Projecting dispersal of subtropical tamarisk beetles towards habitat of endangered Southwestern Willow Flycatchers in Arizona

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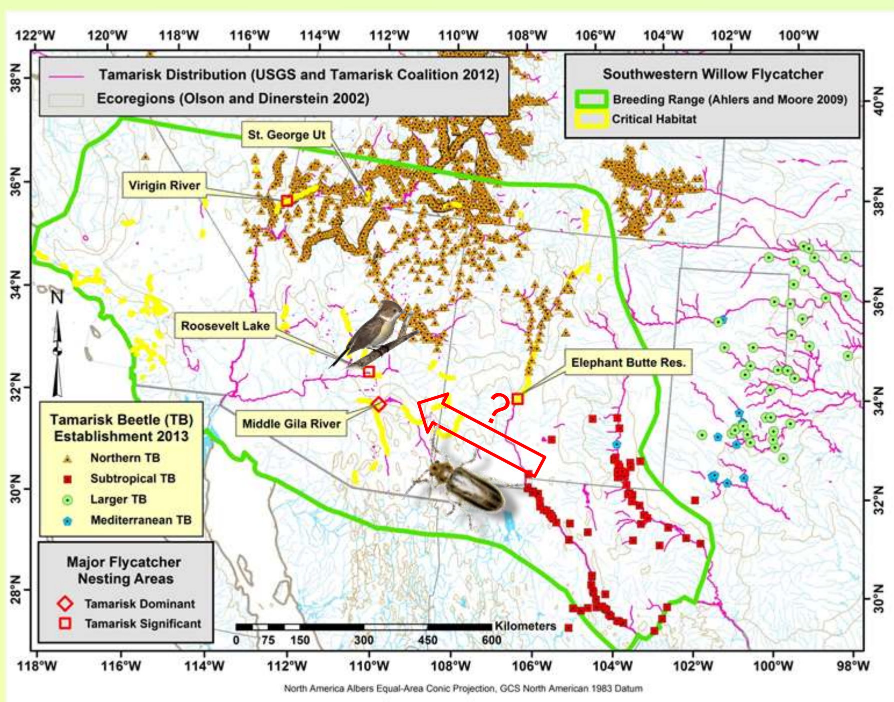
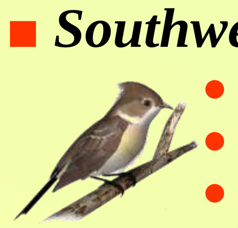
Abstract

Subtropical tamarisk beetles (*Diorhabda sublineata*) were first introduced on the Rio Grande near the Big Bend region of Texas in 2009 for biological control of tamarisk (*Tamarix ramosissima*/*T. chinensis*). They are rapidly dispersing and defoliating extensive areas of tamarisk in the TransPecos region. These beetles may adversely impact tamarisk nesting habitats of the federally endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) in New Mexico and Arizona. The MIGCLIM R dispersal model is calibrated and used to project the timing of arrival of subtropical tamarisk beetles into flycatcher habitats over the next 10 years, and to derive least dispersal time cost paths into these habitats. Beetles are projected to travel north from El Paso along the Rio Grande and arrive at the largest extant flycatcher population on Elephant Butte Reservoir, NM by spring of 2014. Arrival in tamarisk dominated flycatcher habitats on the middle Gila River, AZ is projected for spring of 2017 as beetles travel west from Las Cruces, NM. Willow restoration in these flycatcher habitats should be implemented now in order to mitigate potential flycatcher habitat loss from beetle defoliation.

Introduction



Southwestern Willow Flycatchers (flycatchers)



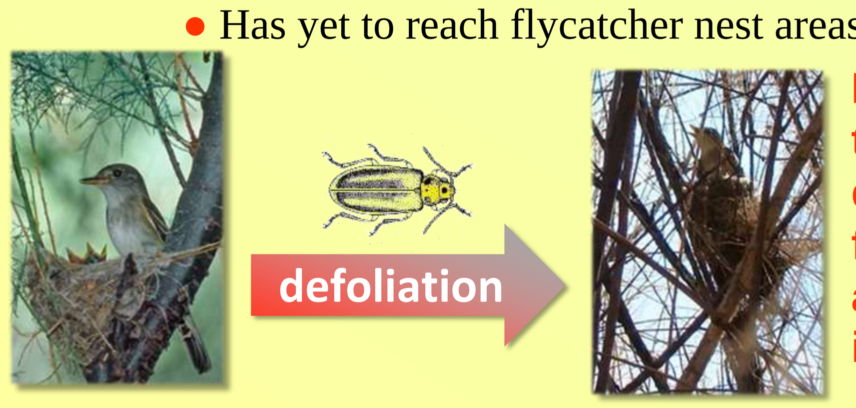
- Endangered due to SW riparian habitat loss
- Tamarisk dominates 28% territories (see above map)
- Prefers exotic tamarisk to native willows for nesting
- Tamarisk beetles defoliated habitat in S Utah in 2009
- Willow plantings provide flycatcher nest habitat within 3 years

Tamarisks

- Invasive desert riparian shrub from Eurasia
- Now second only to cottonwood in SW riparian areas
- Reduces biodiversity native riparian flora and fauna
- Provide substantial riparian bird habitat

Subtropical Tamarisk Beetles

- Introduced to TX from N Africa in 2009
- Can defoliate >95% tamarisk, leading to 50% dieback in 3 years
- Defoliation is generating concern for riparian birds
- Has yet to reach flycatcher nest areas in AZ, NM



Northern tamarisk beetle defoliation of flycatcher habitat at St. George, UT, in 2009

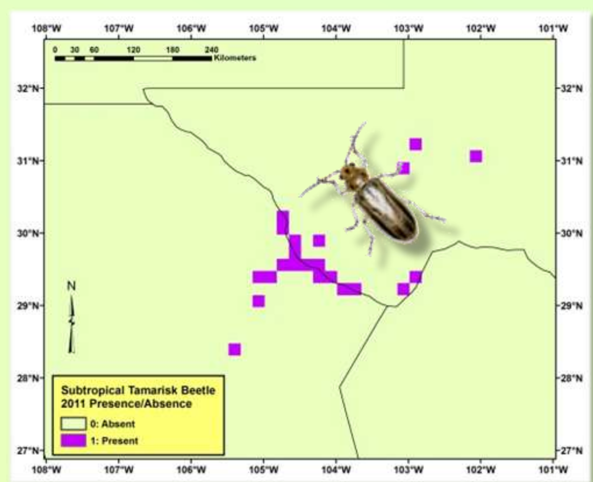
Objectives and Approach

- Develop MIGCLIM R dispersal models over next ten years for subtropical tamarisk beetle
- Link climate suitability model (Envelope Score) and a landscape functional connectivity model (for beetle dispersal paths, accounting for the location of tamarisk, streams, and roads) with the MIGCLIM R dispersal model
- Project timing of beetle arrival at flycatcher habitats in AZ & NM
- Project route of beetle dispersal to flycatcher sites dominated by tamarisk on the Middle Gila River, AZ

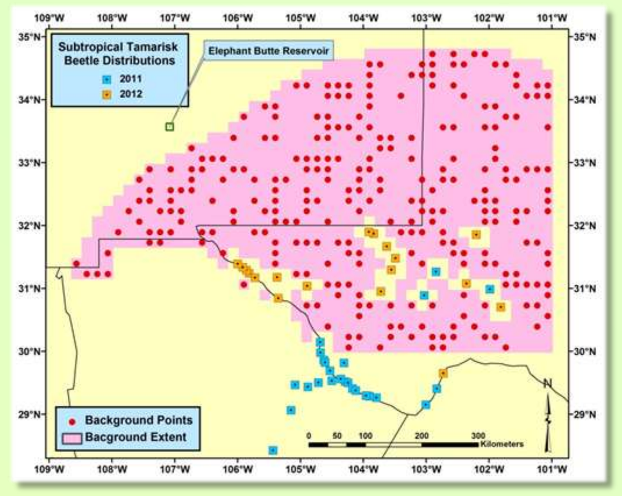
Methods

MIGCLIM R Dispersal Model Inputs

- All model input data are rasters at 10', 18km, resolution.
- 2012 beetle presence points (14) and background points (270) are divided into 3 sets for model evaluation (below).

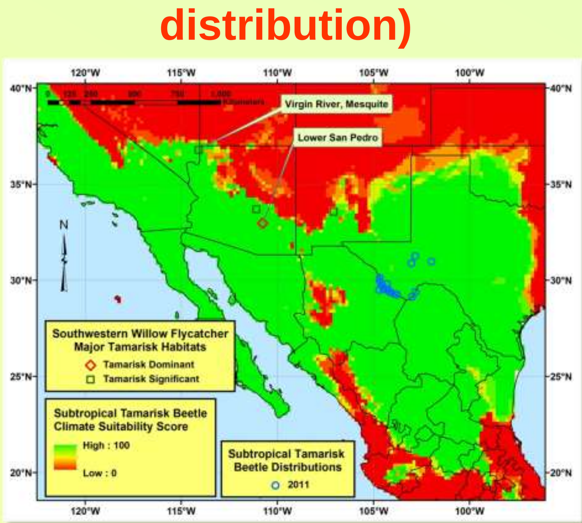


Initial presence points of beetle in 2011

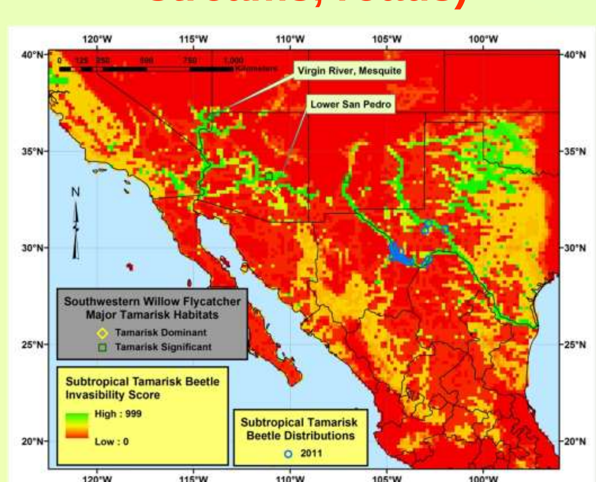


2012 beetle presence points (orange), random absence points (red), & evaluation extent (pink)

- Two different beetle dispersal models are compared based upon the type of invasibility score rasters employed (below)



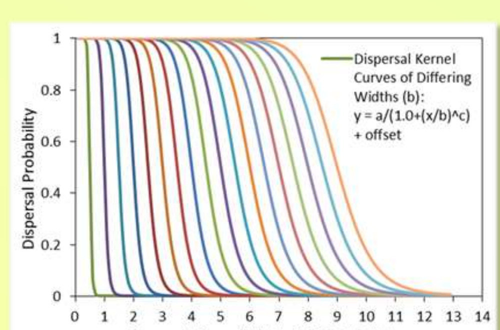
Invasibility Raster for Model 1: Climatic suitability model (Envelope Score, based on Old World beetle distribution)



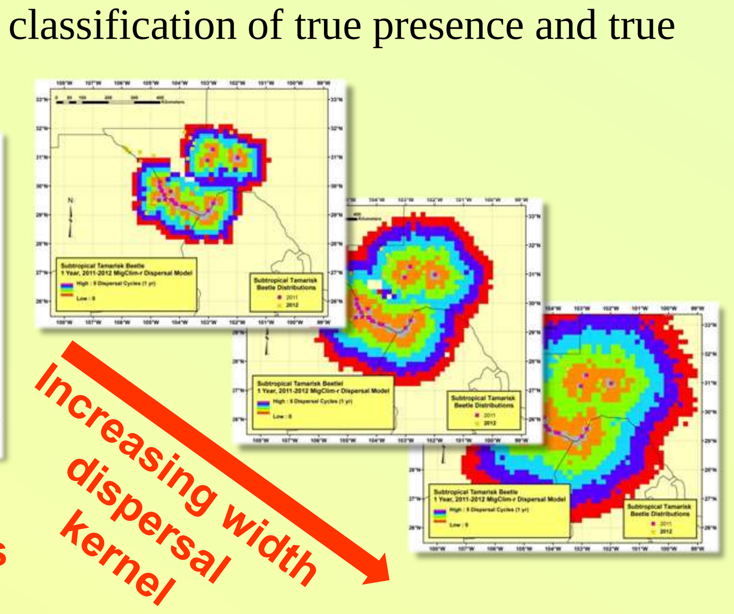
Invasibility Raster for Model 2: Climatic suitability with landscape functional connectivity (tamarisk, streams, roads)

One-Year Calibration/Evaluation

- The dispersal kernel width (below) per each of 5 beetle generations over a single year is calibrated by maximizing the True Skill Statistic (TSS; correct classification of true presence and true absence after one year)



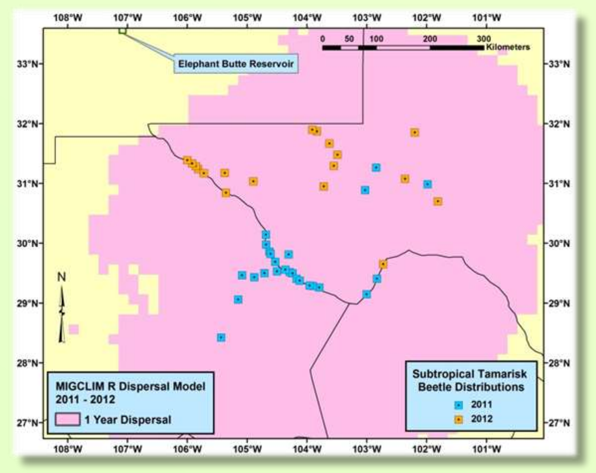
Range of beetle dispersal kernel widths



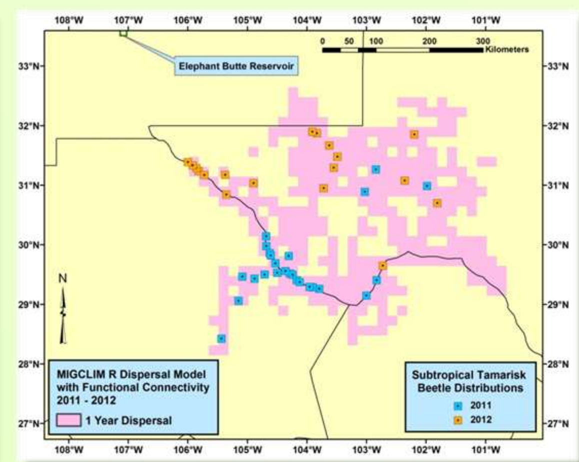
Results

One-Year Dispersal Calibration/Evaluation

- Dispersal Model 2, incorporating functional connectivity (distribution of tamarisks, streams, and roads) in addition to climatic suitability, performed significantly better than Model 1 (climatic suitability alone) according to three evaluation statistics (below)



Model 1: Projected 1-year dispersal



Model 2: Projected 1-year dispersal

Evaluation statistics for 1-year dispersal models

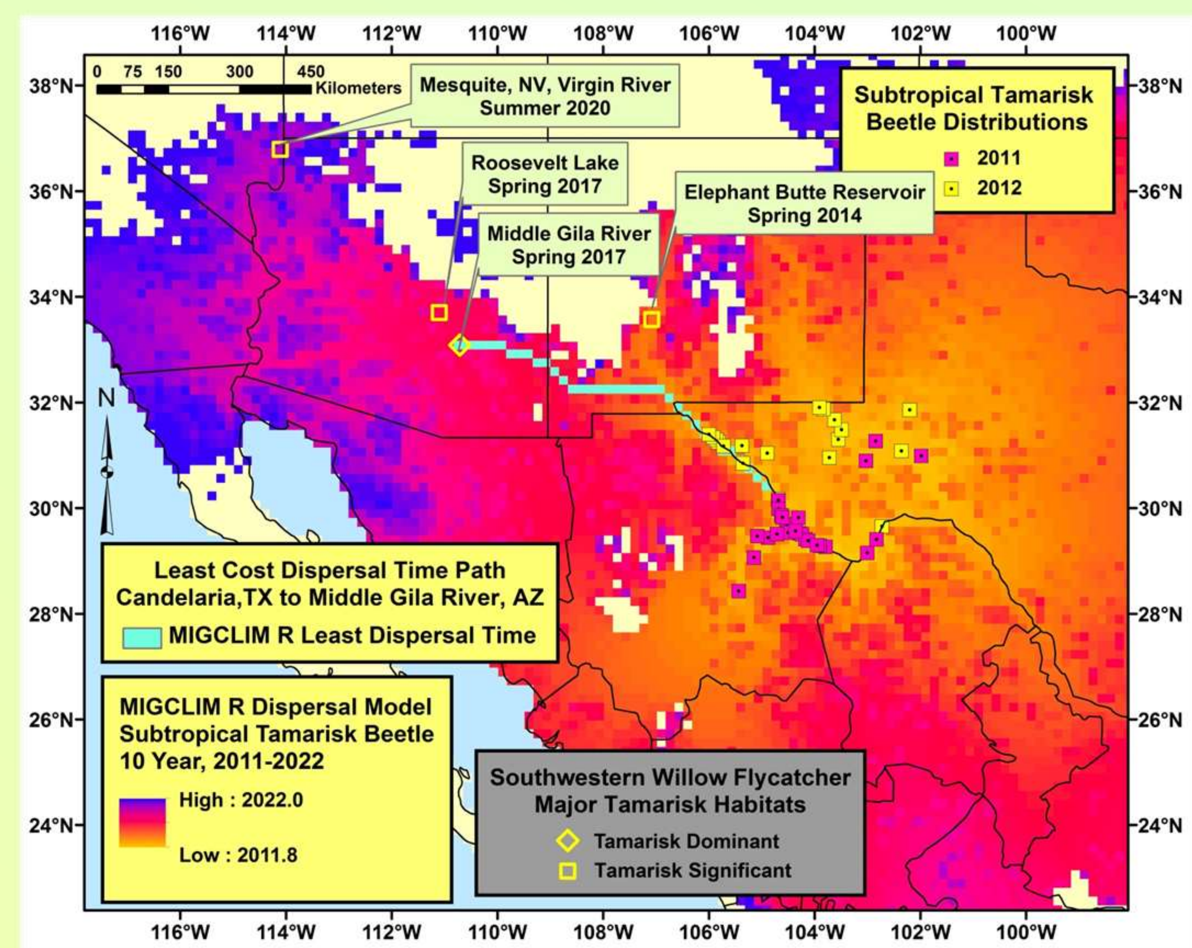
Evaluation Statistic*	Model 1: No Func. Conn.	Model 2: With Func. Conn.	p-value**
	X̄ ± SD (n=3)		
TSS	0.50 ± 0.06b	0.80 ± 0.06a	0.008
AUC	0.77 ± 0.03b	0.90 ± 0.03a	0.0005
Kappa	0.17 ± 0.03b	0.50 ± 0.13a	0.026

*TSS= True Skill Statistic; AUC = Area Under Curve statistic.
**Paired t-test for test statistics across rows using 3-fold partitioning of presence/absence data.

Ten-Year Dispersal Model Projections

- Final 10- year MIGCLIM R dispersal model (below) incorporates functional connectivity and represents mean of ten individual stochastic models with optimized dispersal kernels

Projected 2011-2021 dispersal of subtropical tamarisk beetles



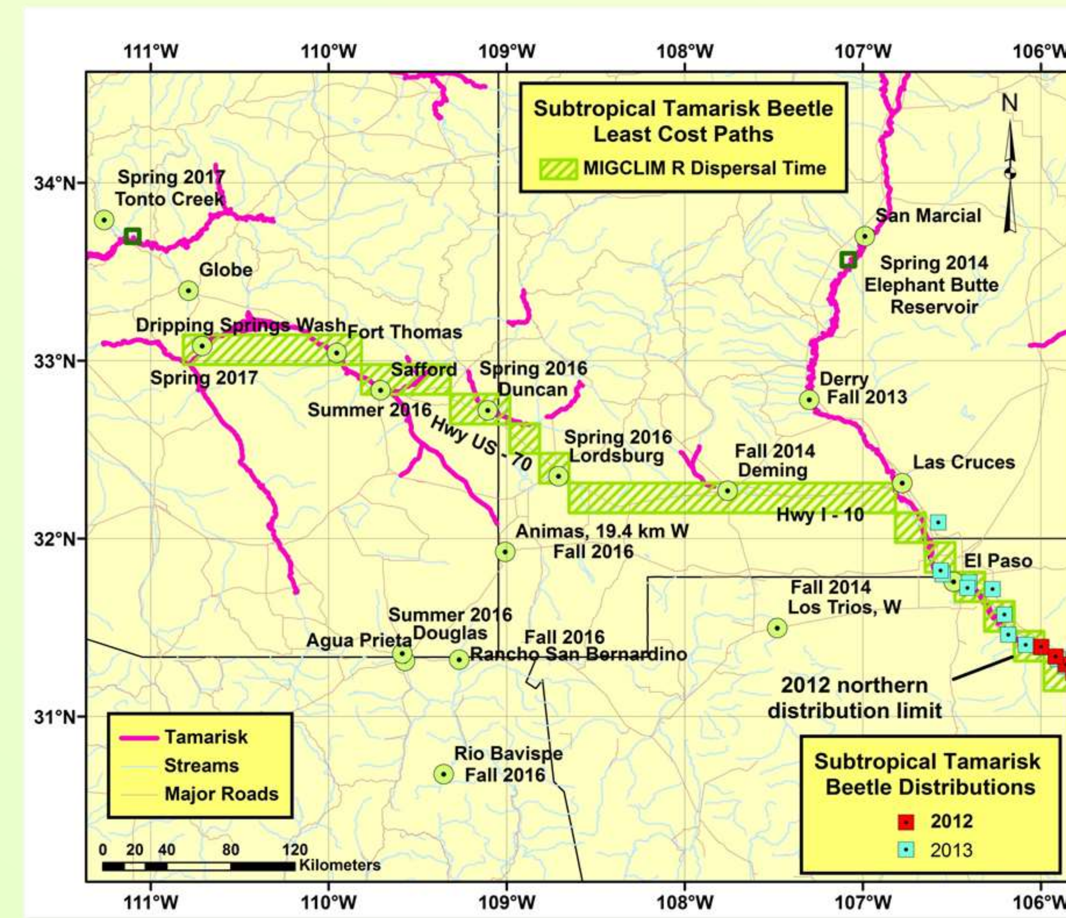
- Model projects a maximum of ca. 210 km per year dispersal by the subtropical tamarisk beetle.
- Subtropical tamarisk beetles are projected to reach flycatcher nesting sites in dense tamarisk on the Middle Gila River, AZ by the spring of 2017 (above)
- Beetles may reach the largest extant flycatcher nesting sites in tamarisk at Elephant Butte Reservoir by spring of 2014

Results (cont.)

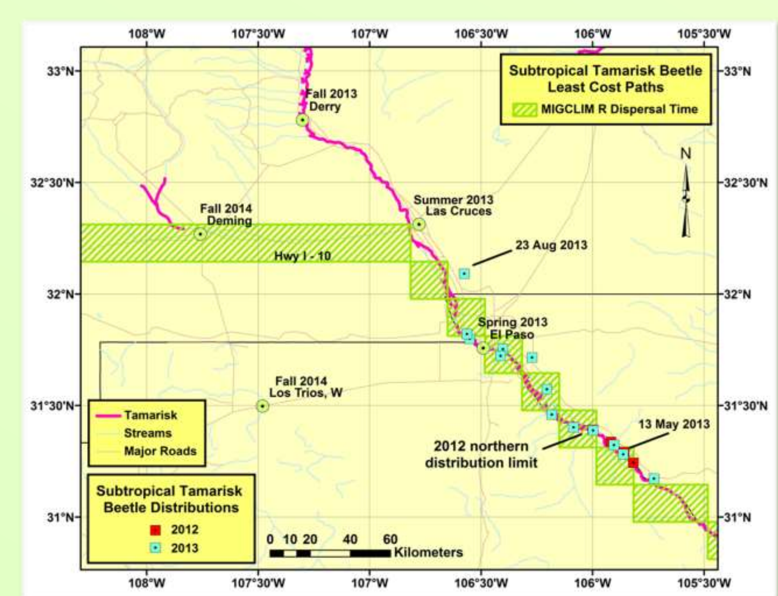
Least-Cost Path Analyses

- Least cost path analysis for dispersal time projects that subtropical tamarisk beetles will move towards flycatchers nesting in dense tamarisk along the Middle Gila River in Arizona through traveling westwards along I-10 to Lordsburg and then northwest along US-70 towards Globe, AZ (below).

Projected westward beetle dispersal routes



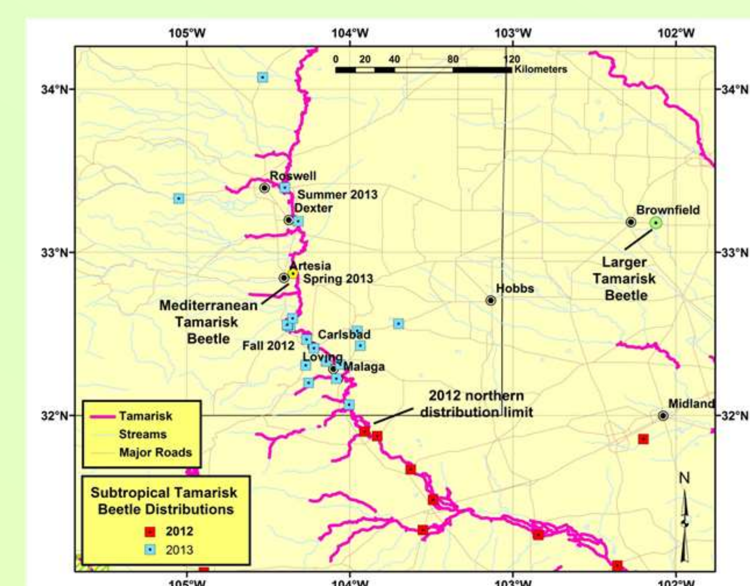
Slower than projected 2013 dispersal in El Paso Valley, TX



- Subtropical tamarisk beetle dispersal fell ca. 80 km short of that projected north of Las Cruces in 2013. Beetles were probably slowed in the El Paso Valley by sparser tamarisk and heavy pesticide applications on crops in this heavily farmed area.

2013 Dispersal as projected along Pecos Riv., eastern NM

- As projected, subtropical tamarisk beetles did reach Roswell, NM along the Pecos River by the summer of 2013. Tamarisk is more uniform in this area and facilitates rapid dispersal.



Discussion

- Subtropical tamarisk beetles may reach major flycatcher sites in tamarisk in southern NM by 2014 and in central AZ by 2017.
- Sentinel monitoring sites should be established to track beetles north along the Rio Grande and west to Arizona along I-10.
- Native willows should be planted now to mitigate potential damage of tamarisk beetles to flycatcher habitats in S NM and central AZ.