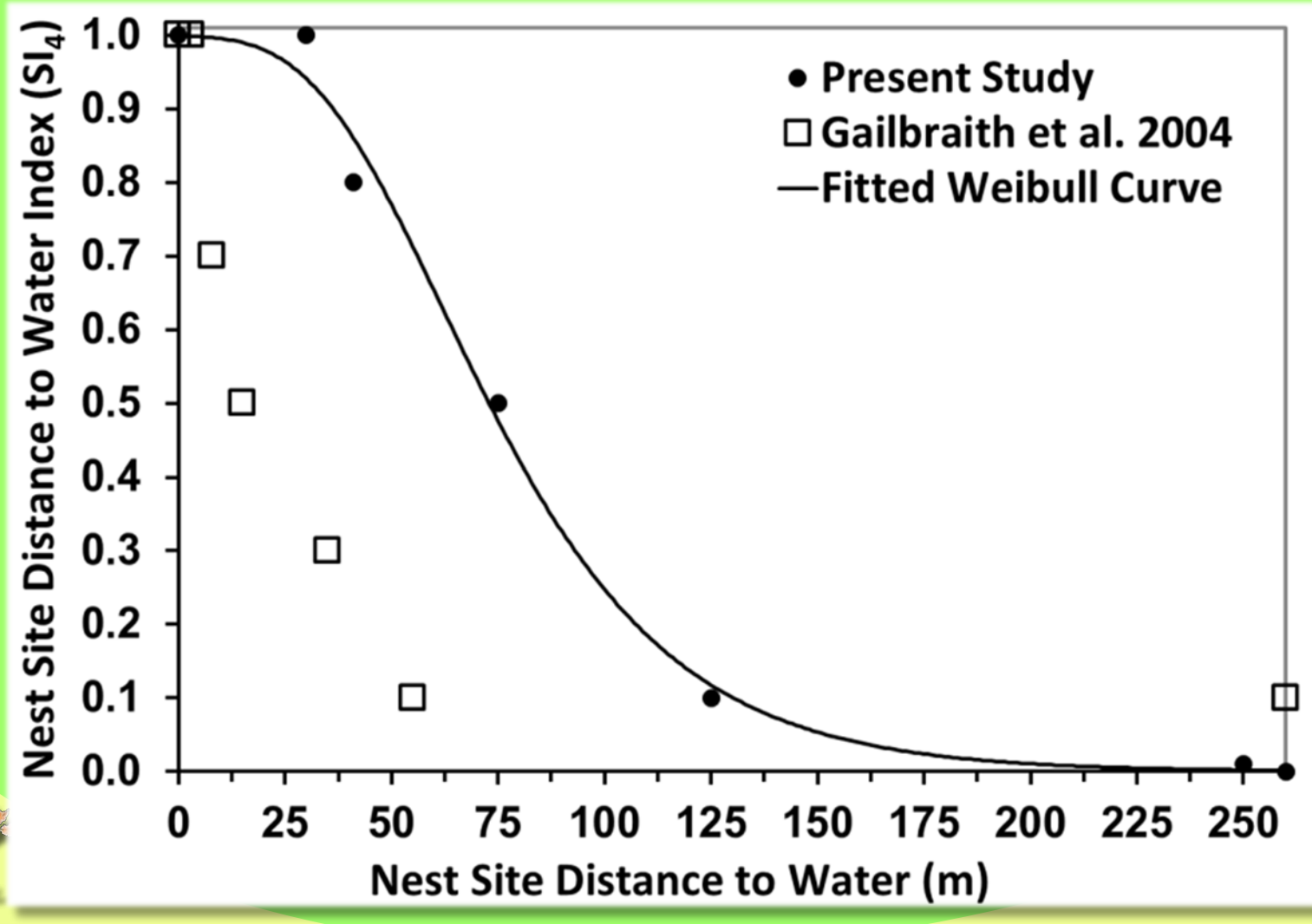

Gila River, AZ


Verde River, AZ

(Sogge et al. 1997)

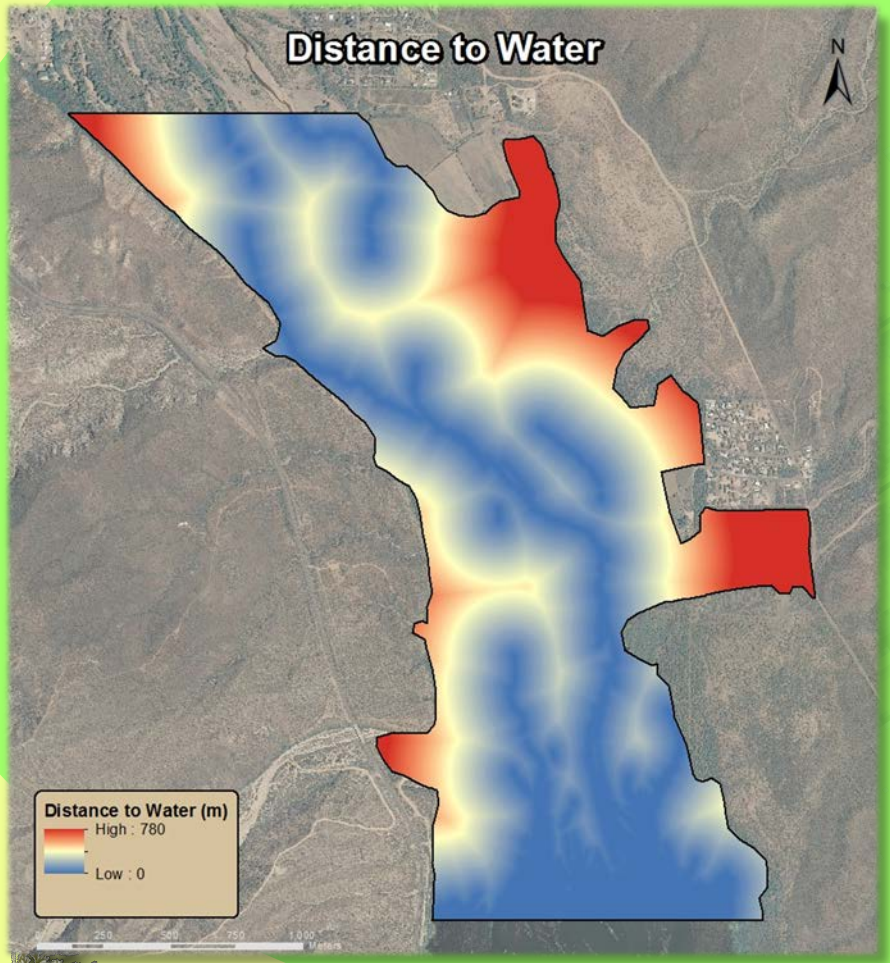
Habitat Suitability Index Model

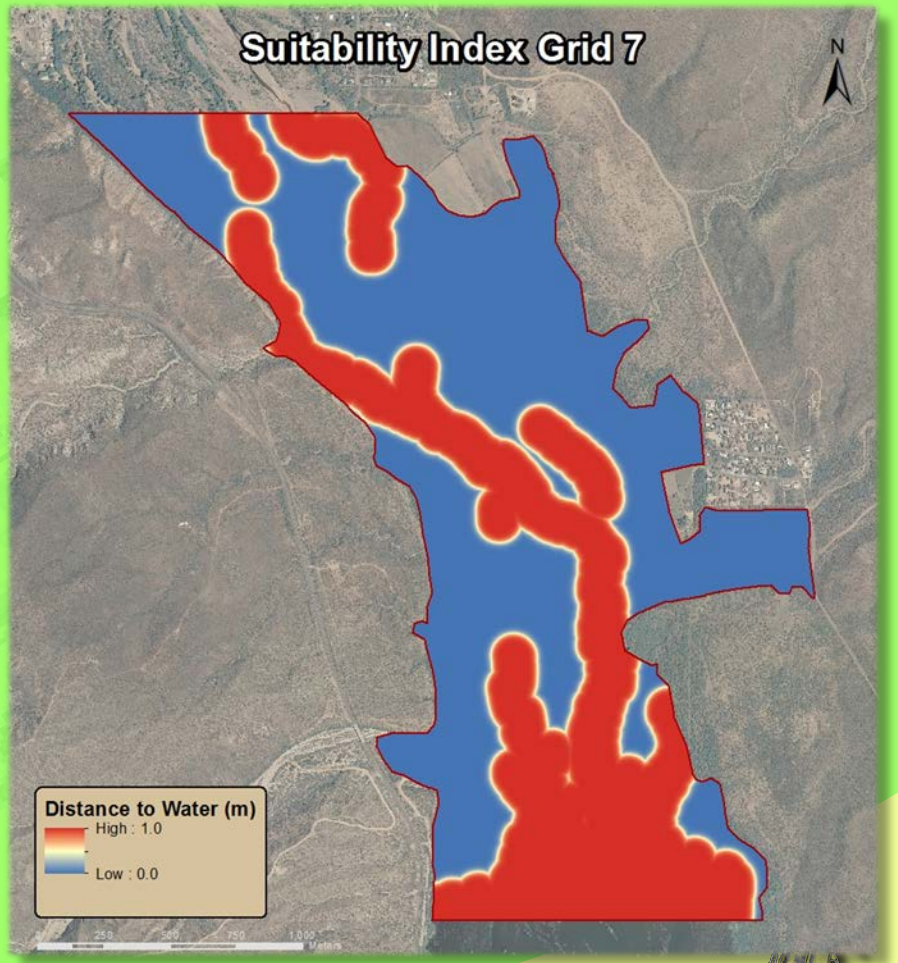
Nest Site Distance to Water Index



Habitat Suitability Index Model

Nest Site Distance to Water Index, Tonto Ck, AZ

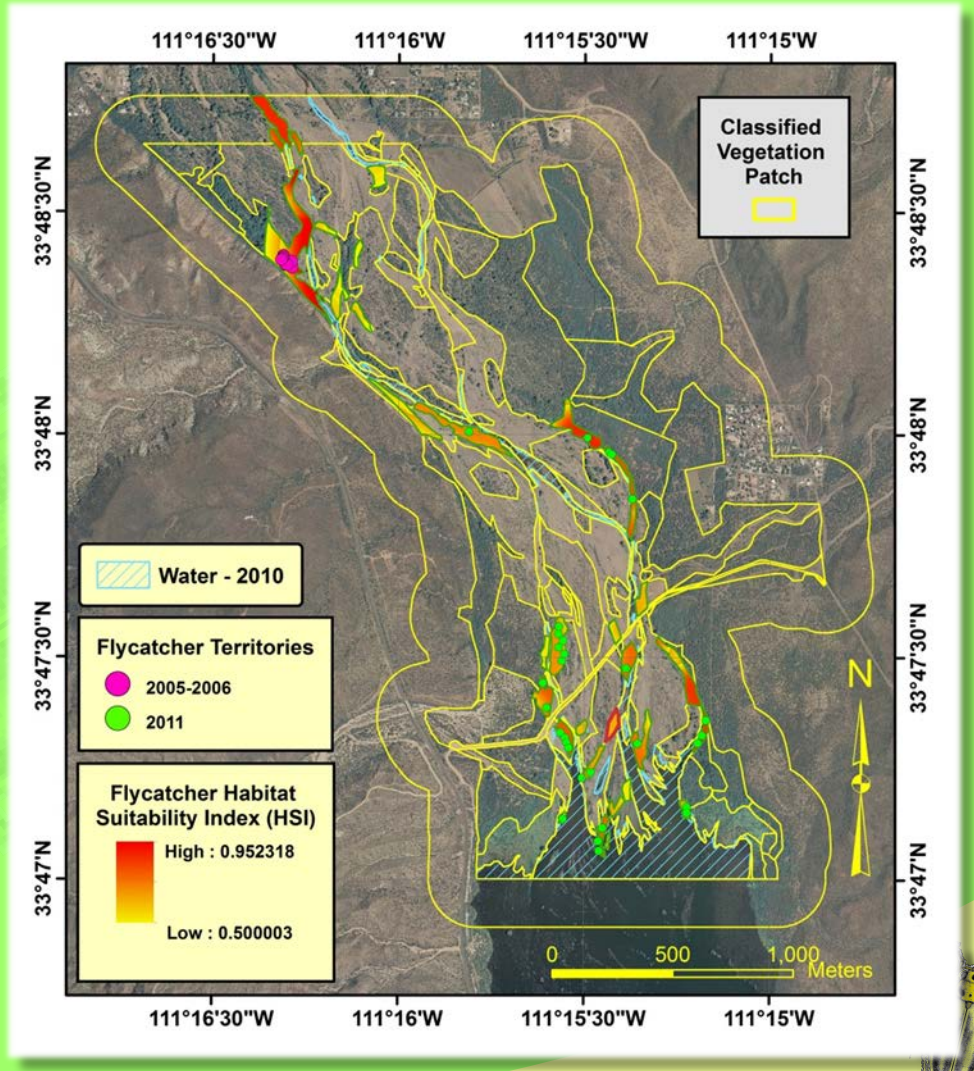




Habitat Suitability Index Model

Baseline Flycatcher Habitat, Tonto Ck, AZ

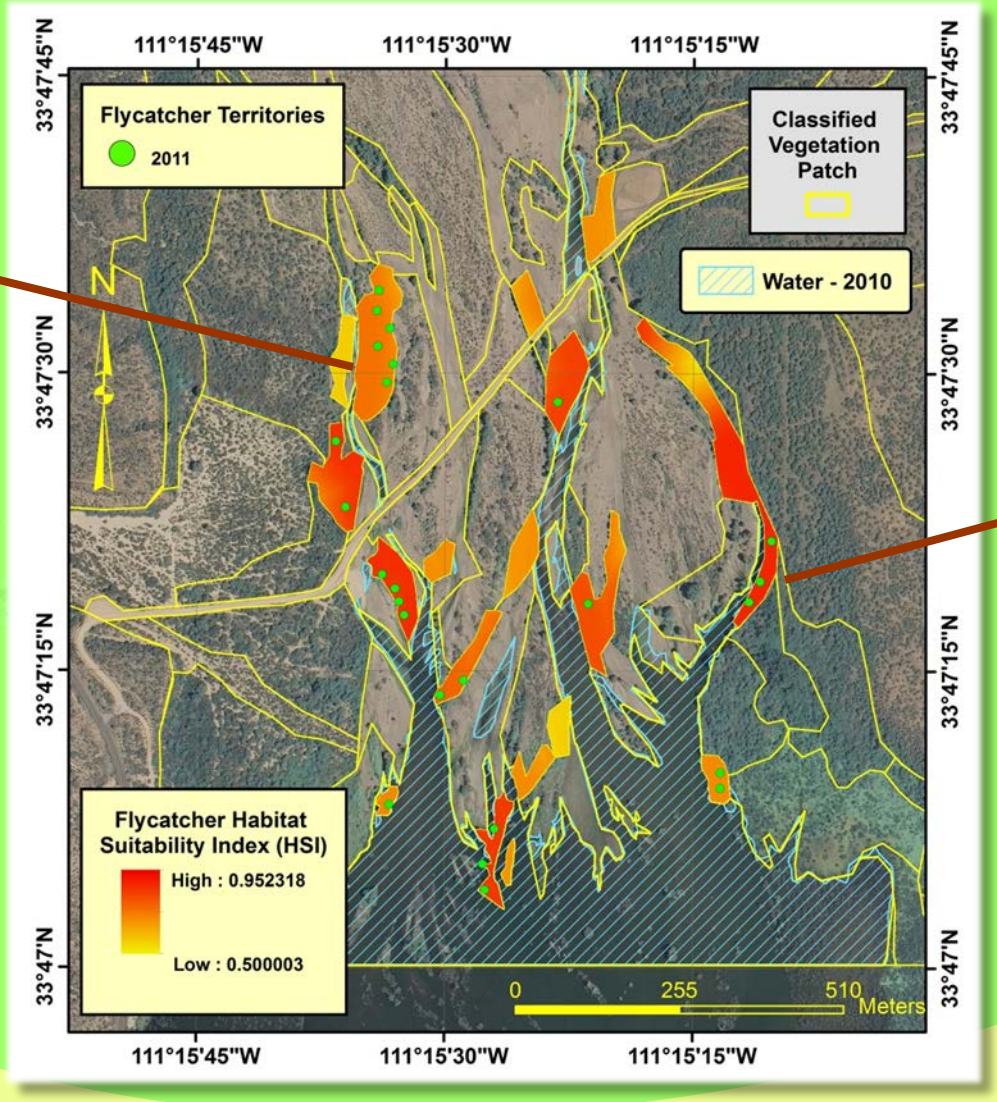
- 19.1 ha suitable flycatcher habitat at site
- habitat quality of 0.77 out of 1.0 (0.5 is threshold)



Habitat Suitability Index Model

Baseline Flycatcher Habitat, Tonto Ck, AZ

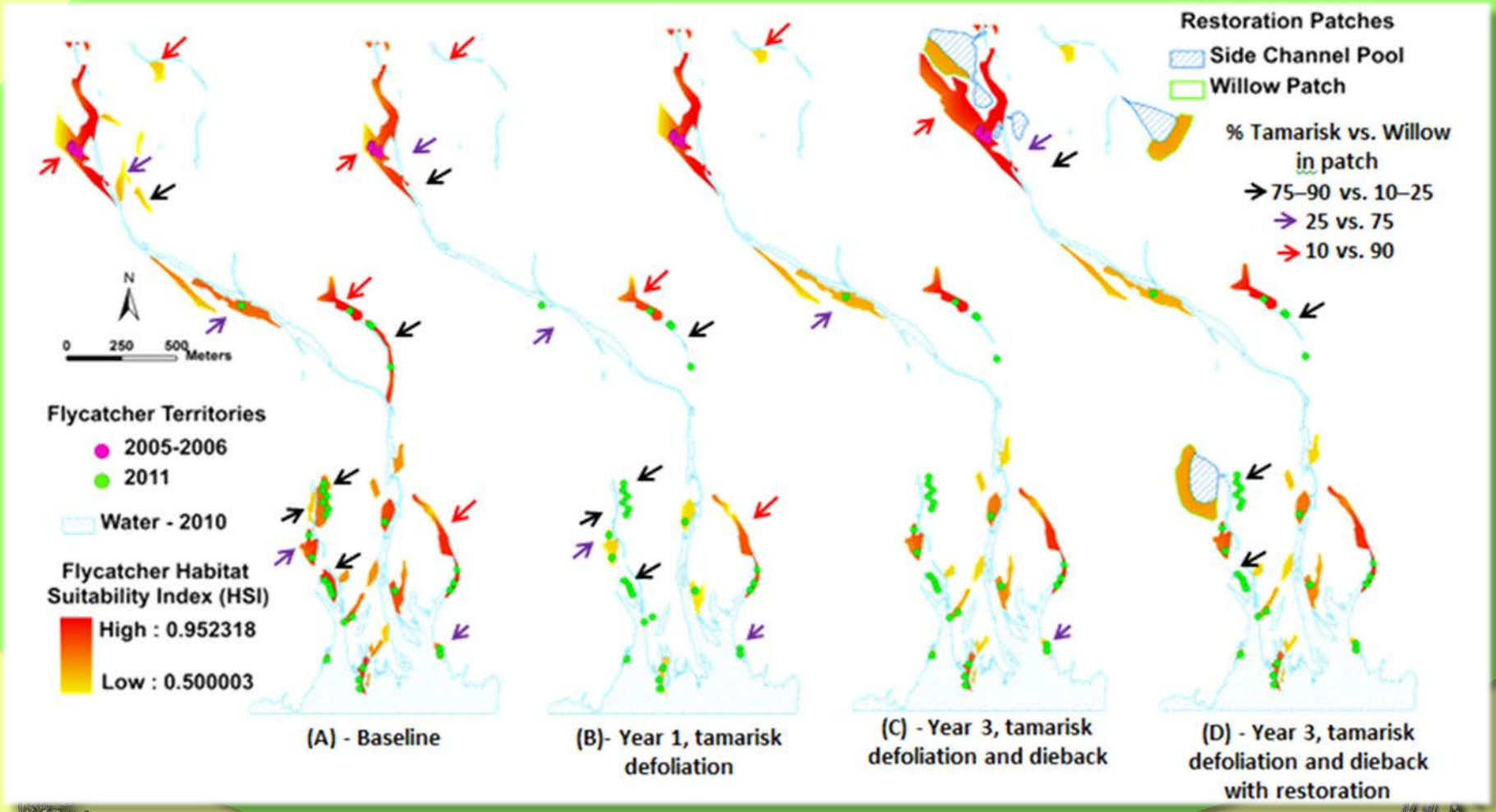
75% tamarisk
25% willow



10% tamarisk
90% willow

Flycatcher Habitat Simulations

Flycatcher HSI Baseline Model and Simulations



3 – Plant Habitat Simulations

Habitat Suitability Index (HSI) models

- **Develop plant HSI models for desired natives**
  - Cottonwoods, Willow, Screwbean, Quailbush
- **Simulate restoration to improve habitat**
  - Excavating to water table for willow/ cottonwood
  - Adding side channel swales for water harvesting
  - Restricting livestock grazing

Beetle Defoliated Tamarisk, Candelaria, TX

Plant Habitat Suitability Index Models

Habitat Suitability Indices

- Soil texture
- Soil salinity (0–5 cm, 5–20 cm)
- Water table depth
- Livestock grazing pressure
- Microtopography/hydrologic regime

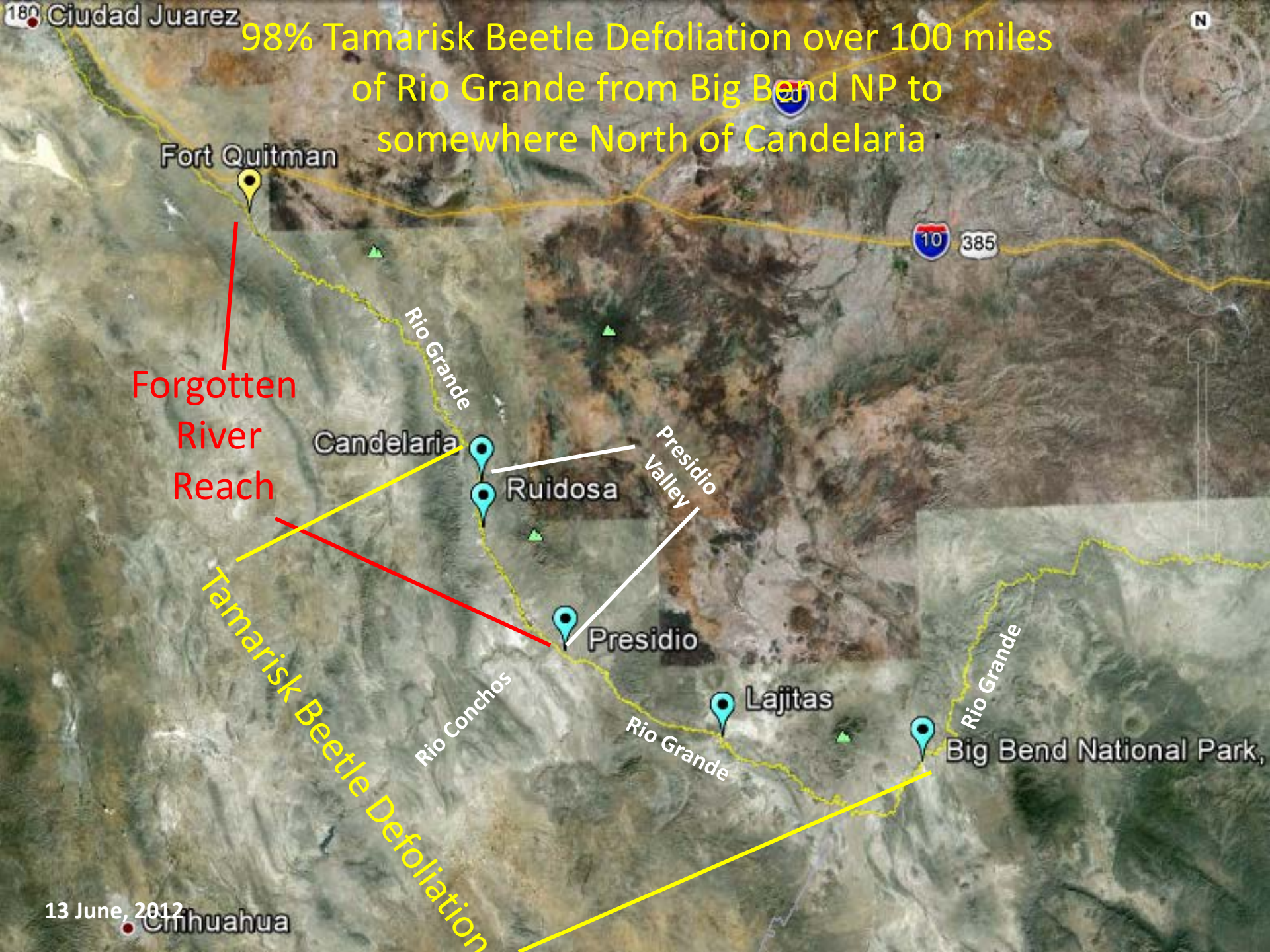
June 2012

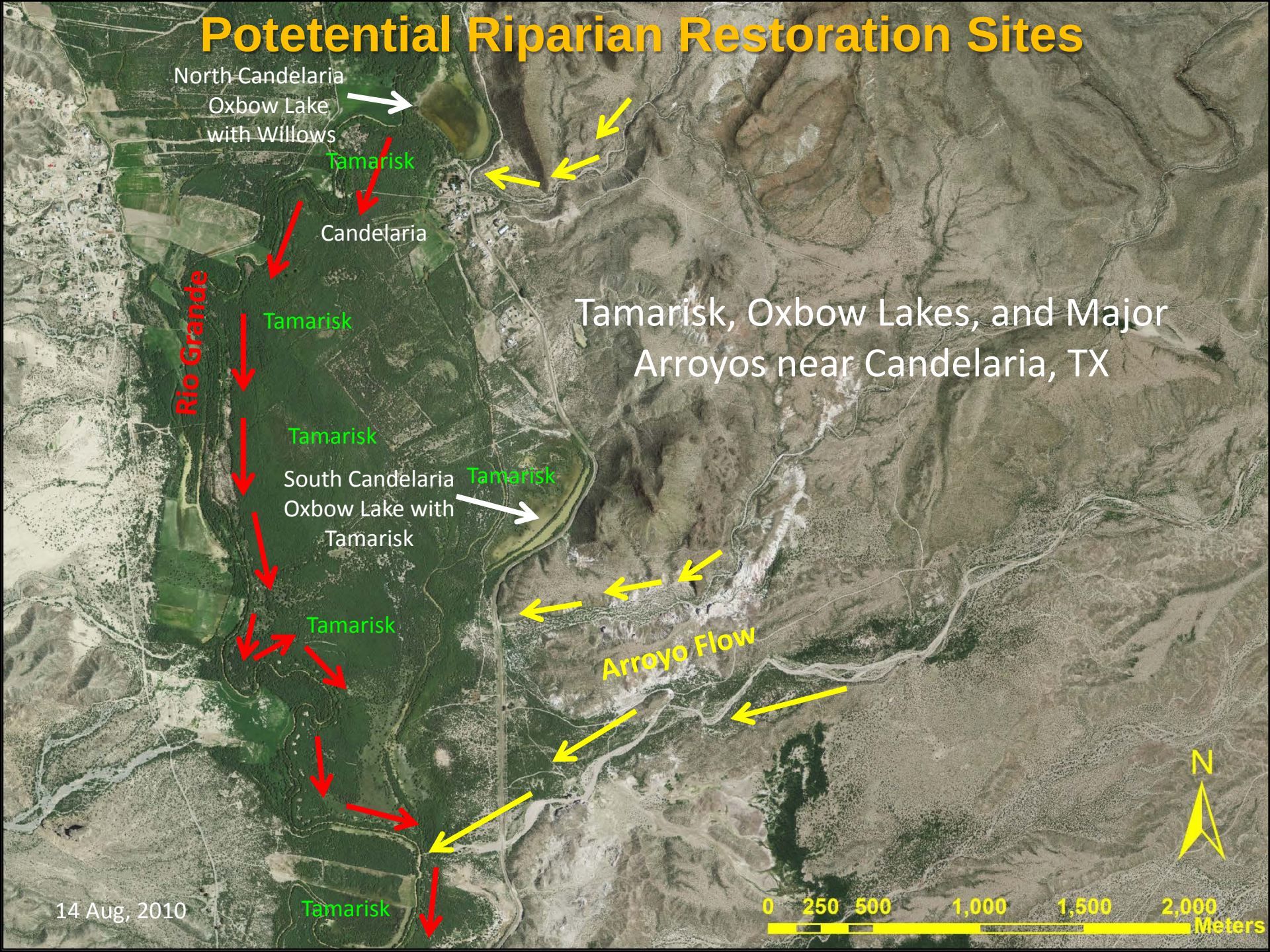
Beetle Defoliated Tamarisk, Candelaria, TX

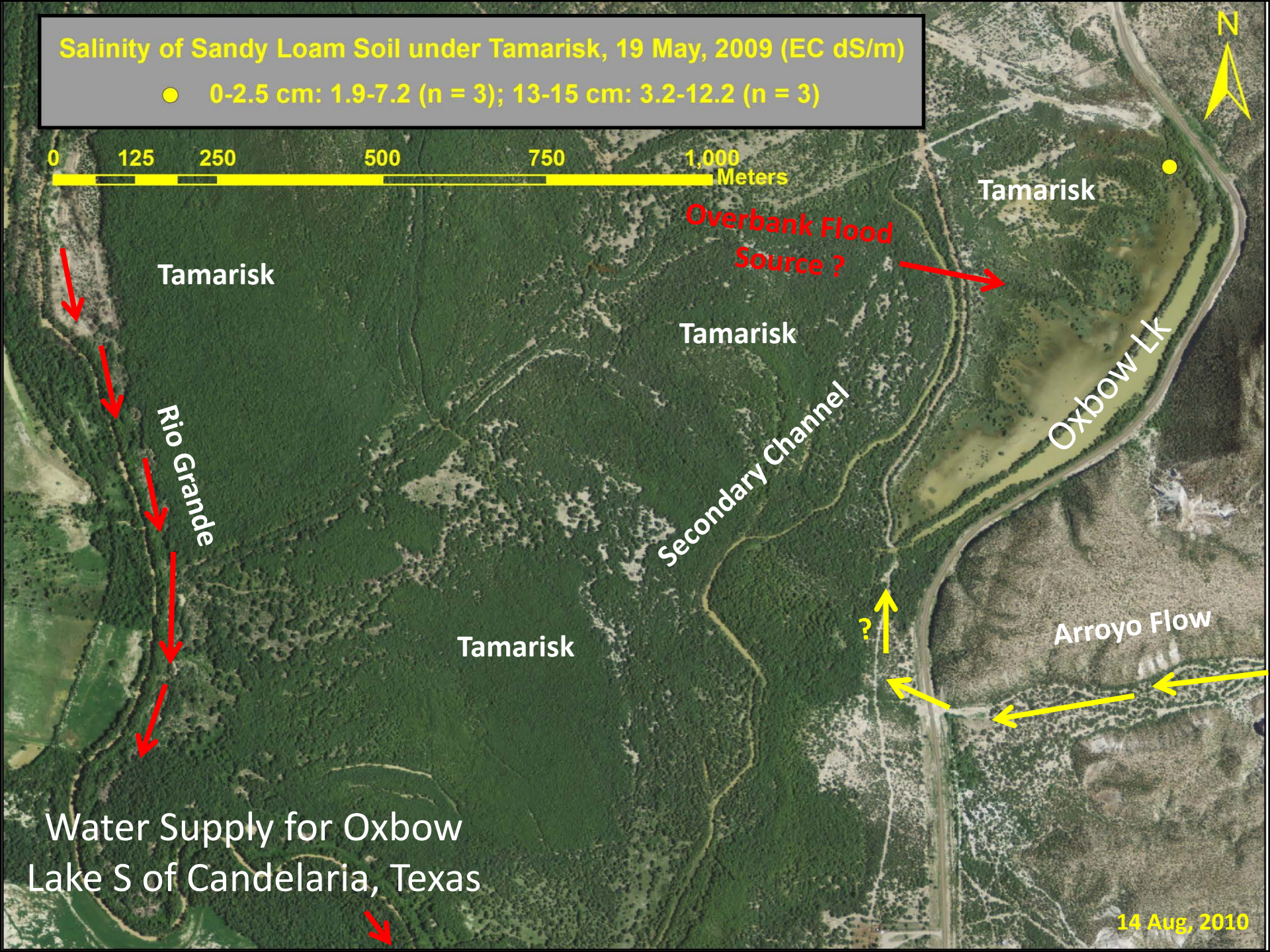
Potential Riparian Restoration Sites

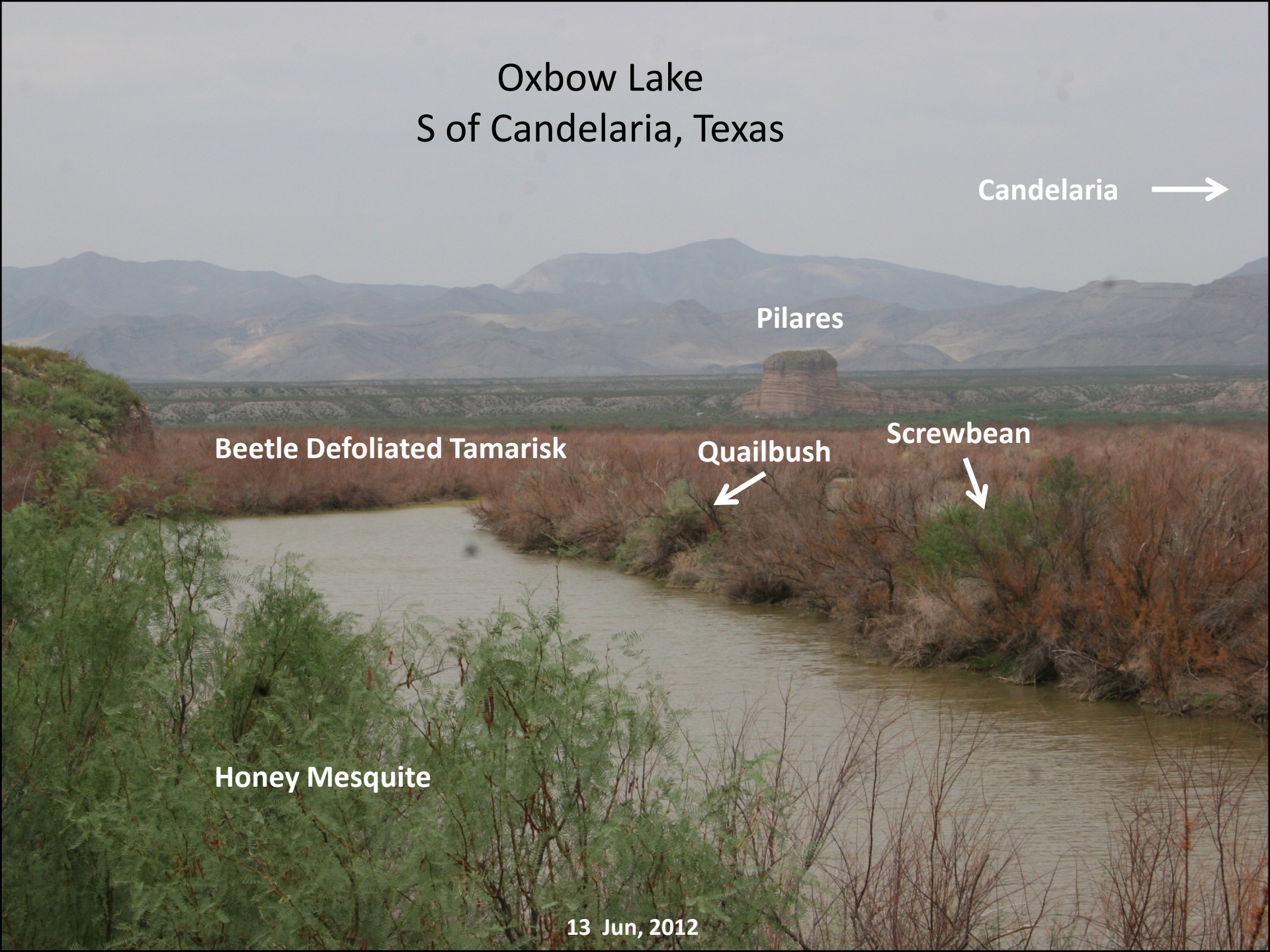
Forgotten River Reach Rio Grande, TX

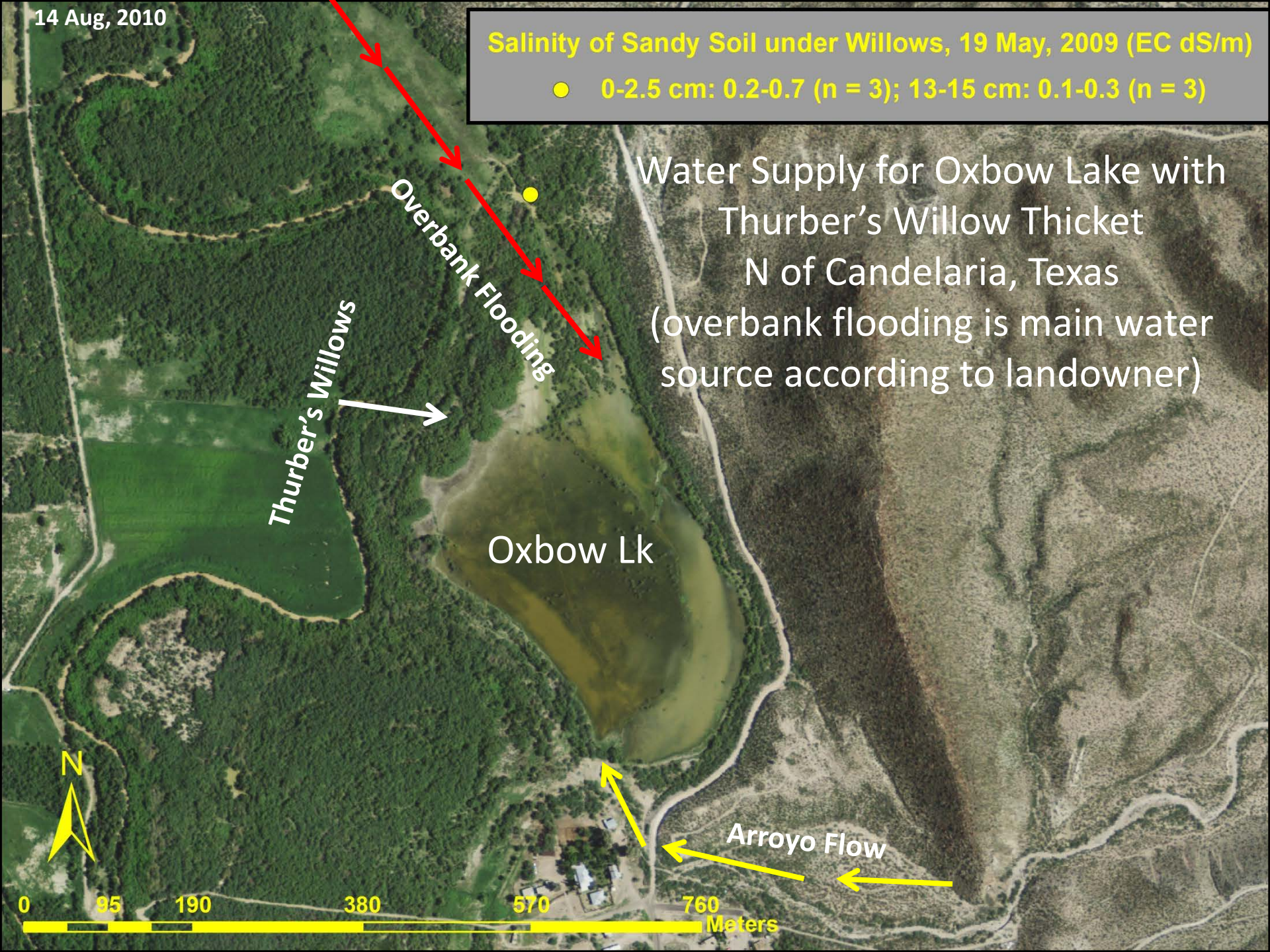
June 2012


98% Tamarisk Beetle Defoliation over 100 miles of Rio Grande from Big Bend NP to somewhere North of Candelaria
Ciudad Juarez
Fort Quitman
10
385
Rio Grande
Forgotten River Reach
Candelaria
Ruidosa
Presidio Valley
Presidio
Rio Conchos
Lajitas
Rio Grande
Rio Grande
Big Bend National Park,
Tamarisk Beetle Defoliation
13 June, 2012
Chihuahua


Potetential Riparian Restoration Sites
North Candelaria
Oxbow Lake
with Willows
Tamarisk
Candelaria
Rio Grande
Tamarisk
Tamarisk
South Candelaria
Oxbow Lake with
Tamarisk
Tamarisk
Tamarisk
Arroyo Flow
Tamarisk
Tamarisk, Oxbow Lakes, and Major
Arroyos near Candelaria, TX
14 Aug, 2010
N
0 250 500 1,000 1,500 2,000
Meters


Salinity of Sandy Loam Soil under Tamarisk, 19 May, 2009 (EC dS/m)
0-2.5 cm: 1.9-7.2 (n = 3); 13-15 cm: 3.2-12.2 (n = 3)
0
125
250
500
750
1,000
Meters
N
Tamarisk
Overbank Flood Source ?
Tamarisk
Tamarisk
Oxbow Lk
Rio Grande
Secondary Channel
?
Arroyo Flow
Tamarisk
Water Supply for Oxbow Lake S of Candelaria, Texas
14 Aug, 2010

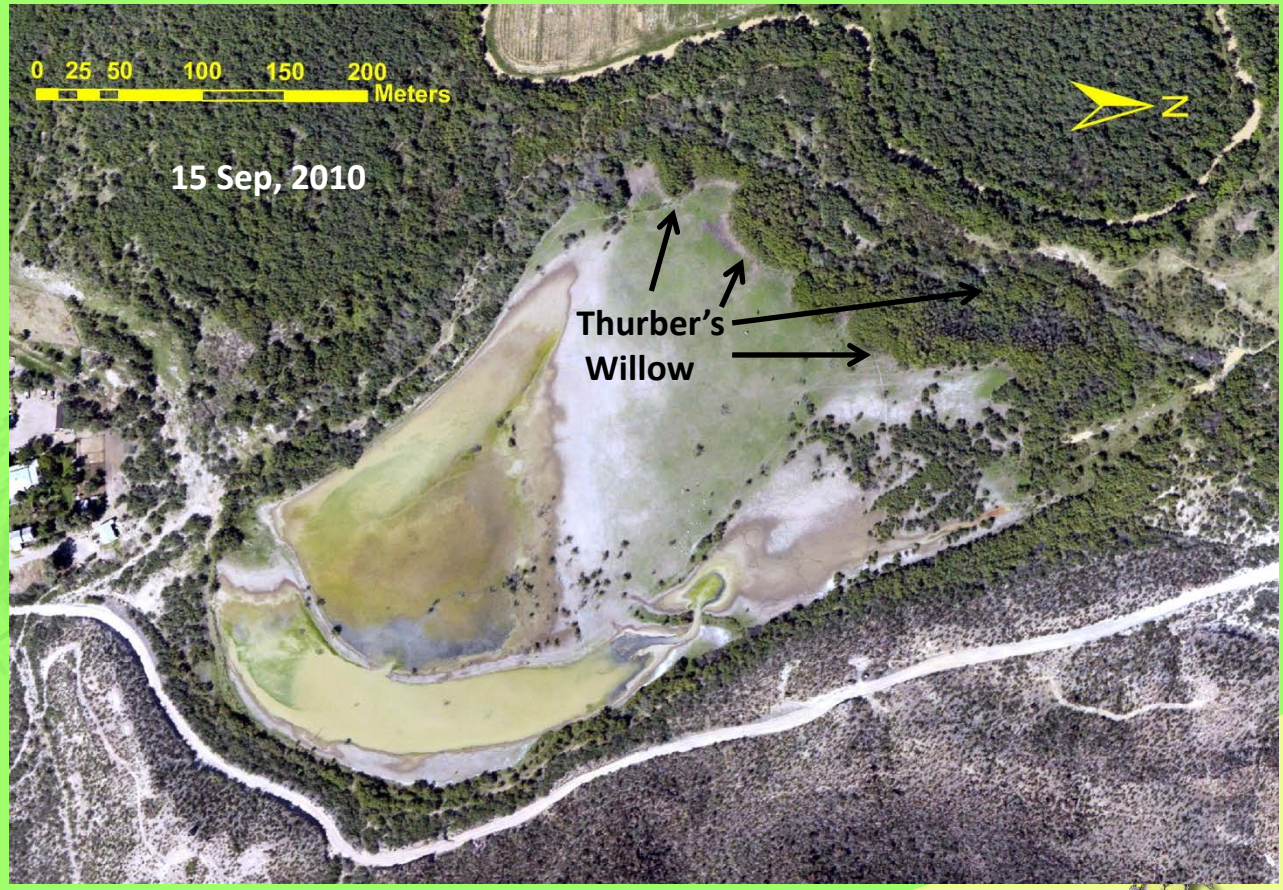

Oxbow Lake
S of Candelaria, Texas
Candelaria
Pilares
Beetle Defoliated Tamarisk
Quailbush
Screwbean
Honey Mesquite
13 Jun, 2012

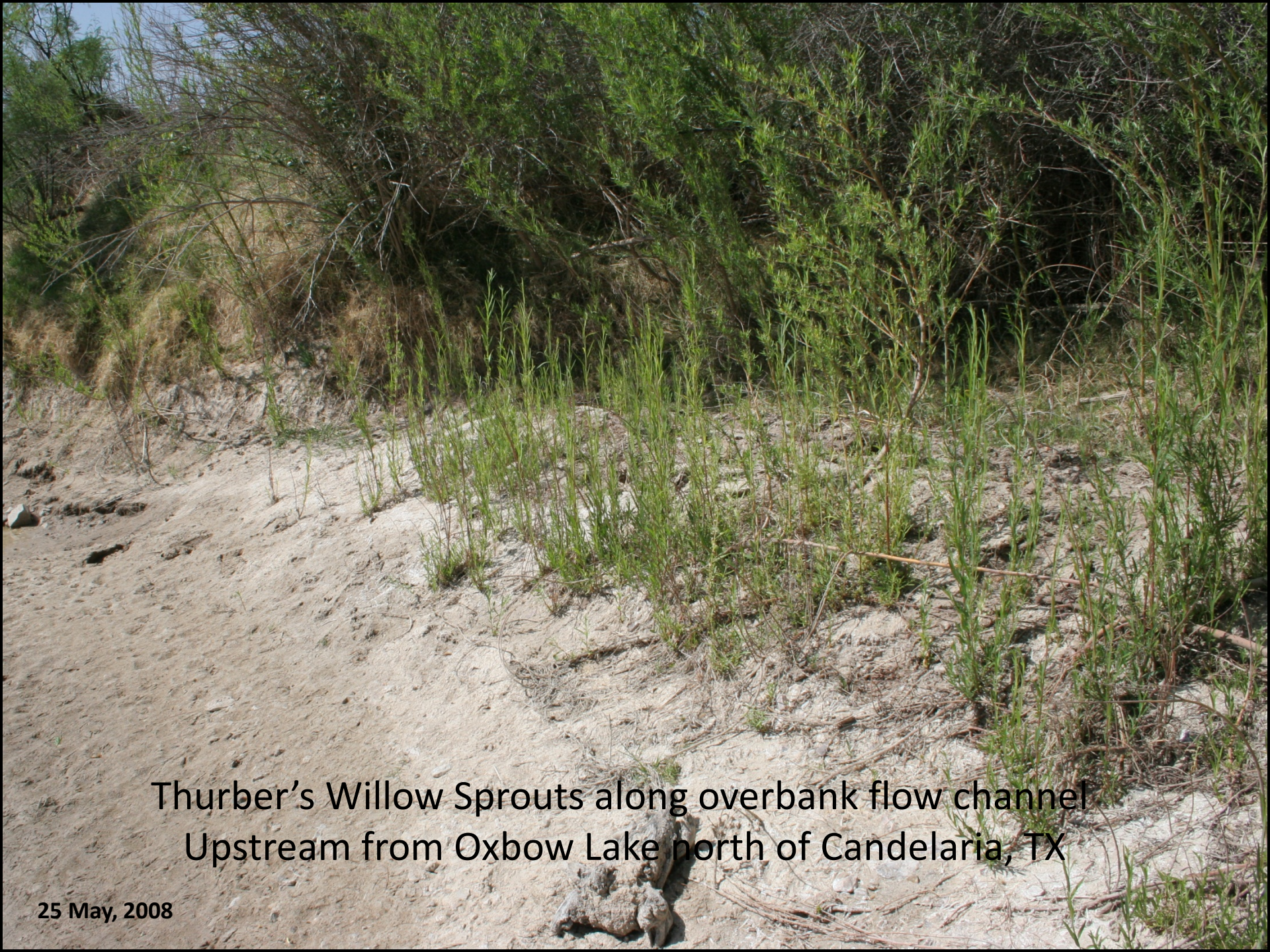

14 Aug, 2010
Salinity of Sandy Soil under Willows, 19 May, 2009 (EC dS/m)
0-2.5 cm: 0.2-0.7 (n = 3); 13-15 cm: 0.1-0.3 (n = 3)
Water Supply for Oxbow Lake with Thurber's Willow Thicket N of Candelaria, Texas (overbank flooding is main water source according to landowner)
Overbank Flooding
Thurber's Willows
Oxbow Lk
Arroyo Flow
N
0
95
190
380
570
760
Meters

Potetential Riparian Restoration Sites

Relict Thurber's Willow Woodlands
Oxbow Lake, Candelaria, TX

Oxbow Lake North of Candelaria, TX with app. 1 ha of Thurber's Willow Thickets at Northwest Edge- Possibly last remaining large willow thicket in the Forgotten River Reach of the Rio Grande





Thurber's Willow Sprouts along overbank flow channel
Upstream from Oxbow Lake north of Candelaria, TX

25 May, 2008

Remnant Younger Thurber's Willow Thicket, Oxbow Lk N Candelaria, TX

13 June, 2012

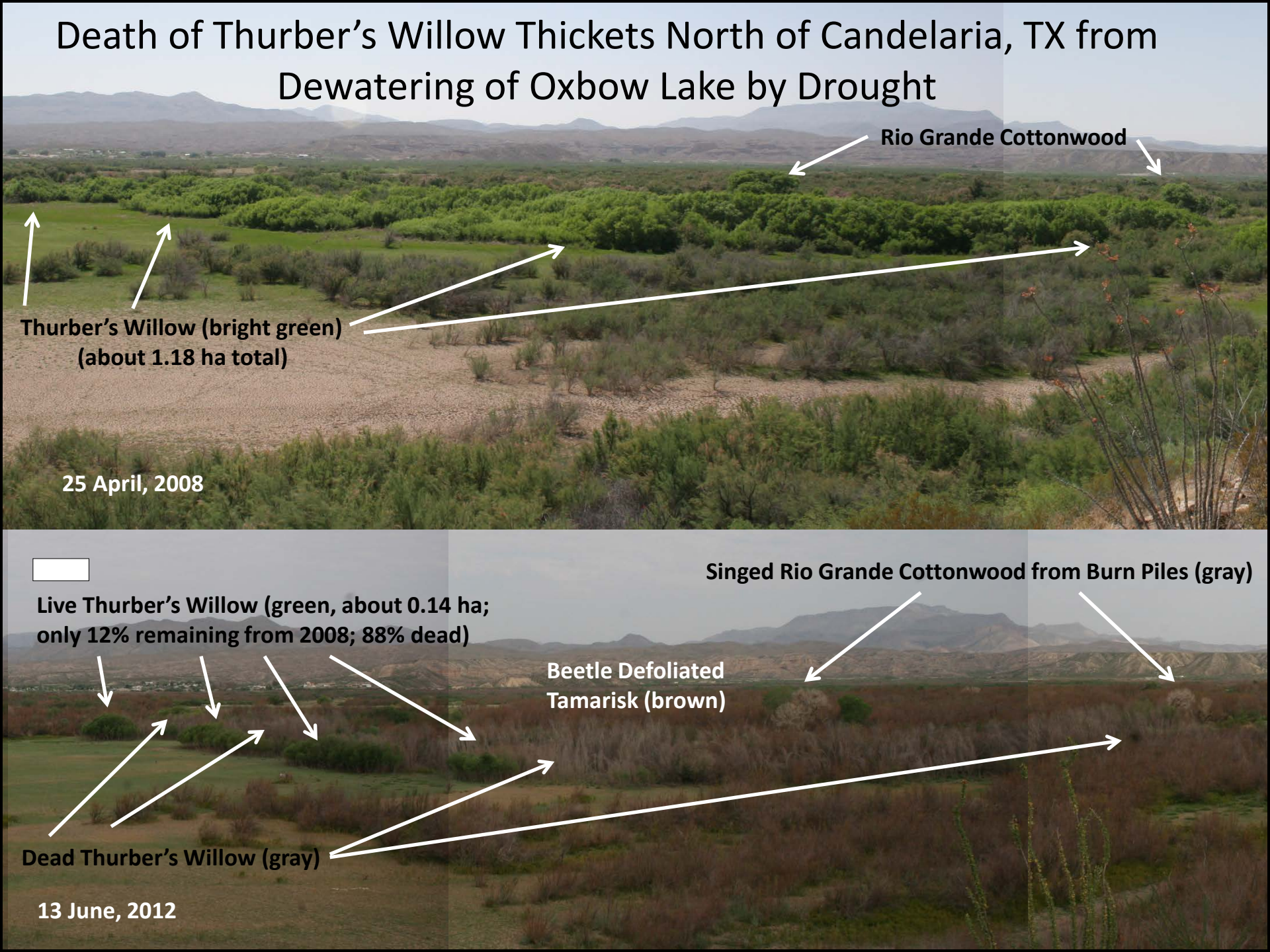
Dead Thurber's Willow Thicket, Oxbow Lk N Candelaria, TX

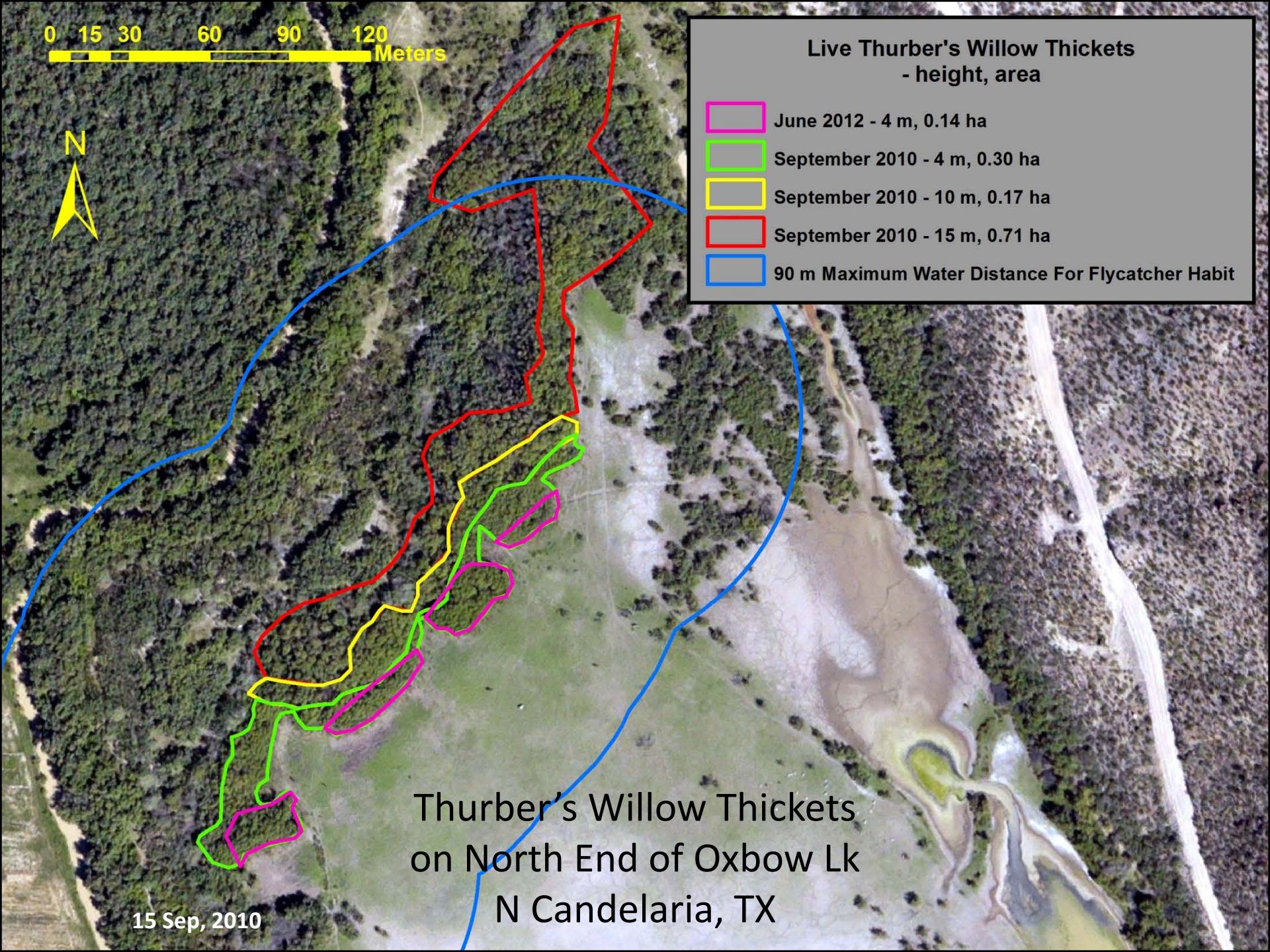
13 June, 2012


Thurber's Willow Woodland
Near Oxbow Lake North of Candelaria, TX
25 May, 2008

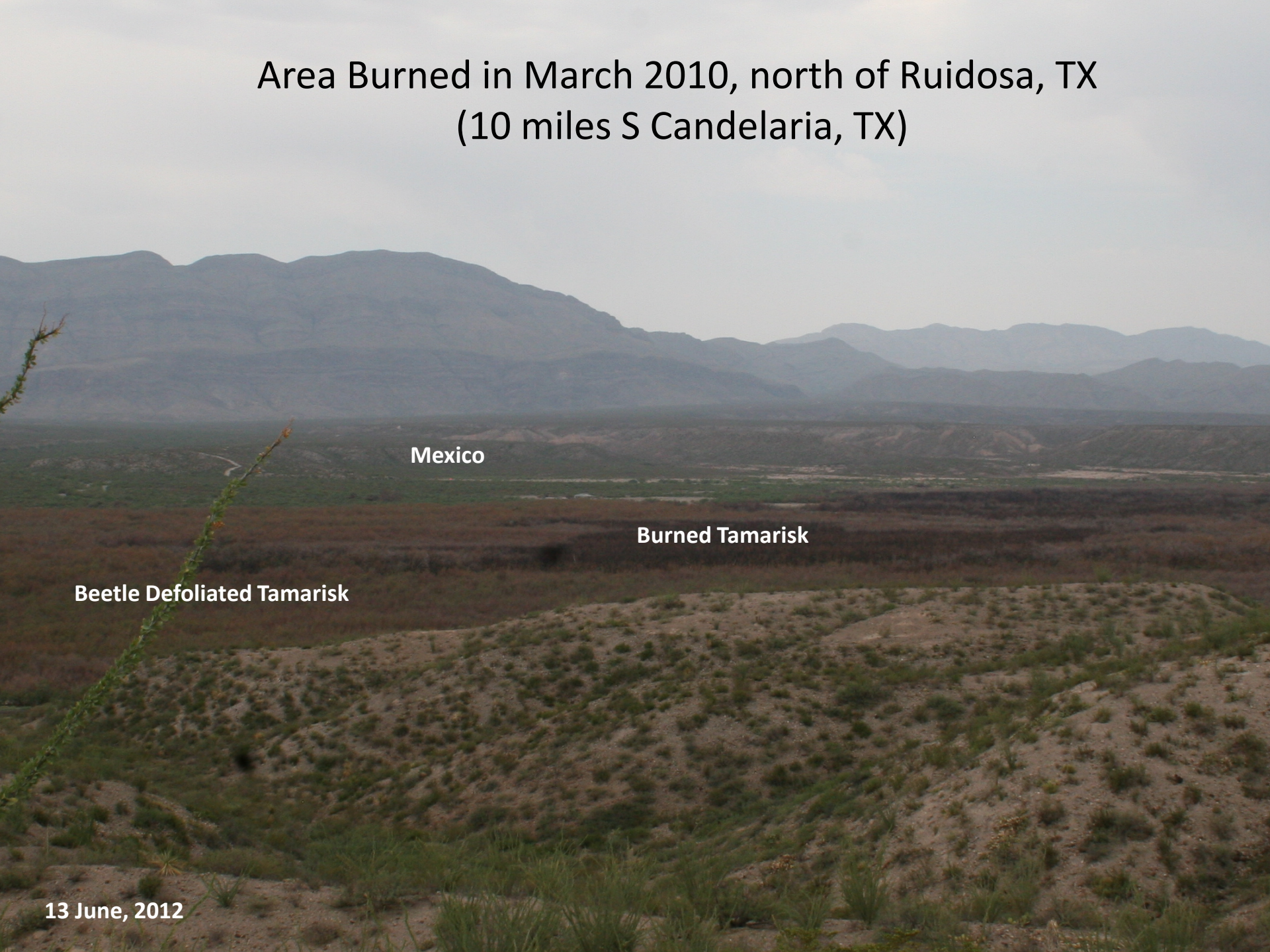

Dead Decadent Thurber's Willow Woodland
Near Oxbow Lake North of Candelaria, TX
13 June, 2012

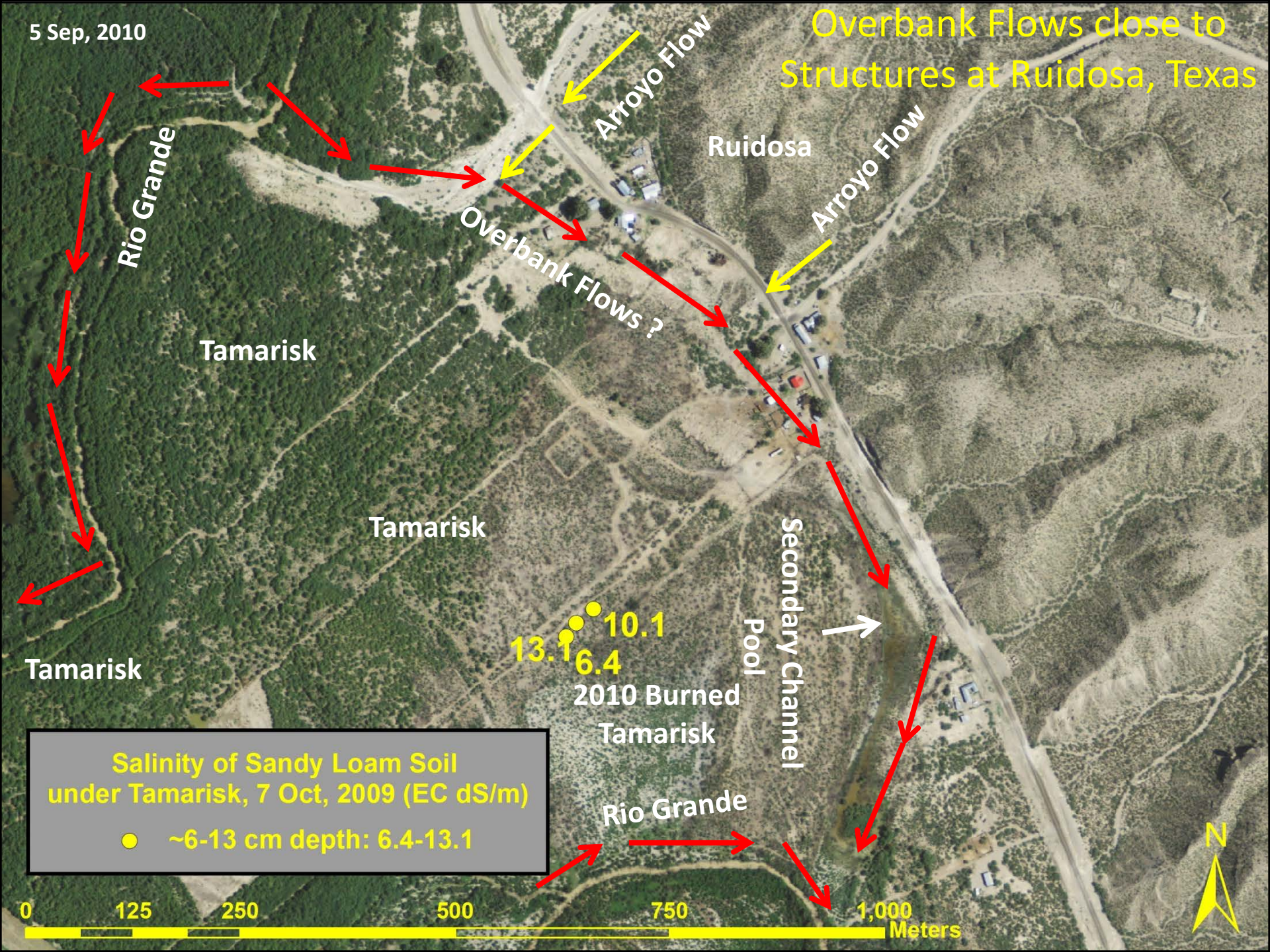
Death of Thurber's Willow Thickets North of Candelaria, TX from Dewatering of Oxbow Lake by Drought




0 15 30 60 90 120
Meters
N
Live Thurber's Willow Thickets
- height, area
June 2012 - 4 m, 0.14 ha
September 2010 - 4 m, 0.30 ha
September 2010 - 10 m, 0.17 ha
September 2010 - 15 m, 0.71 ha
90 m Maximum Water Distance For Flycatcher Habit
Thurber's Willow Thickets
on North End of Oxbow Lk
N Candelaria, TX
15 Sep, 2010

Area Burned in March 2010, north of Ruidosa, TX (10 miles S Candelaria, TX)




5 Sep, 2010
Overbank Flows close to Structures at Ruidosa, Texas
Arroyo Flow
Ruidosa
Arroyo Flow
Rio Grande
Overbank Flows ?
Tamarisk
Tamarisk
Tamarisk
10.1
13.1
6.4
2010 Burned Tamarisk
Secondary Channel Pool
Rio Grande
Salinity of Sandy Loam Soil under Tamarisk, 7 Oct, 2009 (EC dS/m)
~6-13 cm depth: 6.4-13.1
0
125
250
500
750
1,000
Meters
N

Area Burned in March 2010, Ruidosa, TX