



# RiversEdge West

RESTORE + CONNECT + INNOVATE

## Riparian Restoration and Tamarisk Beetle Workshop



Strategic  
Habitat  
Enhancements



Tom Till Photography, Inc.



# Tamarisk and Tamarisk Beetle History, Release, and Spread



***Ben Bloodworth***  
***Program Coordinator***

Tamarisk is a non-native phreatophyte that can dominate riparian lands





# Getting to know tamarisk...

In the U.S., tamarisk is an invasive species

Invasive species = non-native to the ecosystem in which they are found and can cause environmental, economic, or human harm

Leaves are scale-like with salt-secreting glands

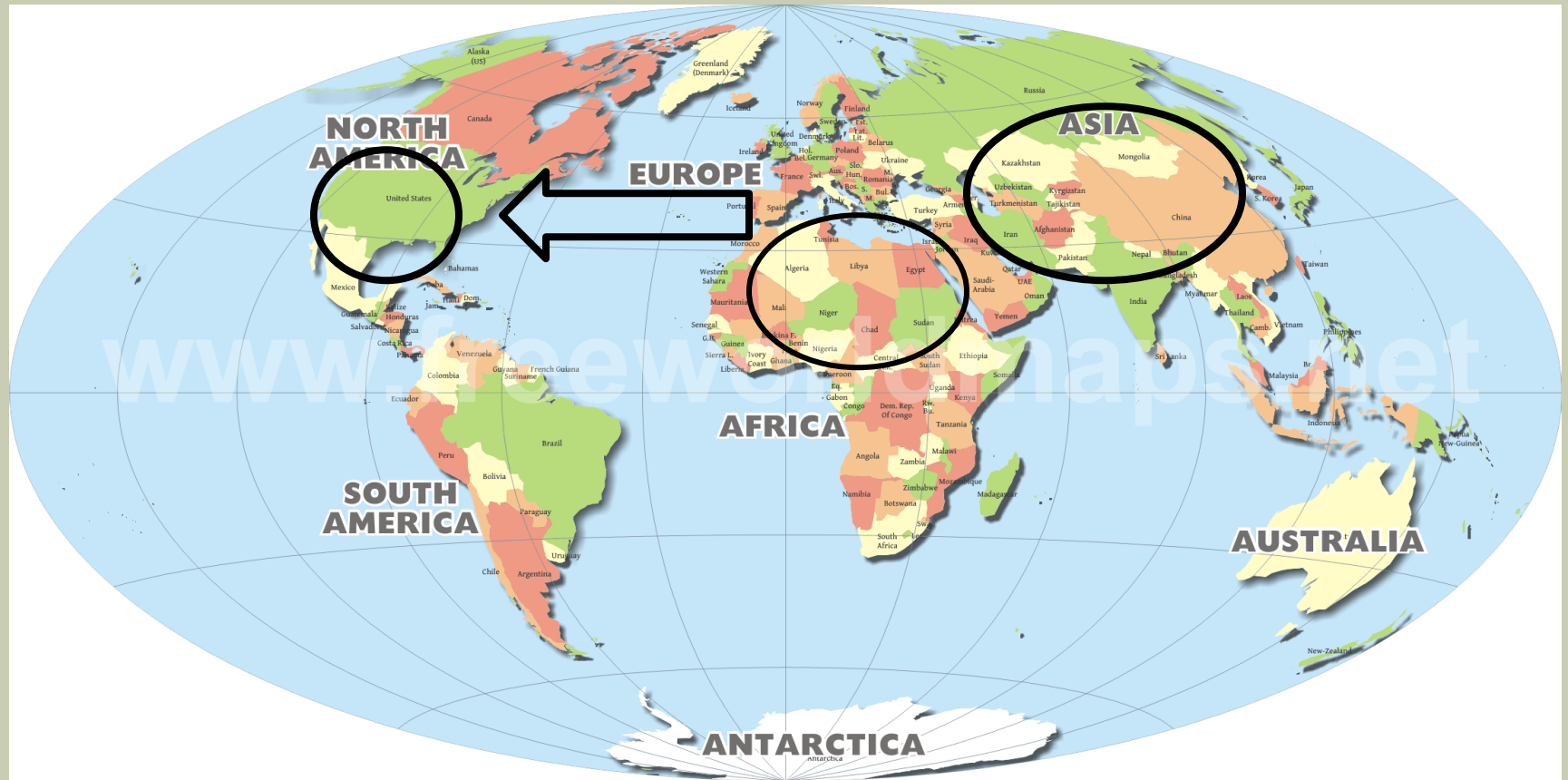
Produces 500,000 seeds/yr

Dispersed by wind, water, animals





# How did it get here?



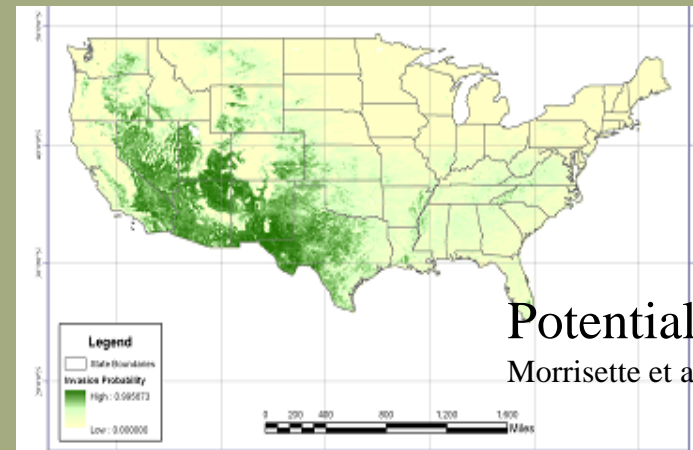
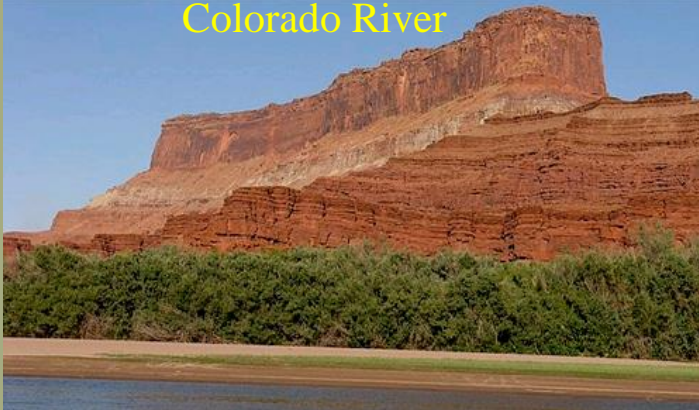
- $\geq 5$  *Tamarix* species; most are *T. ramosissima* X *chinensis* hybrids
- 3<sup>rd</sup> most common tree in western rivers, both regulated and free-flowing
- > 1 million ha. in No. America



Colorado River



Virgin River, NV

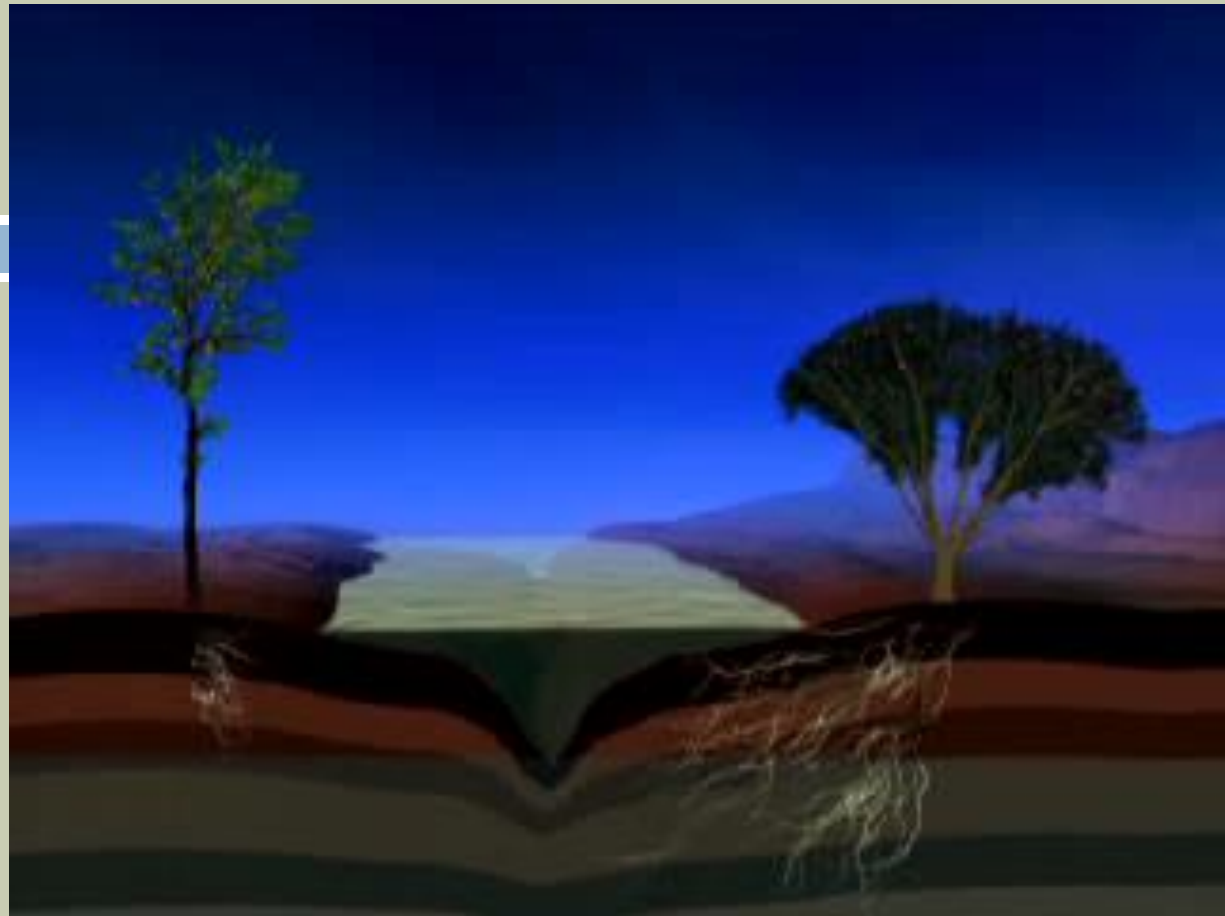


Potential Range

Morrisette et al. 2006

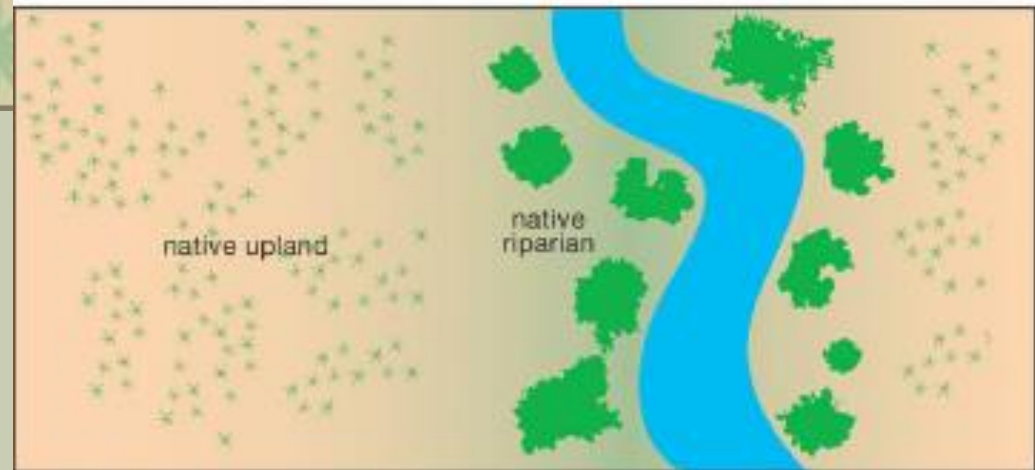
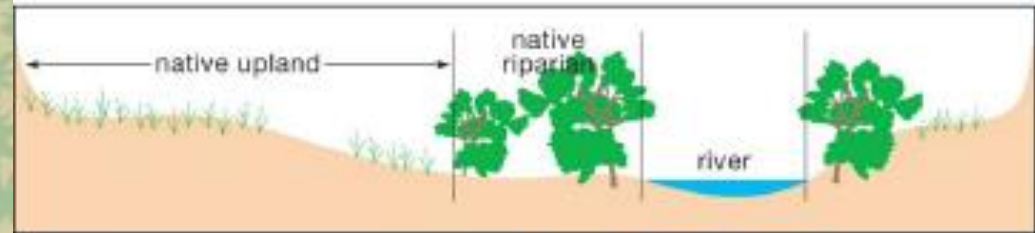
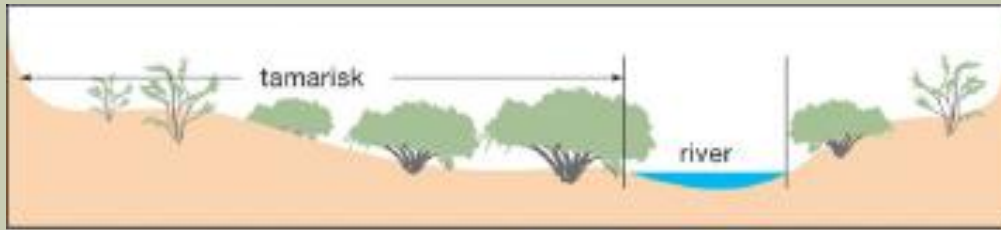


- Deeper roots than most natives (mesquite has roots almost as deep)
- Does **NOT** use 200 gallons of water per day, but has water use roughly equal to native riparian species
- Can survive in dryer areas/upper benches and in times of drought where native trees cannot reach water table
- Grows more densely than other native plants



## Tamarisk Water Use

# Simplified Conceptual Model of Tamarisk Dominated vs. Native Riparian Areas



From USU and Metro  
Water Cibola NWR  
study handout

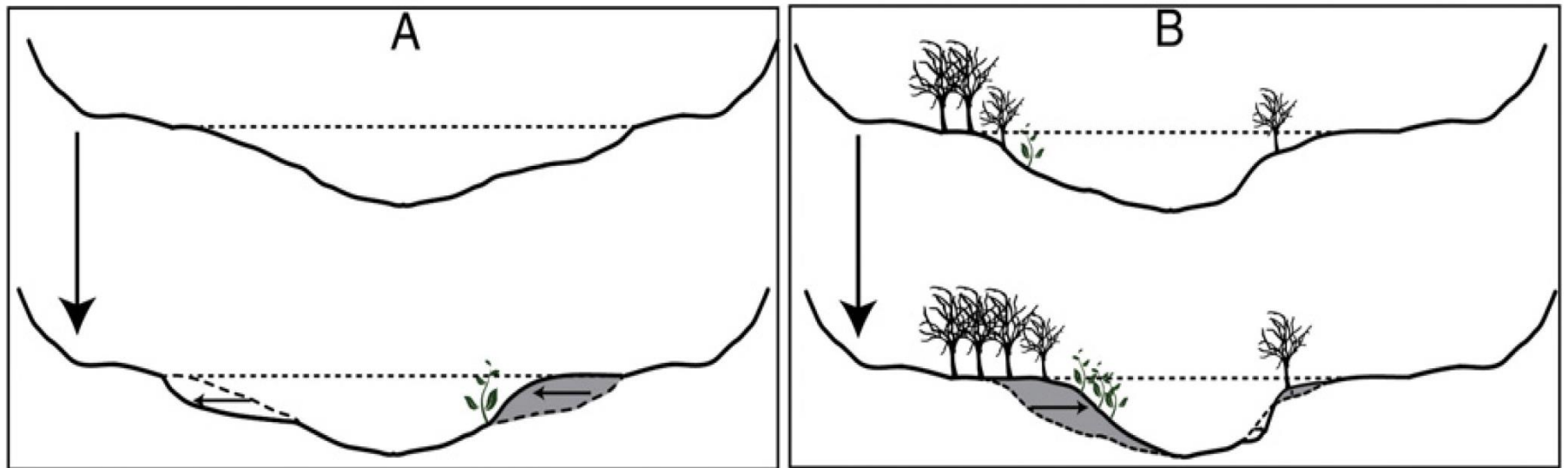


# More flood/drought resistant than other species



Roots can remain under water for up to 70 days and grow up to 25 feet deep

# Tamarisk and Channel Narrowing



From: Manners, et al. (2014). *Mechanisms of vegetation-induced channel narrowing of an unregulated canyon river: Results from a natural field-scale experiment*. *Geomorphology* 211 (2014) 100-115.



# Bridge Over San Rafael



*taken by Biology Teacher & principal  
Floyd Kelly about 1921-1924*

Flow alterations, both man-made and vegetation induced, have reduced habitat complexity (ditch-like river).

The bank stabilizing effects of the tamarisk prevent floodplain access and limit the creation of complex habitat (split channels, backwaters, pools, and riffles).

**[Historic bridge supports circled in red]**





# Landscape-Level Control isn't Practical



Humboldt River, NV



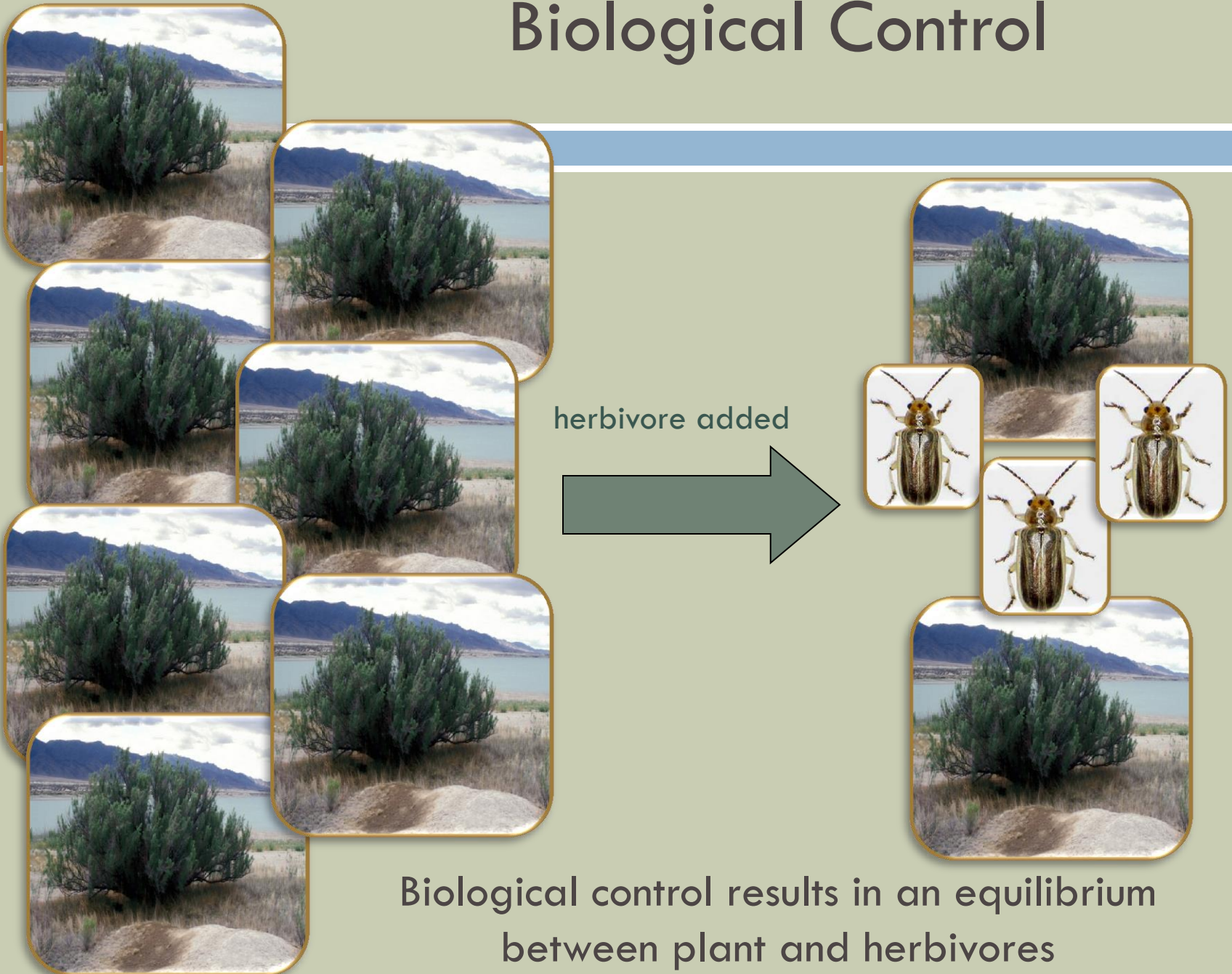
# Tamarisk (*Diorhabda* spp.) leaf beetle



Photo courtesy of Ed Kosmicki

Photo Sonoran Joint Venture

# Biological Control

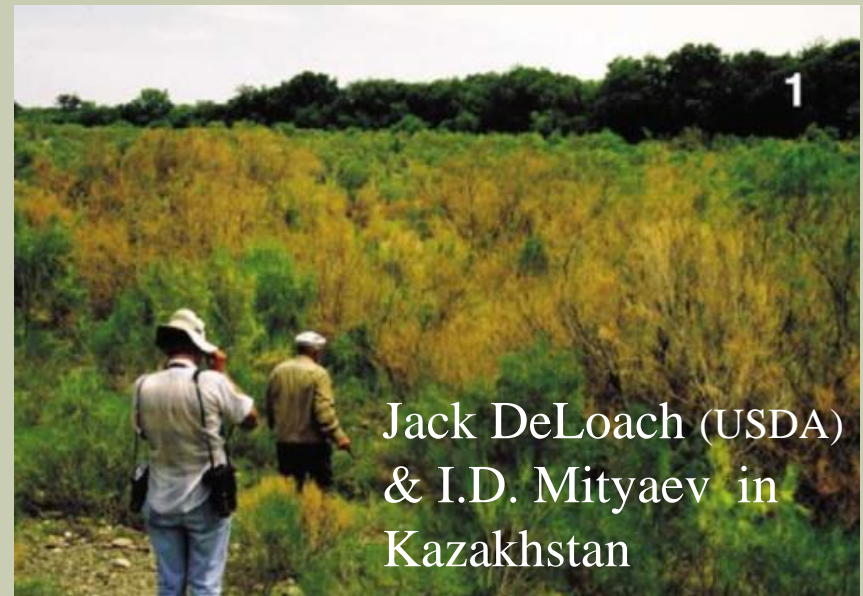




# Classical Biological Control

## Ideal Candidate:

- No native Tamaricaceae
- Envir. impacts strong
- Low economic value
- Unusual chemistry, thus many specialist herbivores



Jack DeLoach (USDA)  
& I.D. Mityaev in  
Kazakhstan

# Overseas Exploration: >300 specialist insects

Montpellier, France



*Diorhabda carinulata*  
(tamarisk leaf beetle)



*Coniatus tamarisci*  
(weevil)



*Trabutina mannipara*  
(mealy bug)

1996 – 3 candidates  
approved by USDA



# Tamarisk biological control timeline



**1987:**

Overseas exploration and research to find agent or agents



**1989-1994:**

Host specificity testing



**1994:**

TAG approval



**1998-2000**

Field cage tests and monitoring plan put into place



**2001:**

**Limited open releases**



Humboldt River Basin in 2003 showing extensive tamarisk defoliation by *D.*  
(photo: A. Brinkerhoff)



With 40,000 acres defoliated  
Lovelock became the prime  
collection site for *Diorhabda* in  
North America





*Diorhabda carinulata*  
from Nevada, site of  
the first success

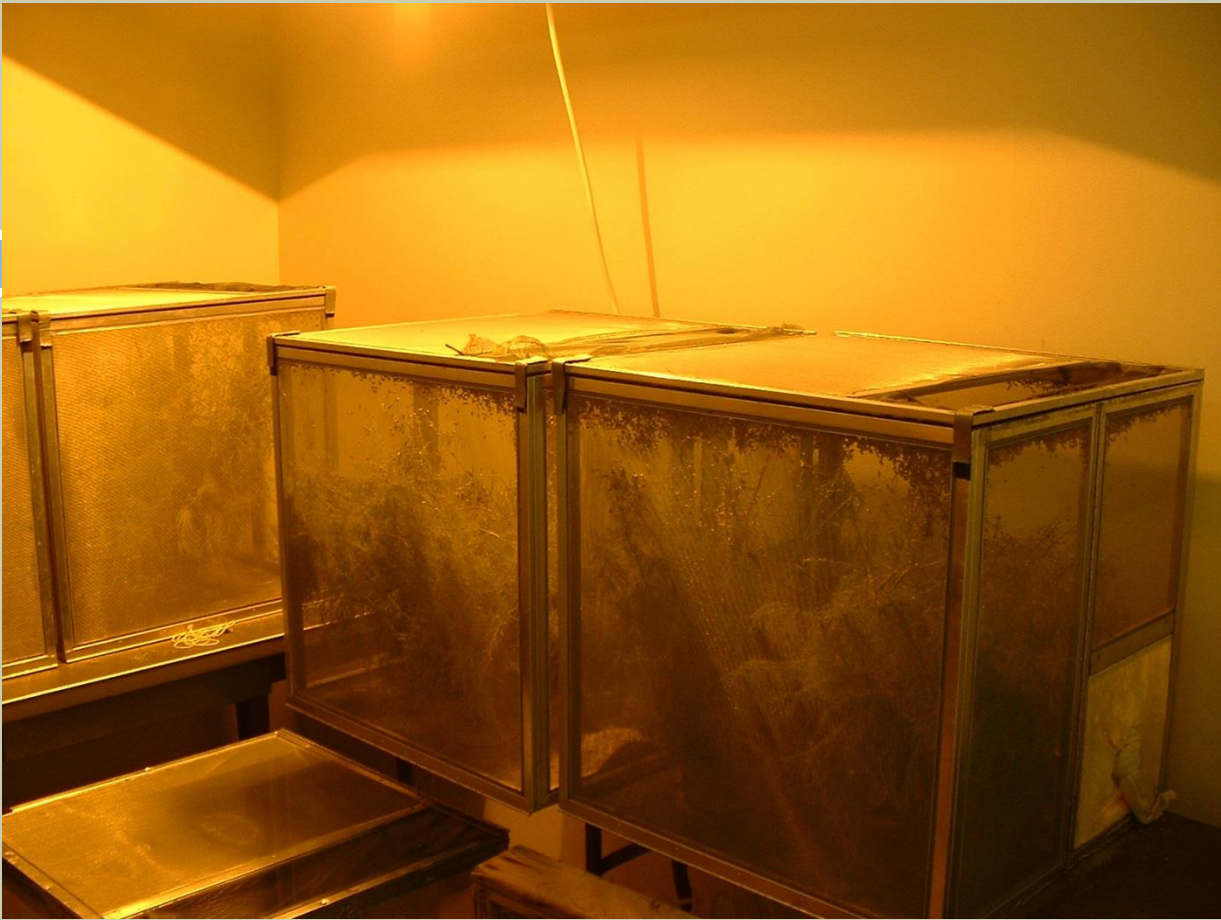
(2005)



Terri Locke, CDA

Collecting beetles near Lovelock, NV, 2005





Cages filled with beetles from Nevada



Trays of *Diorhabda* for distribution





Sparky Taber, BLM

August, 2005, first open field release in western Colorado, BLM site, Horsethief Bench



# Larvae & Adults only eat Tamarisk (10+ years Testing)

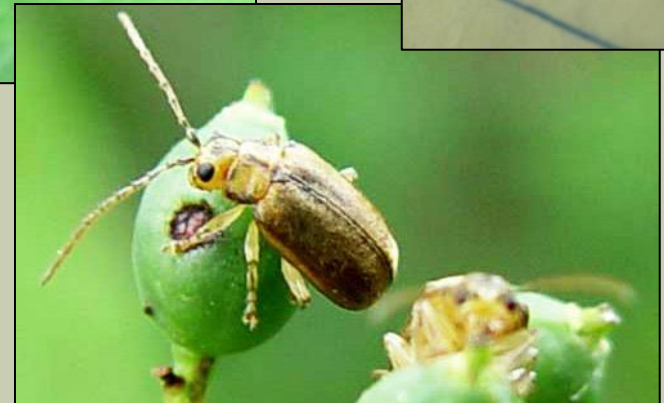


Adults pupate &  
over-winter in litter





# Other Similar leaf beetles



# Tamarisk Beetle - *Diorhabda* spp.



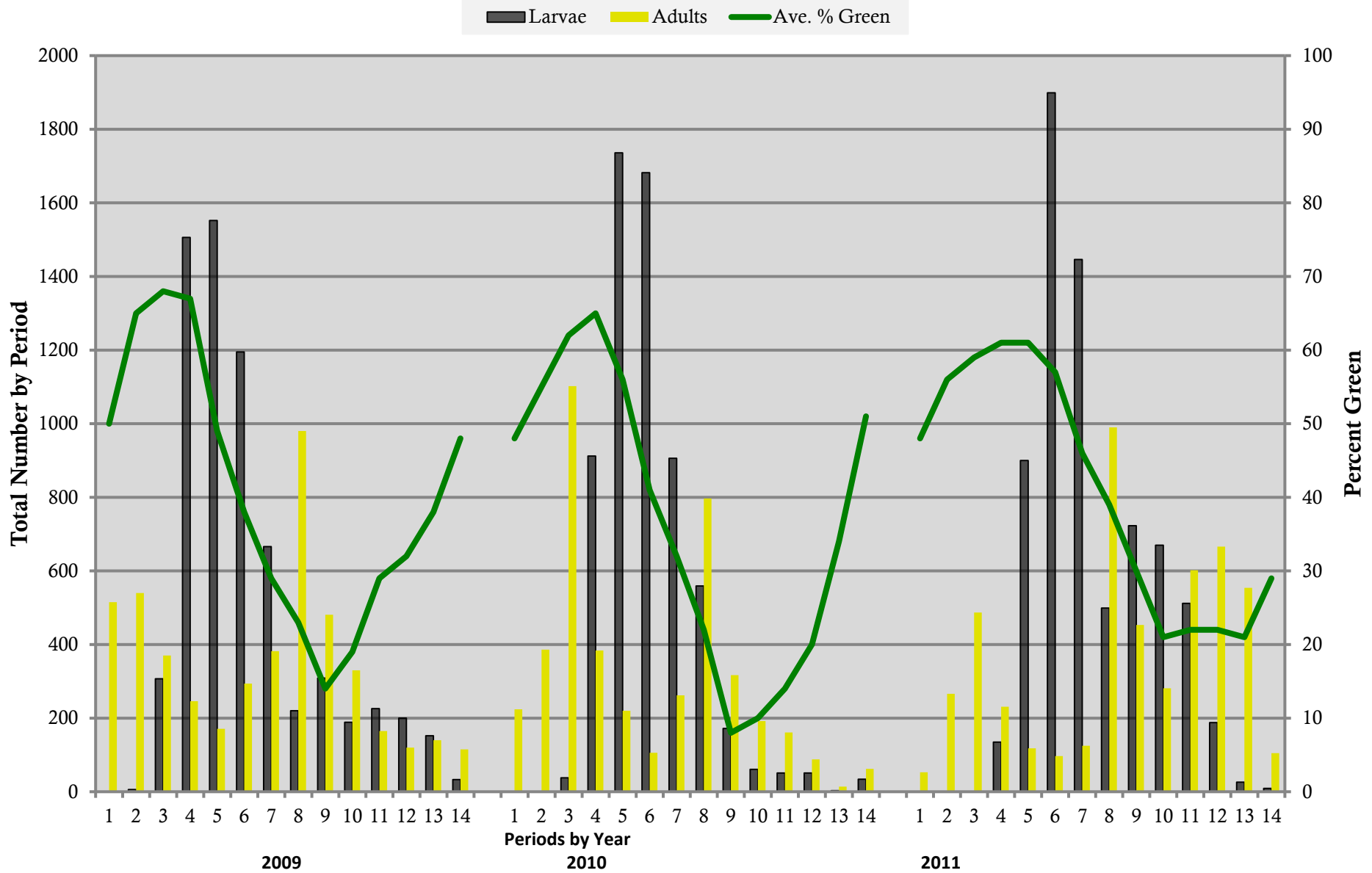


# Beetles and larvae defoliating tamarisk



*Courtesy of Dr. Dan Bean, Palisade Insectary*

# Beetle/Tamarisk Interaction: Green to Brown 2009 - 2011





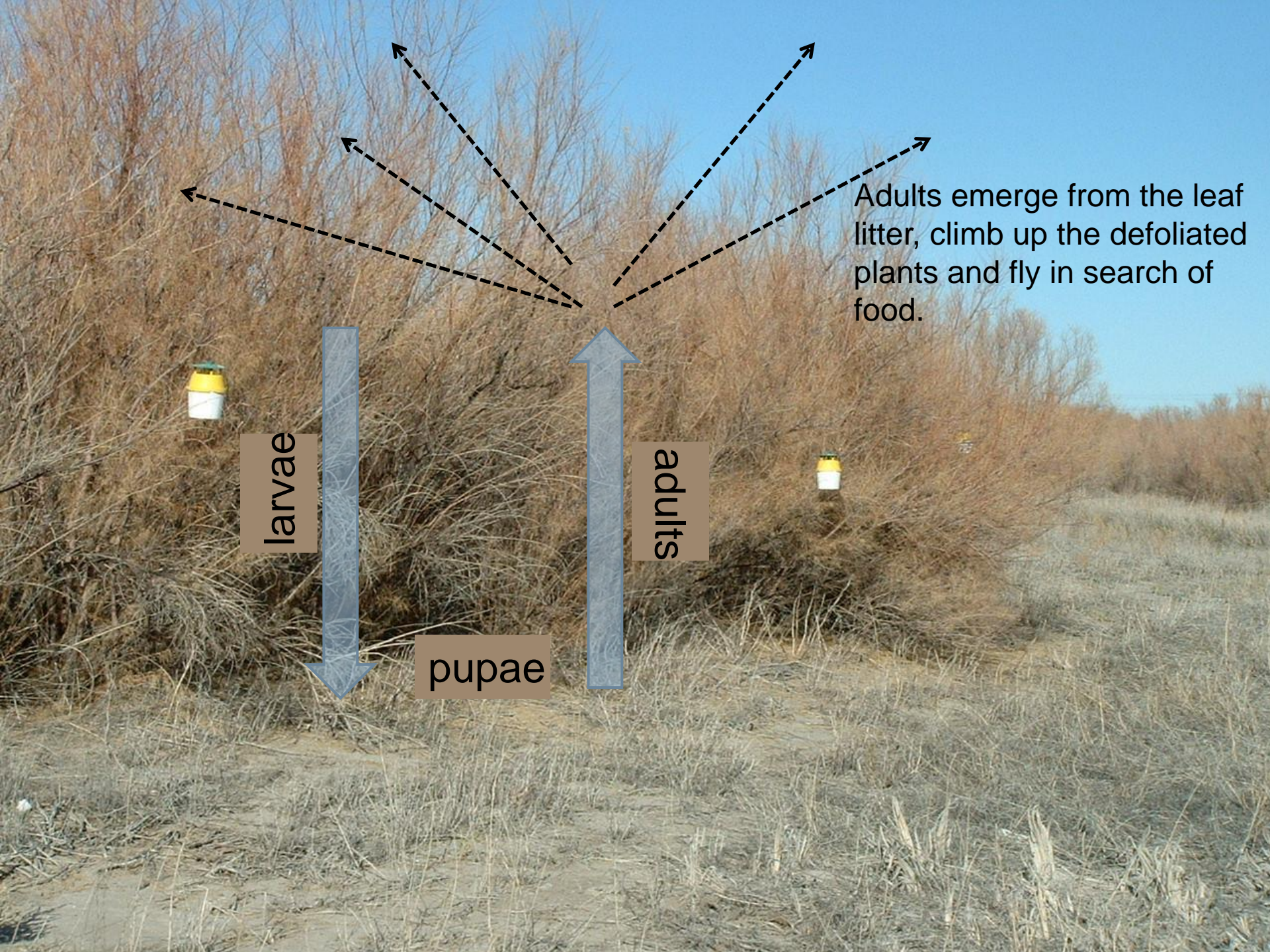
Beetles drop from host plant  
and pupate in the leaf litter

larvae

pupae







larvae

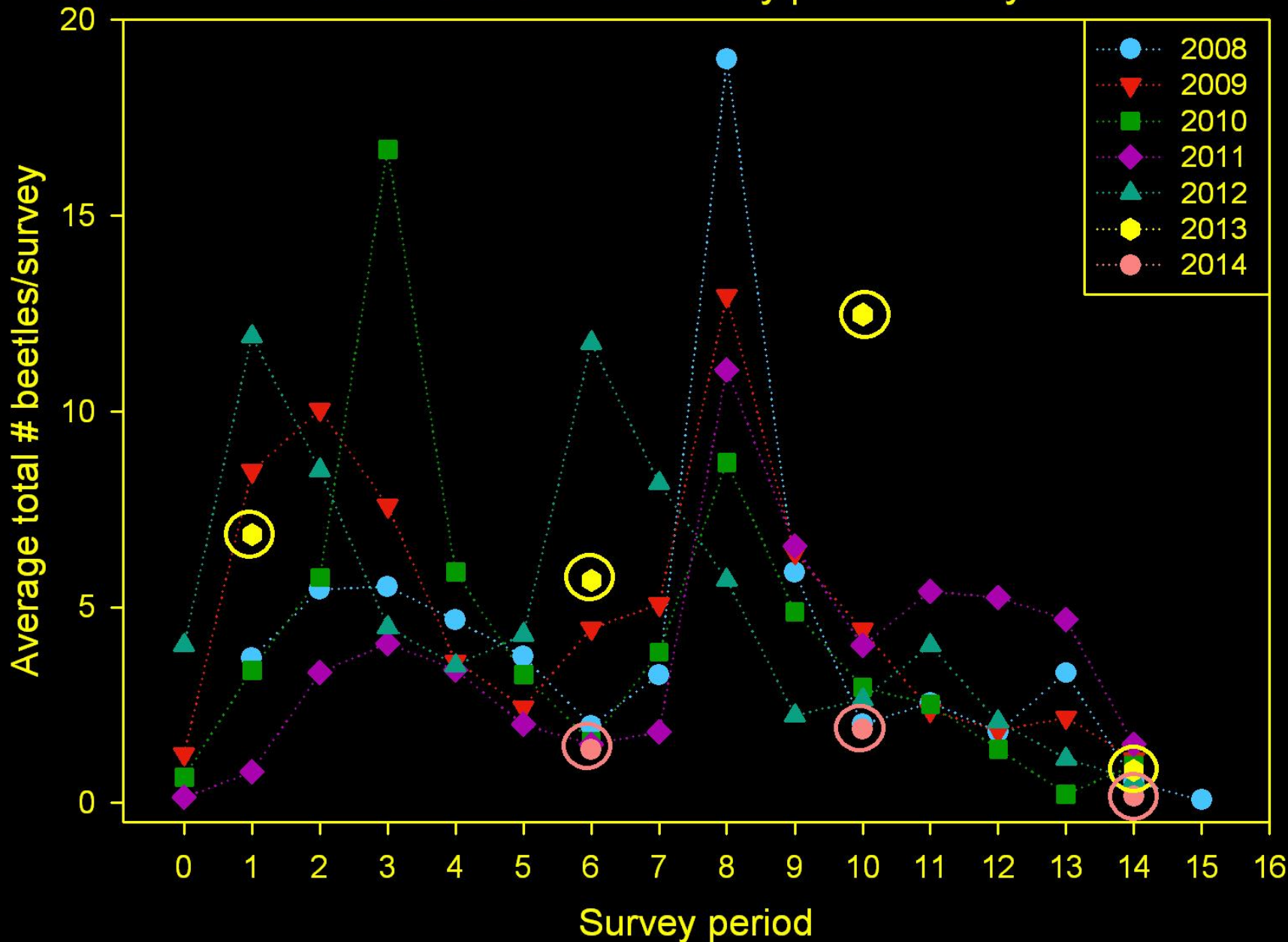
adults

pupae

Adults emerge from the leaf litter, climb up the defoliated plants and fly in search of food.



Average number of adult beetles counted per site across Grand Co. UT each survey period each year





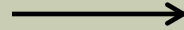




# Beetles will not eradicate *Tamarix*



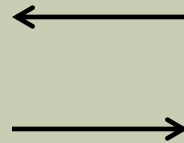
**An ecological relationship is established between the herbivore and the plant**



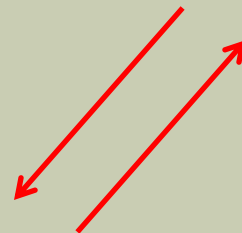
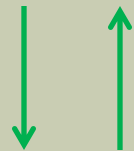


# Beetles will shift ecological relationships

Biology of  
*Tamarix*

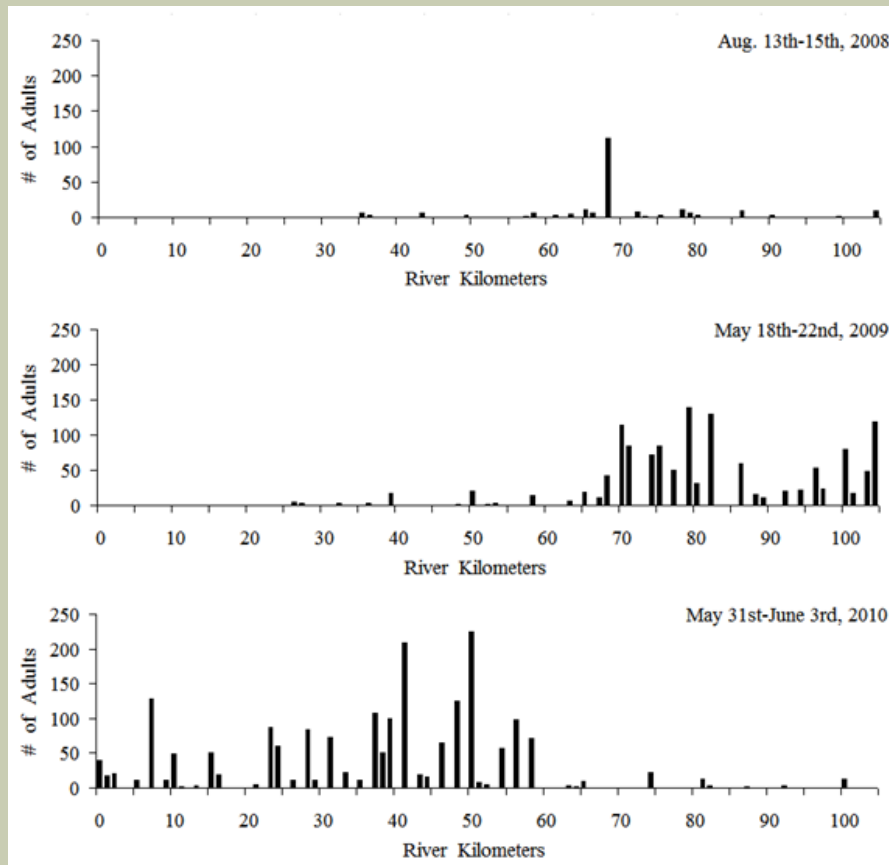


Biology of  
*Diorhabda*



**biotic and abiotic ecosystem components**

# Beetles will defoliate *Tamarix* and the timing and frequency will be variable.



Beetles will move over large distances, periodically defoliating tamarisk stands, as illustrated by their movements on the Dolores River.



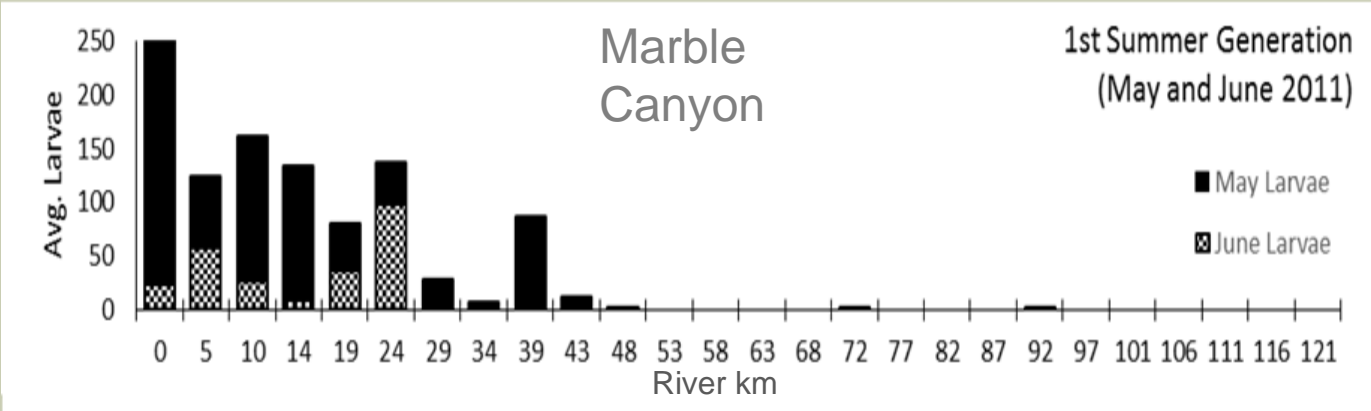
# Tamarisk foliates in spring



# Larvae hatch

# OW/F

1



↑  
Lee's Ferry

↑  
Supai narrows begin

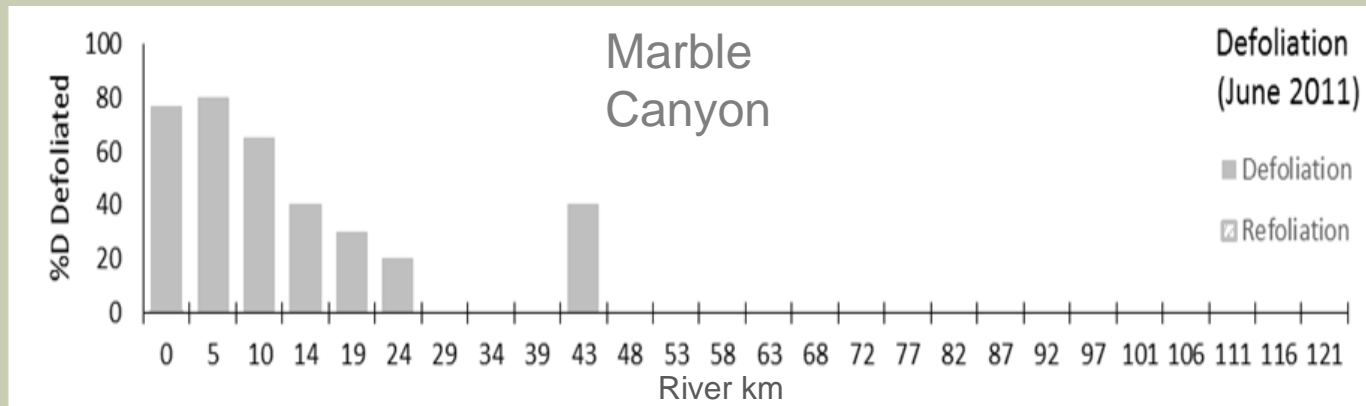
↑  
Redwall narrows begin

↑  
Little Colorado River



# Larval feeding leads to defoliation!!

# F1



↑  
Lee's Ferry

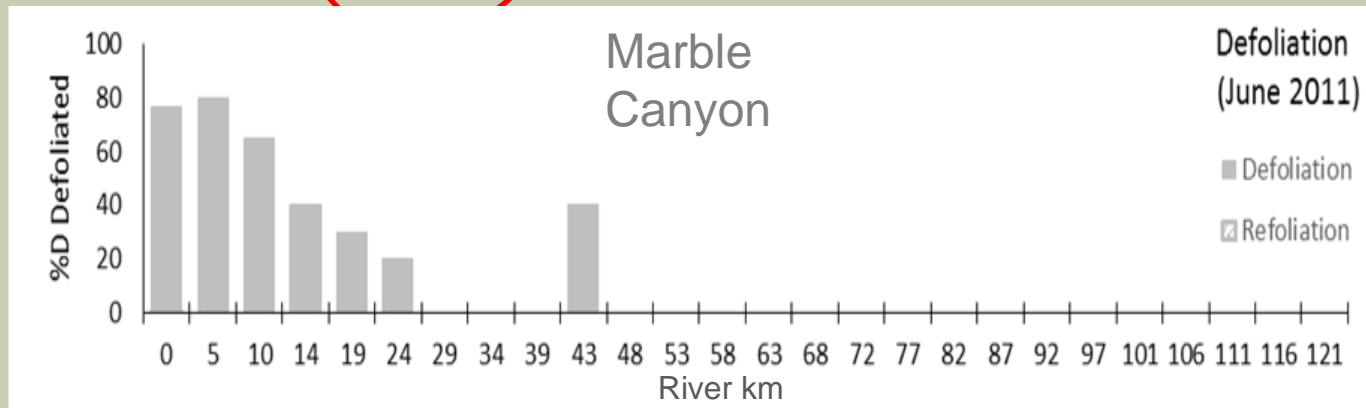
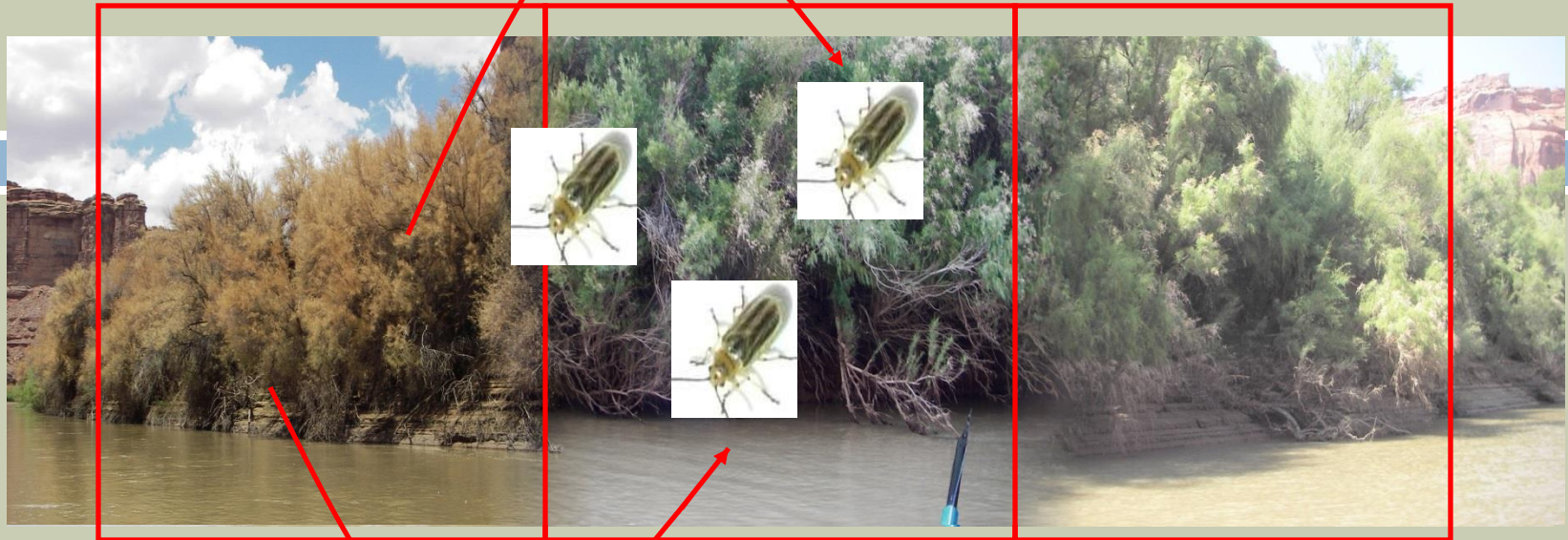
↑  
Supai narrows begin

↑  
Redwall narrows begin

↑  
Little Colorado River

# Larvae pupate and new adults disperse in search of green tamarisk

# F1



↑  
Lee's Ferry

↑  
Supai narrows begin

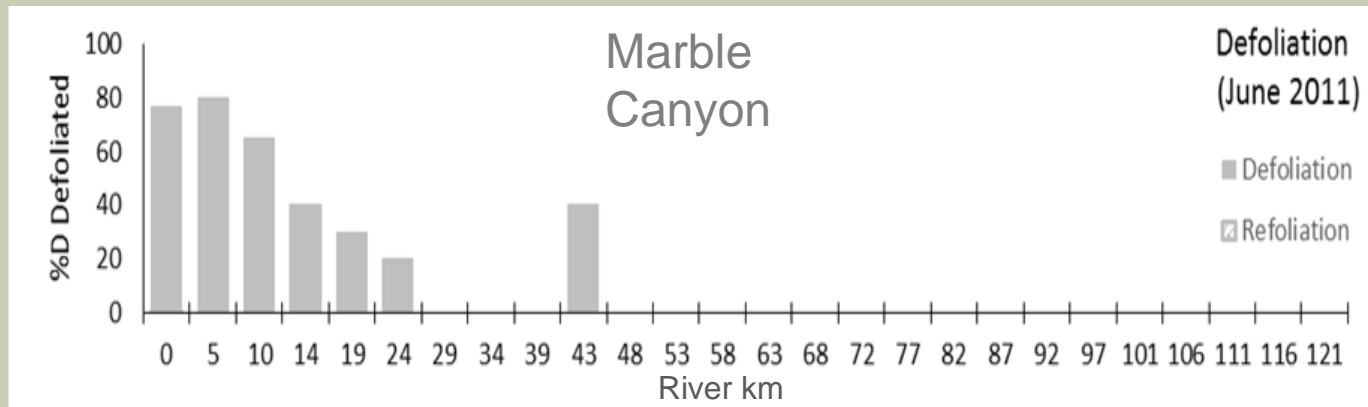
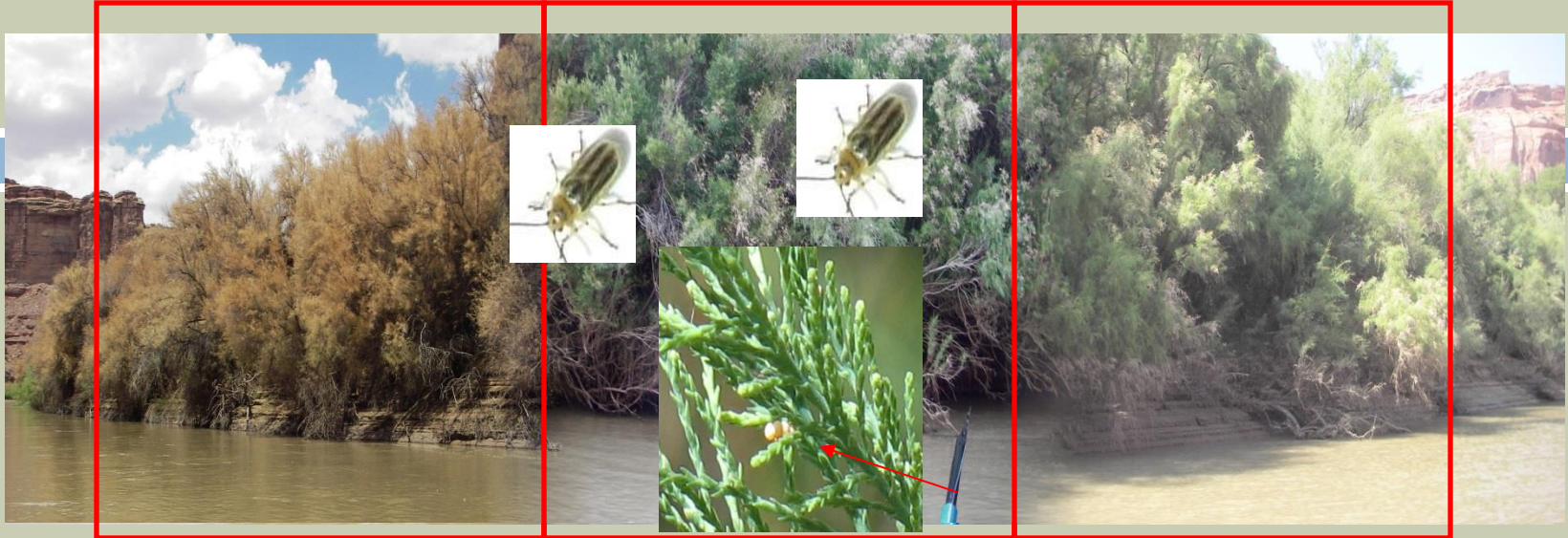
↑  
Redwall narrows begin

↑  
Little Colorado River



New generation established

F1/F2



↑  
Lee's Ferry

↑  
Supai narrows begin

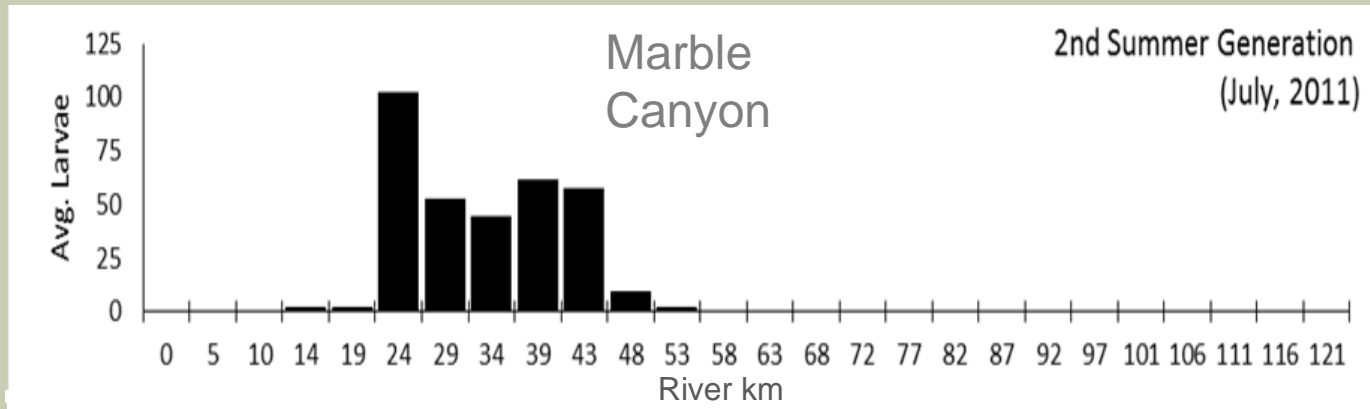
↑  
Redwall narrows begin

↑  
Little Colorado River

# Larvae hatch and begin **F1/F**

to feed

**2**



↑  
Lee's Ferry

↑  
Supai narrows begin

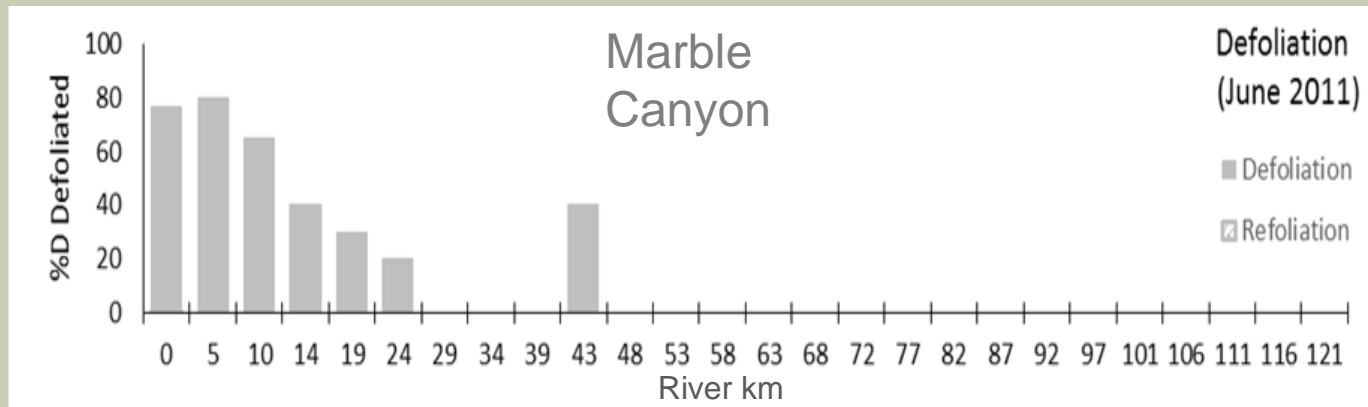
↑  
Redwall narrows begin

↑  
Little Colorado River



# Larval feeding leads to defoliation!!

# F1



↑  
Lee's Ferry

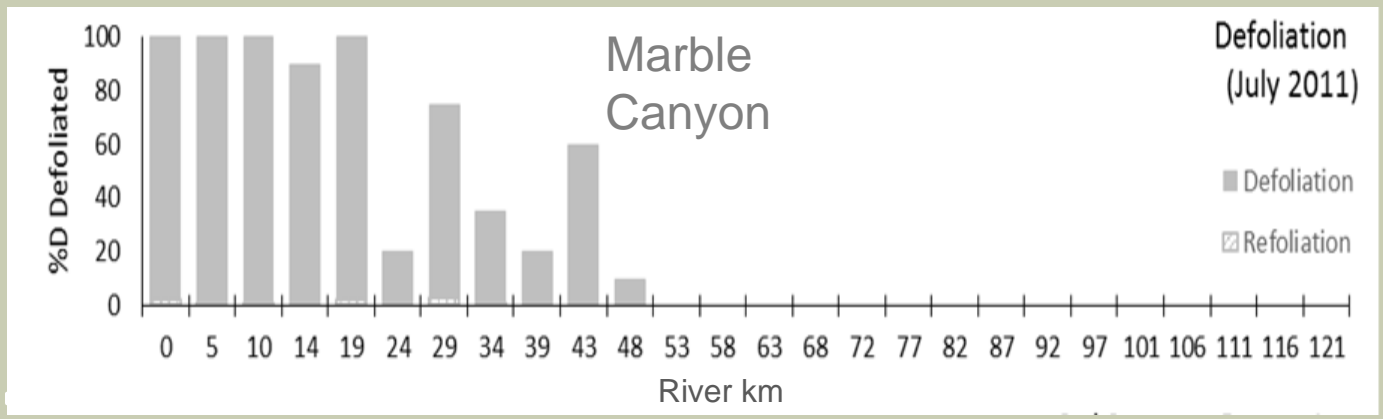
↑  
Supai narrows begin

↑  
Redwall narrows begin

↑  
Little Colorado River

# Larvae defoliate new zone

# F2



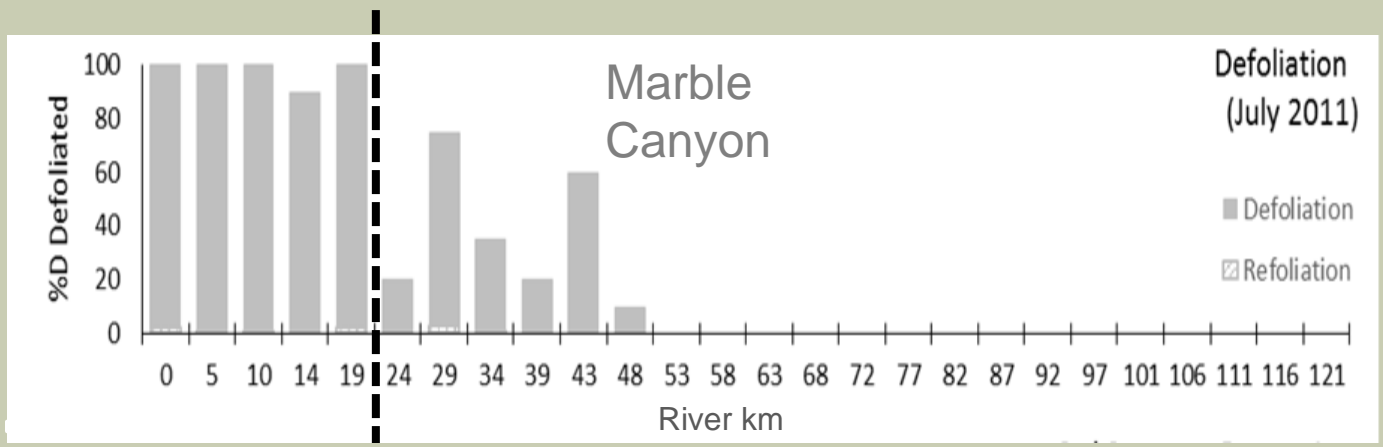
↑ Lee's Ferry  
 ↑ Supai narrows begin  
 ↑ Redwall narrows begin  
 ↑ Little Colorado River



# Larvae defoliate new F

zone

2



↑  
Lee's Ferry

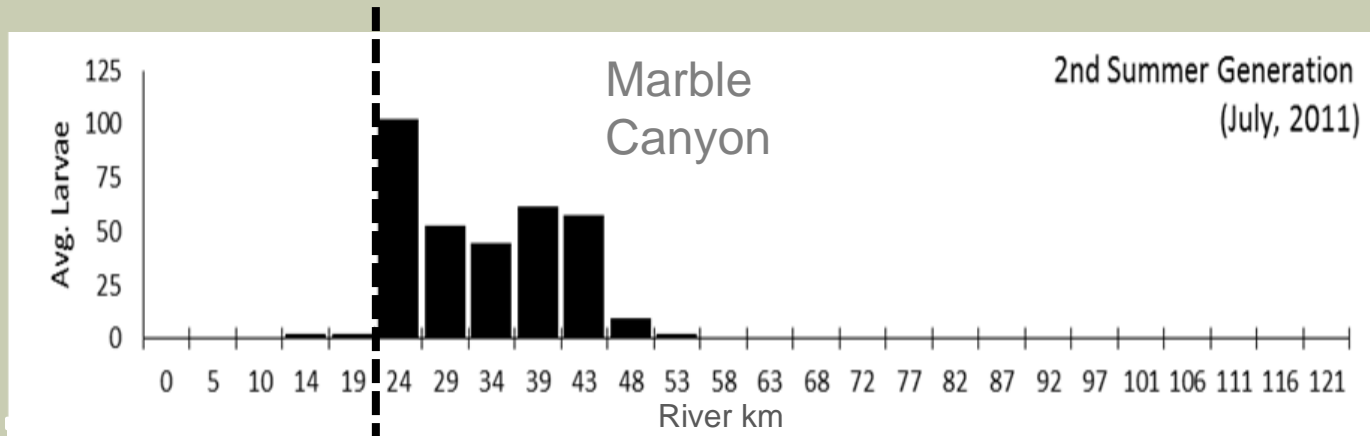
↑  
Supai narrows begin

↑  
Redwall narrows begin

↑  
Little Colorado River

# Larvae hatch and begin **F1/F2**

to feed



↑  
Lee's Ferry

↑  
Supai narrows begin

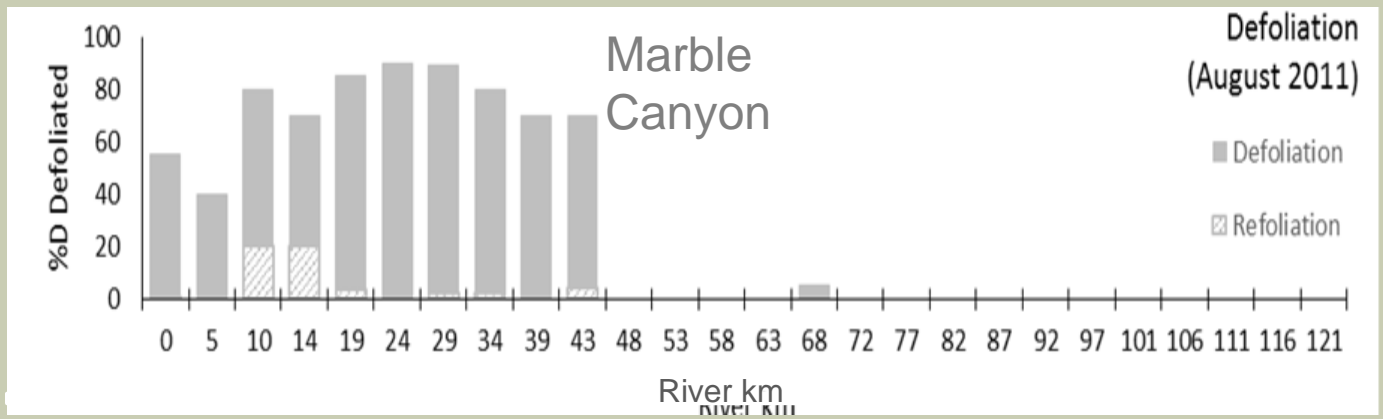
↑  
Redwall narrows begin

↑  
Little Colorado River



# F3

## Defoliation continues, refoliation is new refugia



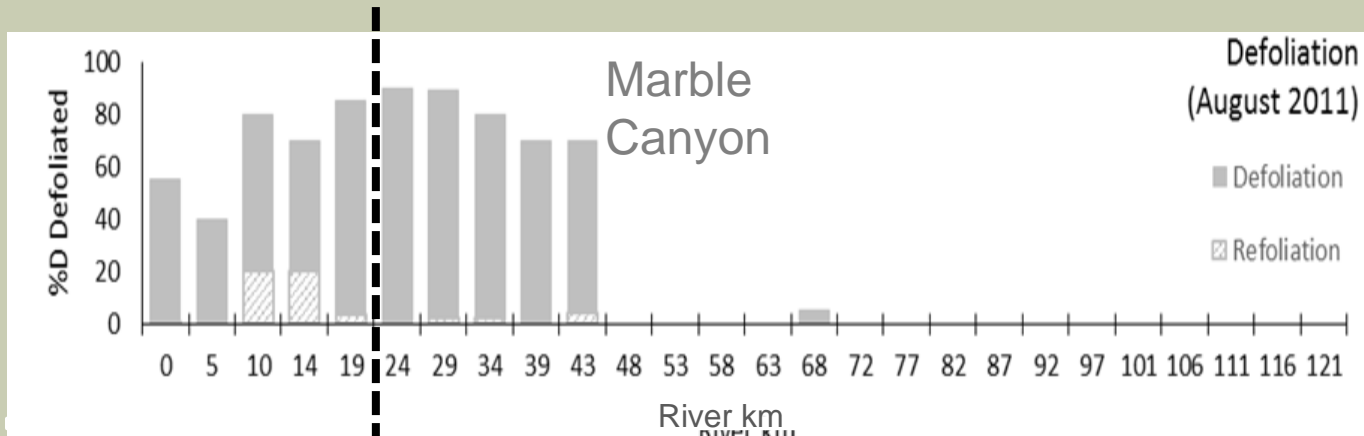
↑  
Lee's Ferry

↑  
Supai narrows begin

↑  
Redwall narrows begin

↑  
Little Colorado River

# F3 Defoliation continues, refoliation is new refugia



Lee's Ferry

Supai narrows begin

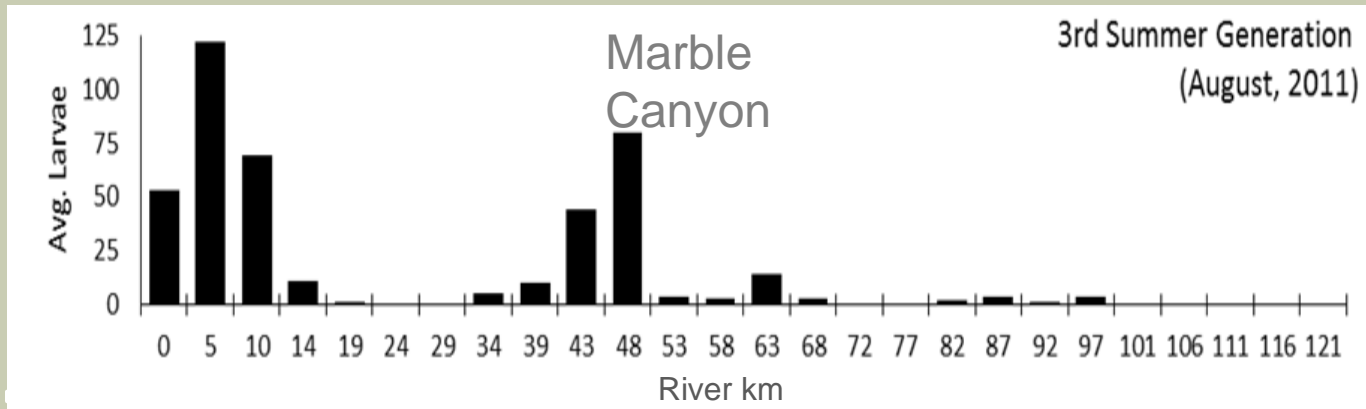
Redwall narrows begin

Little Colorado River



# F3

Next generation of larvae are established

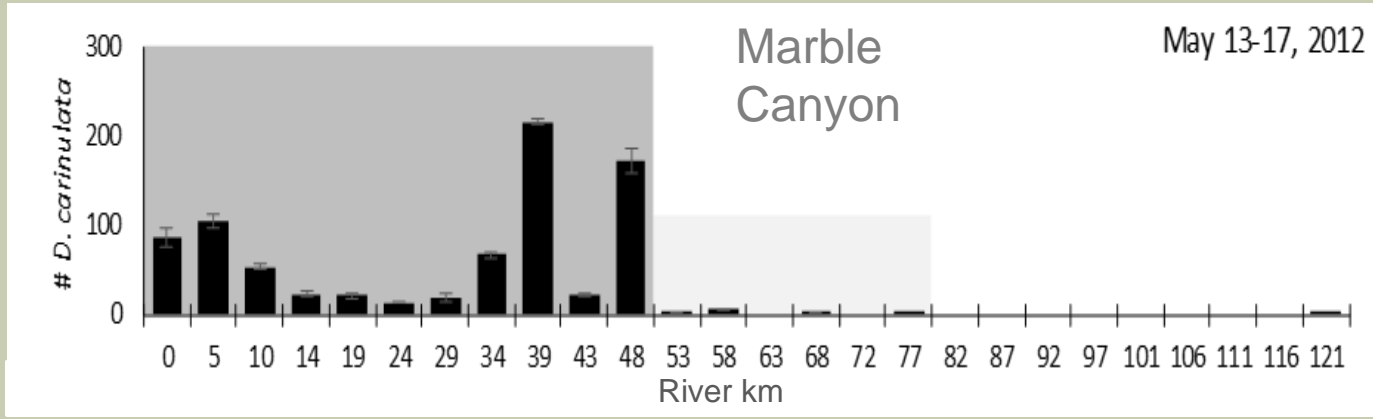
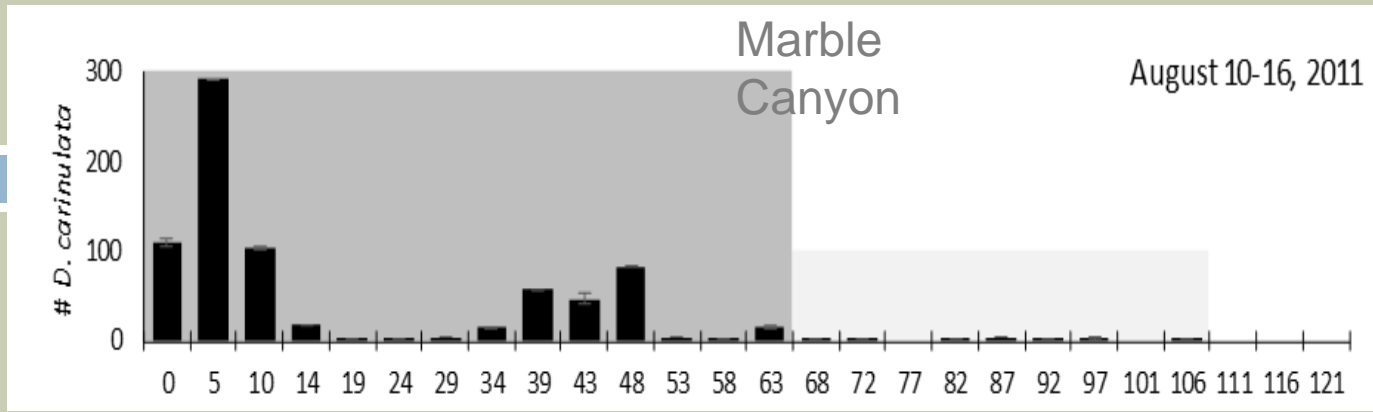


↑  
Lee's Ferry

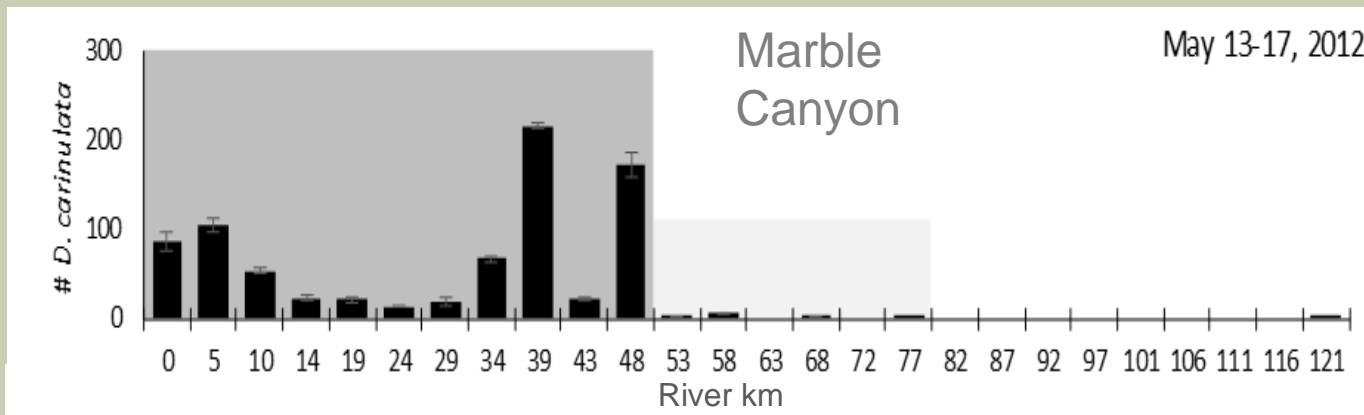
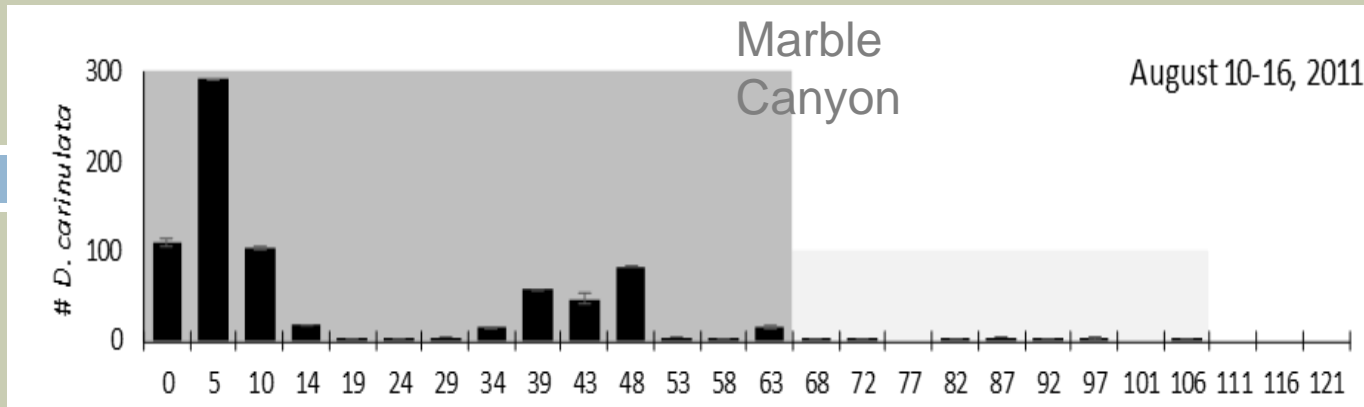
↑  
Supai narrows begin

↑  
Redwall narrows begin

↑  
Little Colorado River







**The distribution of beetles in the fall is predictive of where they'll start the following year.**





# Beetle Browning 2005 at WB Site



Jerry Shue (2005)



# Beetle Browning 2008 at WB Site





2006: 400 ha browned (add black flags)



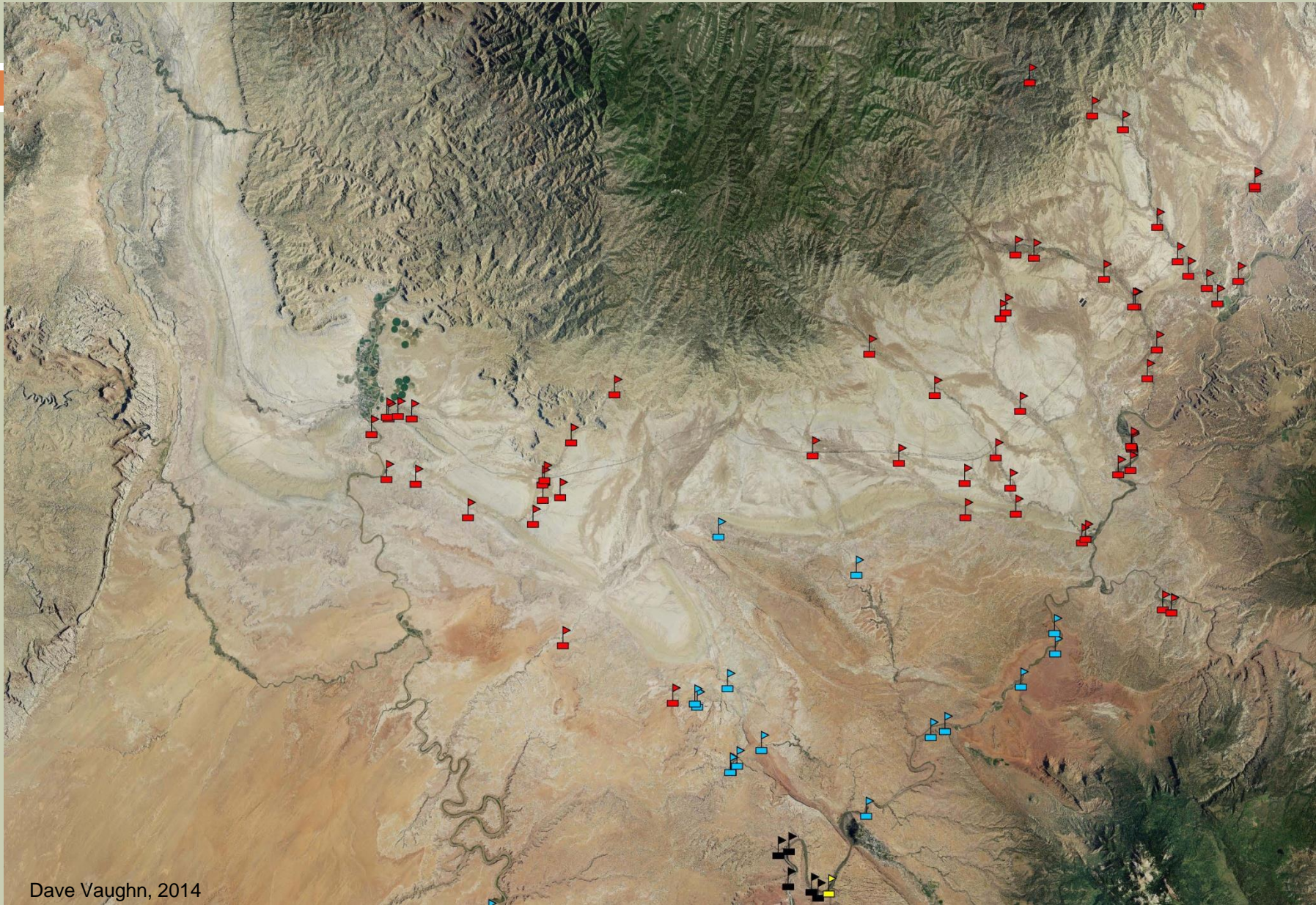


# 2007: 4000 ha browned (add blue flags)



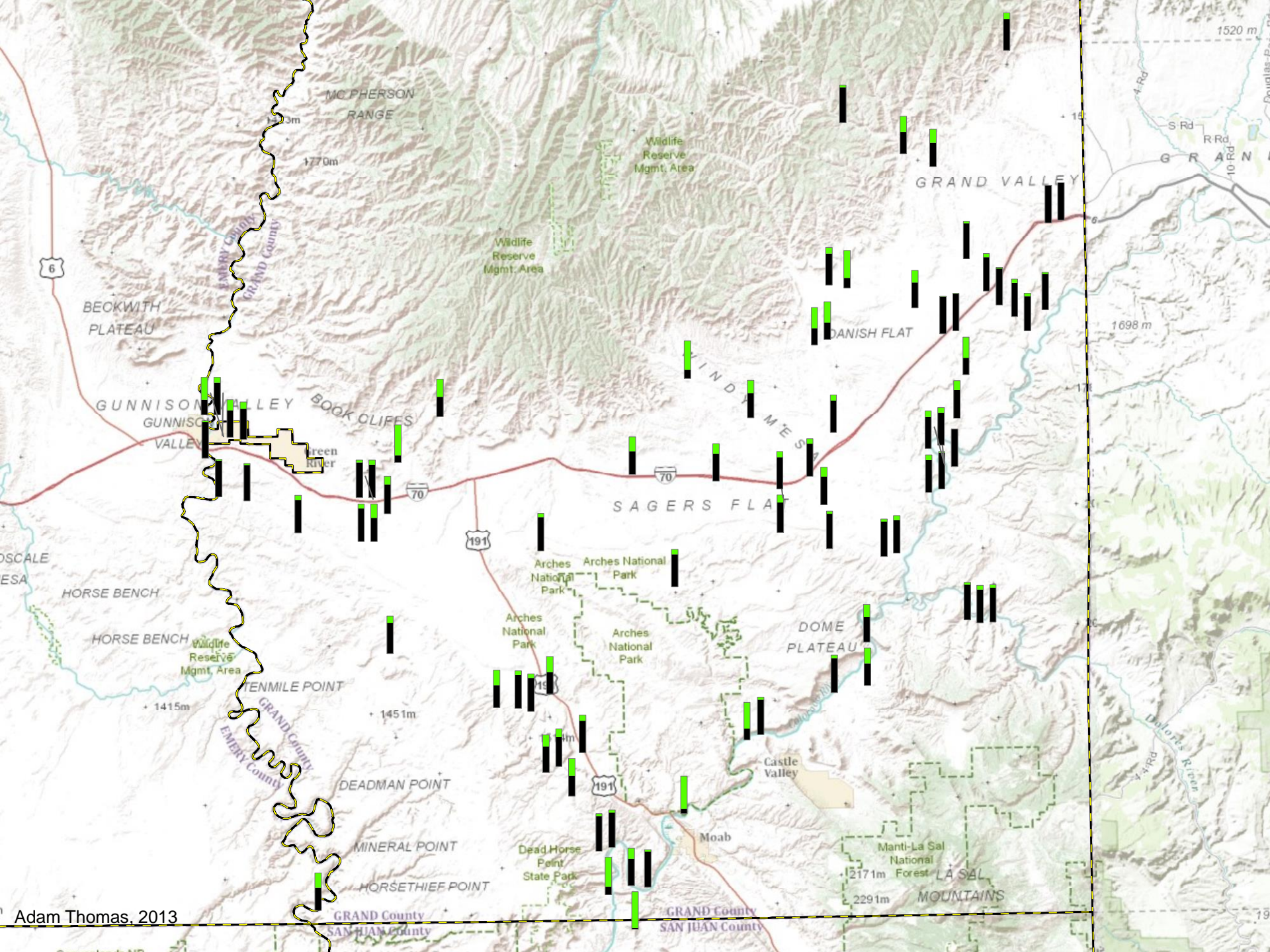


2008 – 2013: > 650,000 ha browned (add red flags)



Dave Vaughn, 2014







2007 pre-beetle



Stan Young ranch along East Salt Creek in Mesa County before and after beetles released.

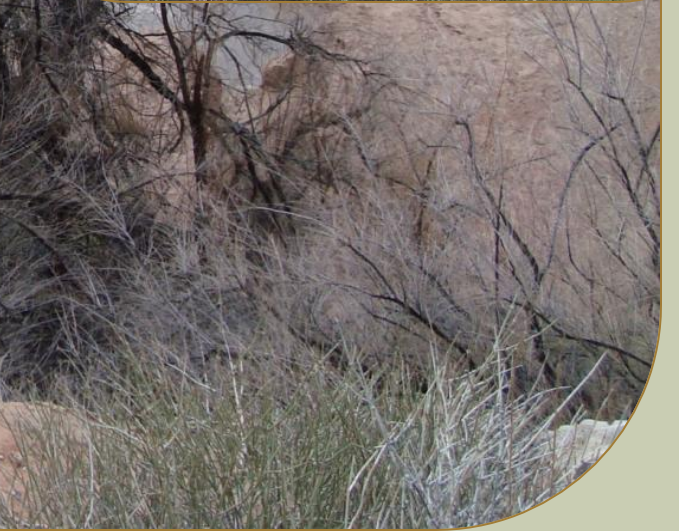
2010 post-beetle



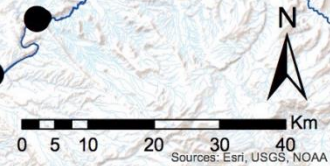
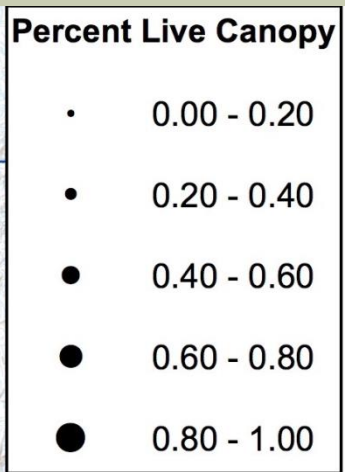
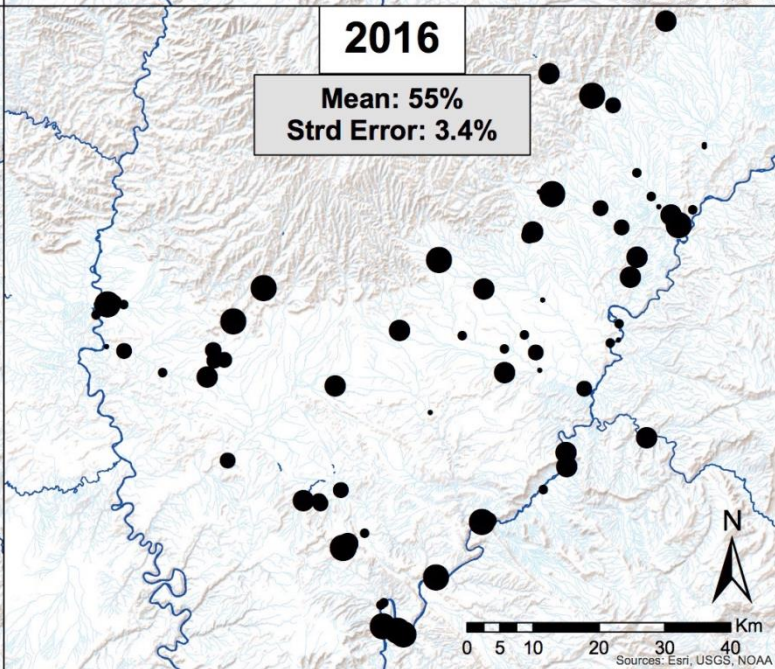
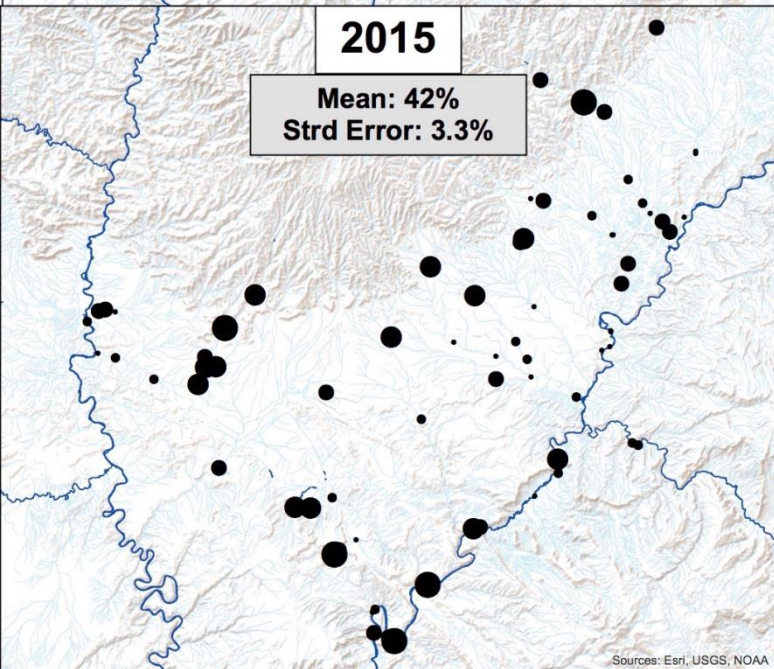
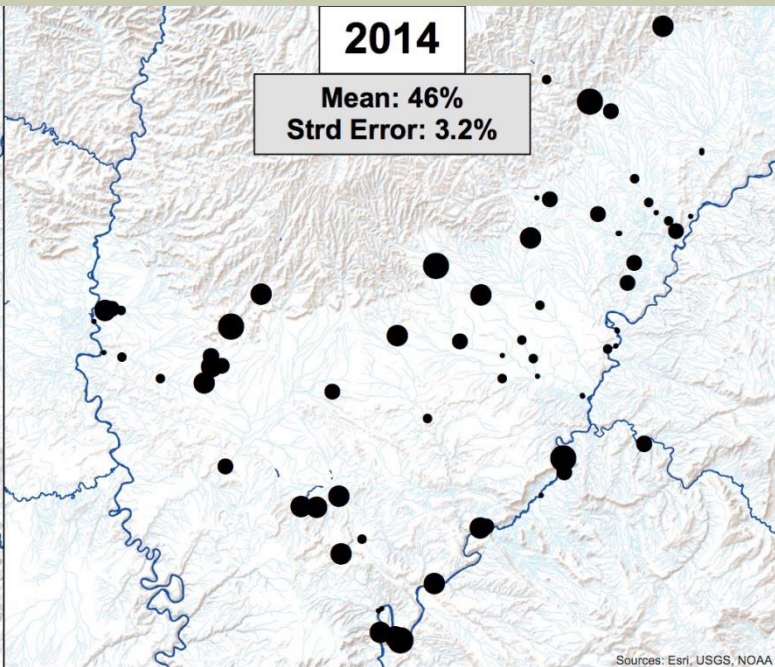
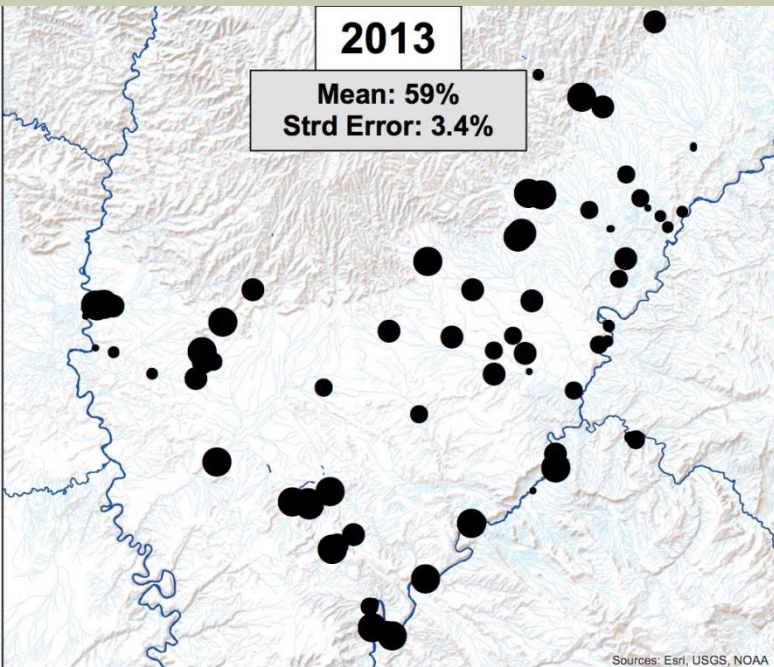


Colorado  
River near  
Moab, Utah



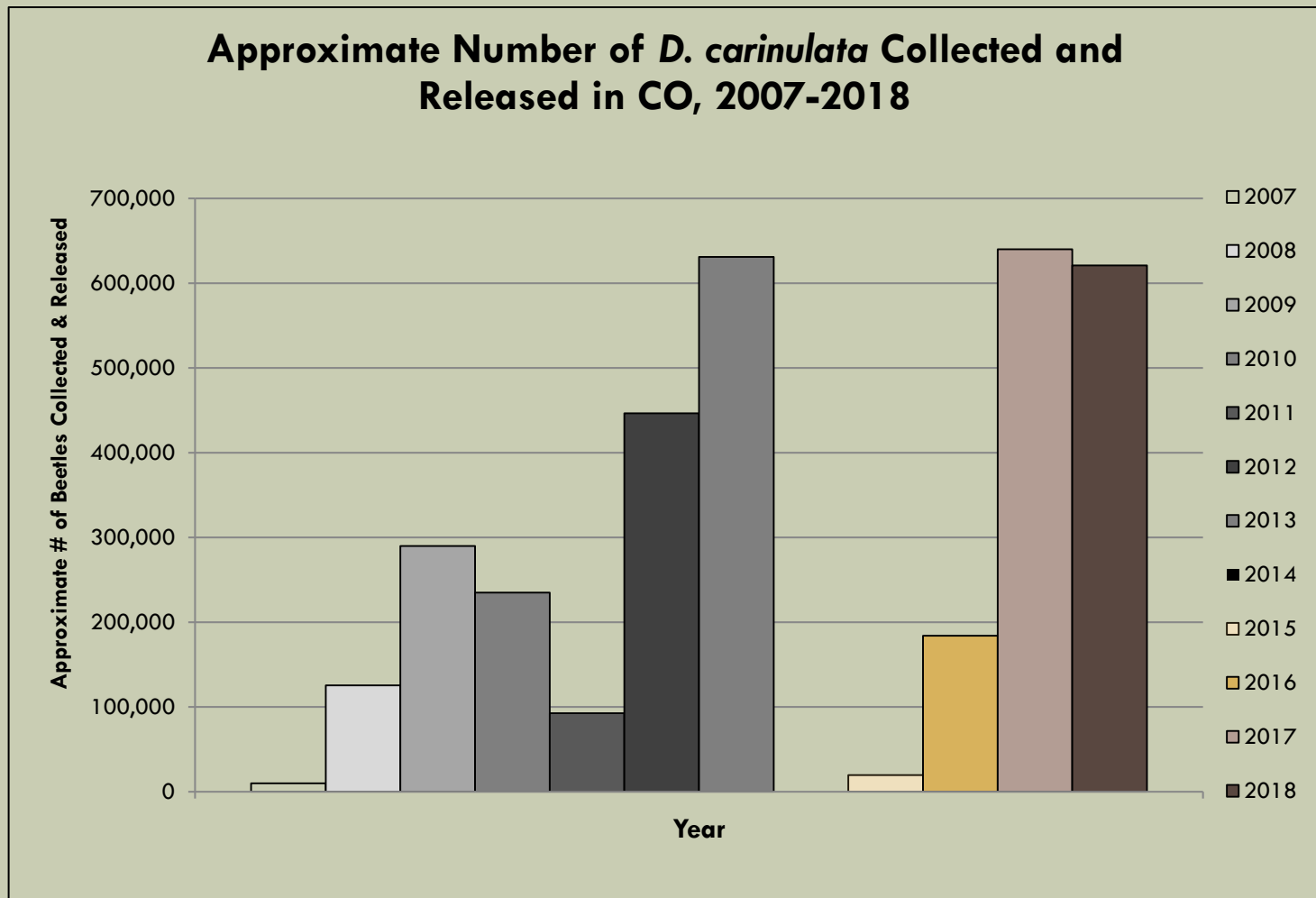


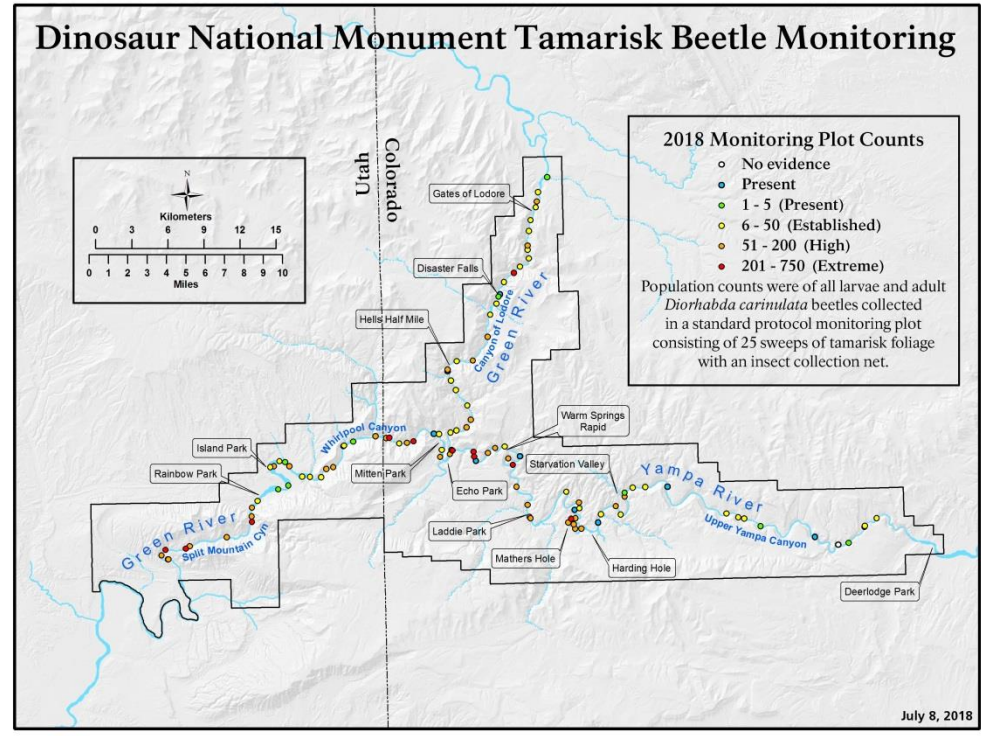
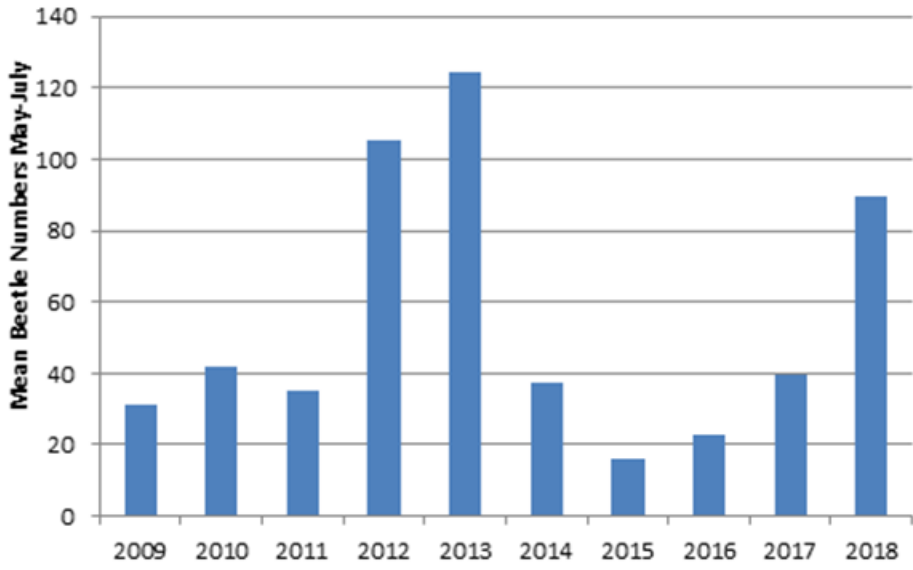






Steady rise in populations across western CO with widespread defoliation across sites in 2017 and 2018.







# Origins of the Biological Control Monitoring Program

- ❖ Colorado Department of Agriculture Palisade Insectary wanted to expand monitoring outside of CO
- ❖ 2007 TC worked with CDAPI and UC Santa Barbara to develop landscape scale monitoring program
- ❖ Focused on the Colorado River Basin



# Monitoring the beetles



Date	GPS Point ID	UTM Coordinates	River m/km	Sweep	Sweep	Sweep	Sweep	Sweep	Eggs	Contactus Spp	Defoliation	Re-foliation	Photo	Comments
				1	2	3	4	5						
		Lat:		Adults						<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ID:	
		Long:		Early Larvae									Direction	
				Late Larvae										



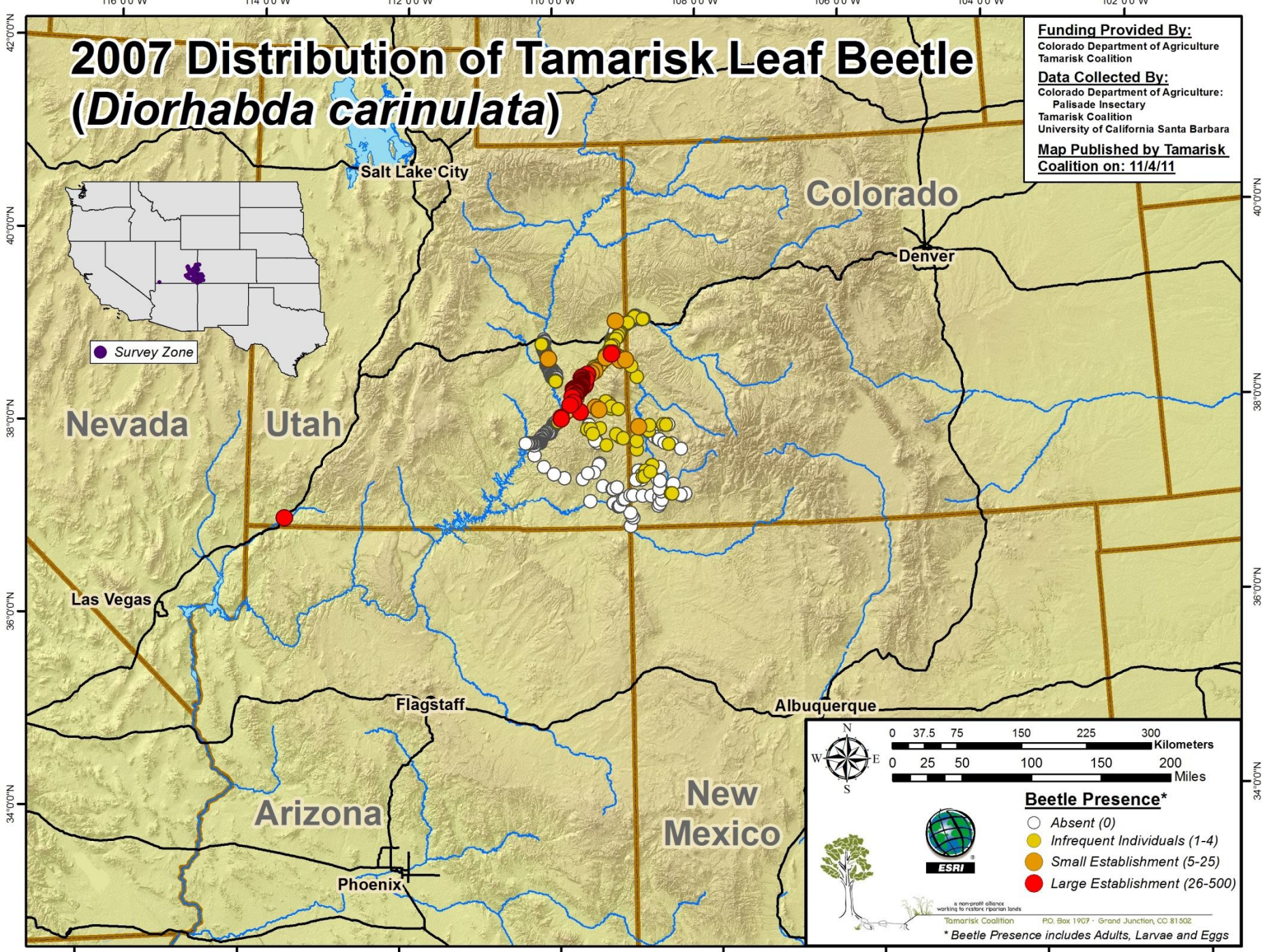


# 2007 Distribution of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

**Funding Provided By:**  
Colorado Department of Agriculture  
Tamarisk Coalition

**Data Collected By:**  
Colorado Department of Agriculture:  
Palisade Insectary  
Tamarisk Coalition  
University of California Santa Barbara

**Map Published by Tamarisk Coalition on: 11/4/11**



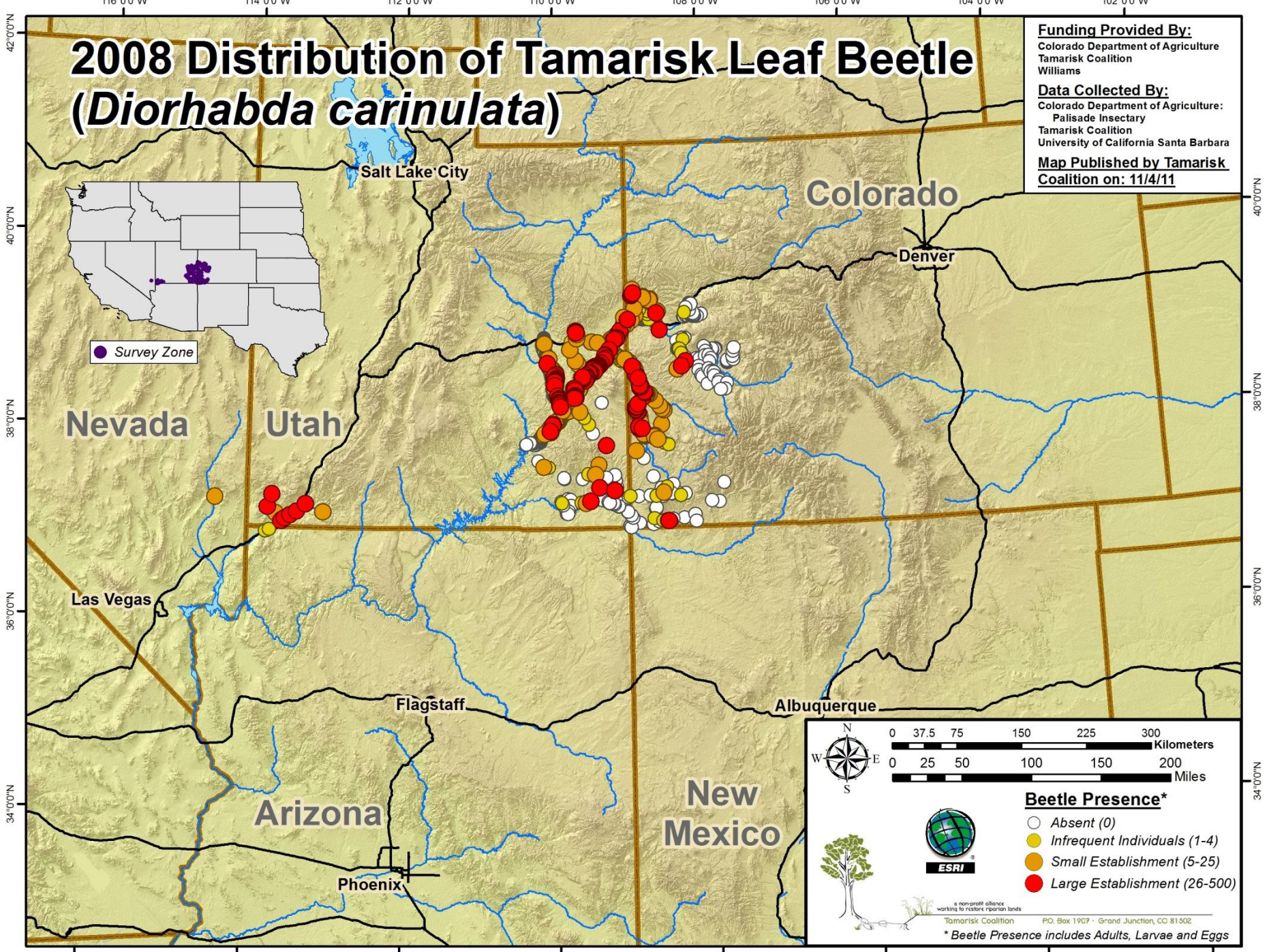


# 2008 Distribution of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

**Funding Provided By:**  
Colorado Department of Agriculture  
Tamarisk Coalition  
Williams

**Data Collected By:**  
Colorado Department of Agriculture:  
Palisade Insectary  
Tamarisk Coalition  
University of California Santa Barbara

**Map Published by Tamarisk Coalition on: 11/4/11**





# 2009 Distribution of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

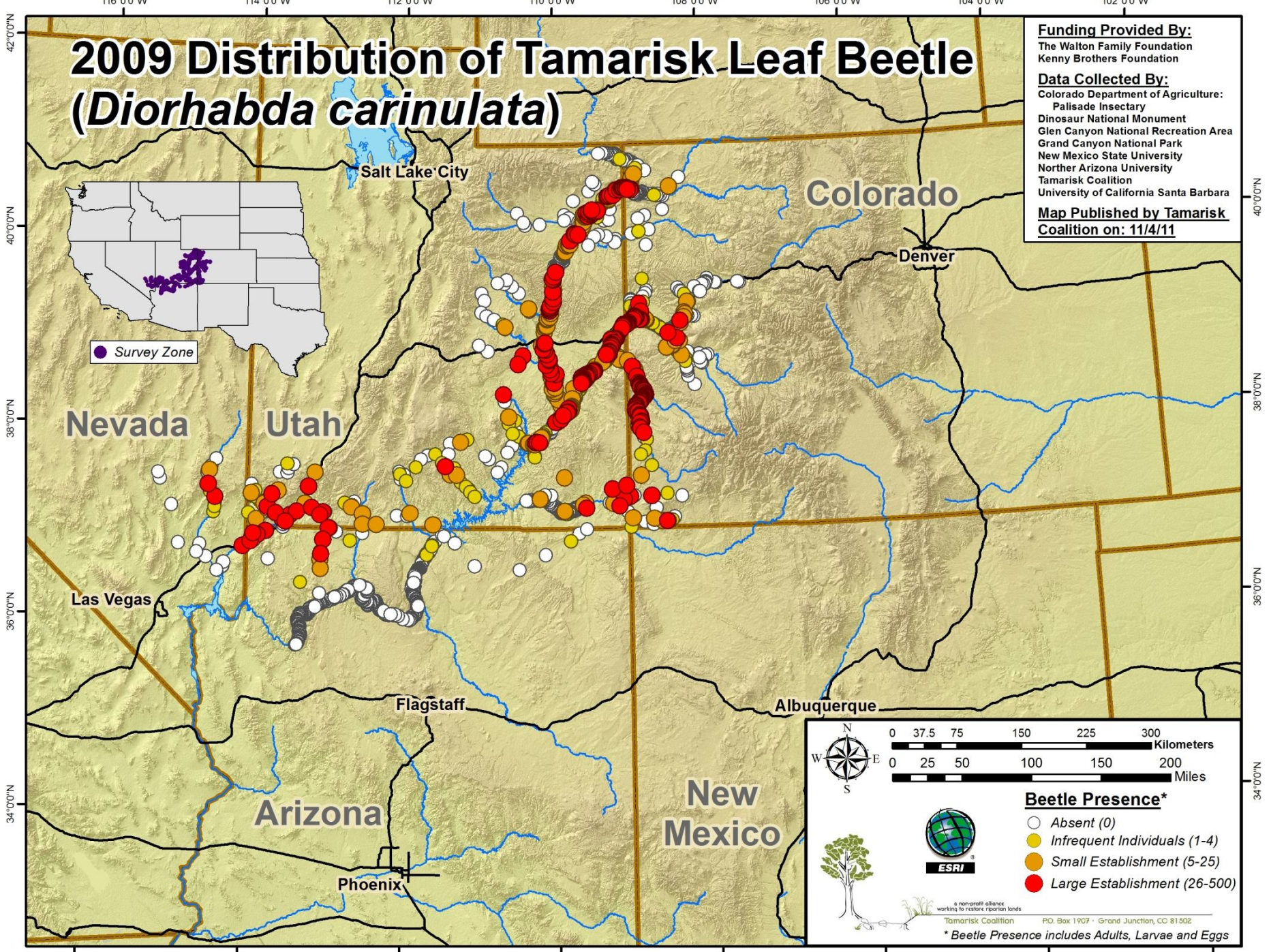
**Funding Provided By:**

The Walton Family Foundation  
Kenny Brothers Foundation

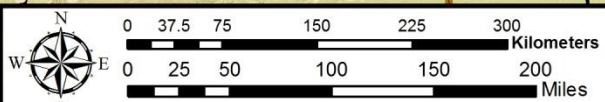
**Data Collected By:**

Colorado Department of Agriculture:  
Palisade Insectary  
Dinosaur National Monument  
Glen Canyon National Recreation Area  
Grand Canyon National Park  
New Mexico State University  
Northern Arizona University  
Tamarisk Coalition  
University of California Santa Barbara

**Map Published by Tamarisk Coalition on: 11/4/11**



Survey Zone



**Beetle Presence\***

- Absent (0)
- Infrequent Individuals (1-4)
- Small Establishment (5-25)
- Large Establishment (26-500)



© nonprofit alliance working to restore riparian lands  
Tamarisk Coalition P.O. Box 1907 • Grand Junction, CO 81502  
**\* Beetle Presence includes Adults, Larvae and Eggs**

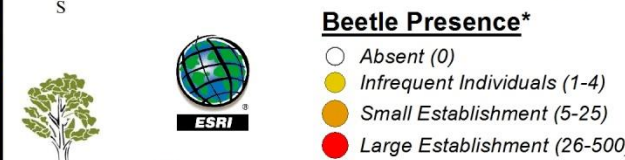
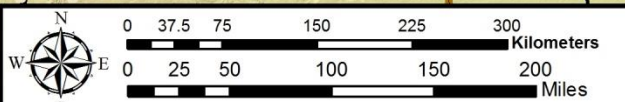
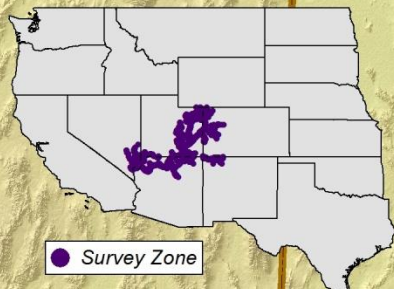
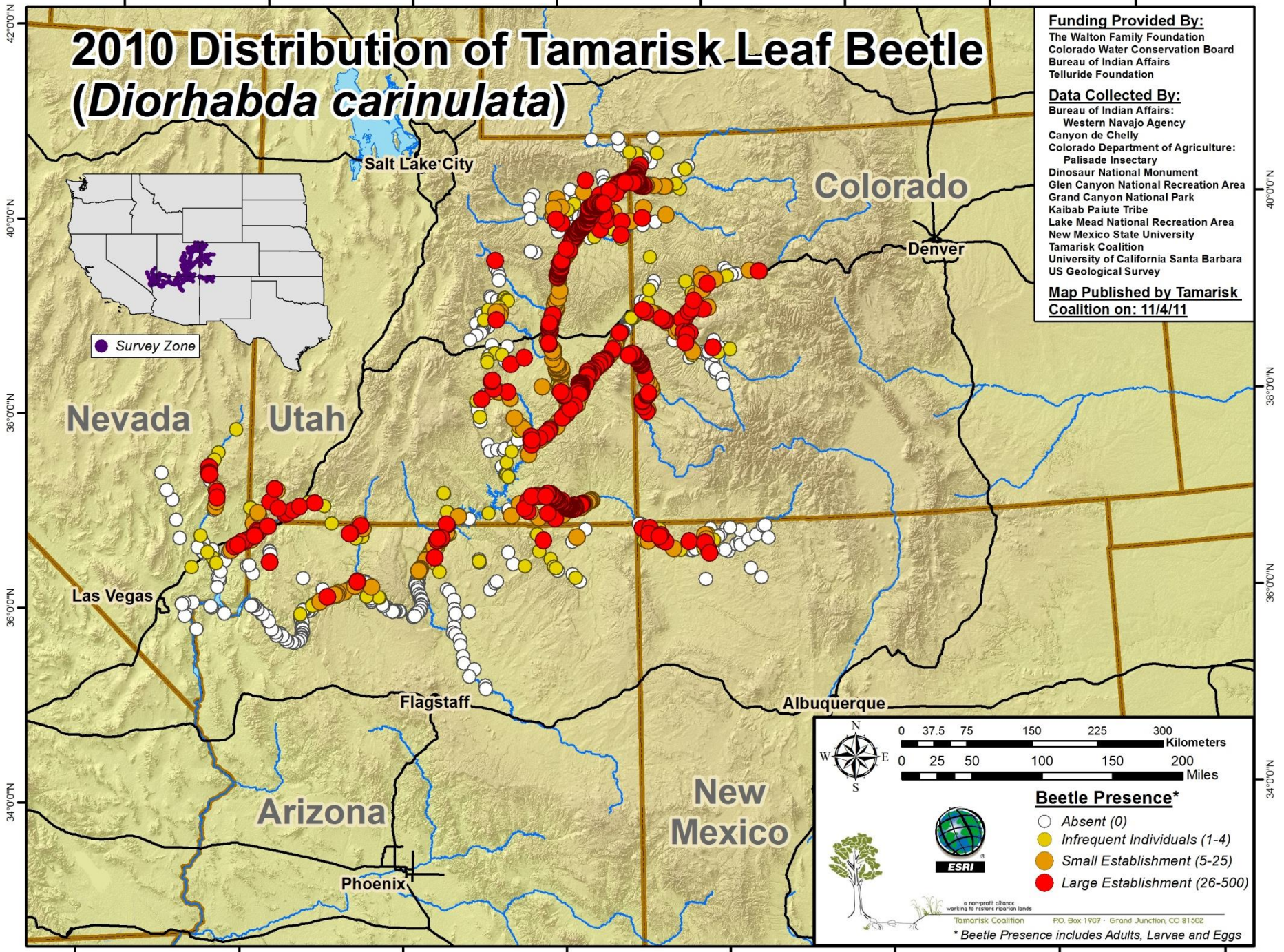


# 2010 Distribution of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

**Funding Provided By:**  
 The Walton Family Foundation  
 Colorado Water Conservation Board  
 Bureau of Indian Affairs  
 Telluride Foundation

**Data Collected By:**  
 Bureau of Indian Affairs:  
 Western Navajo Agency  
 Canyon de Chelly  
 Colorado Department of Agriculture:  
 Palisade Insectary  
 Dinosaur National Monument  
 Glen Canyon National Recreation Area  
 Grand Canyon National Park  
 Kaibab Paiute Tribe  
 Lake Mead National Recreation Area  
 New Mexico State University  
 Tamarisk Coalition  
 University of California Santa Barbara  
 US Geological Survey

**Map Published by Tamarisk Coalition on: 11/4/11**



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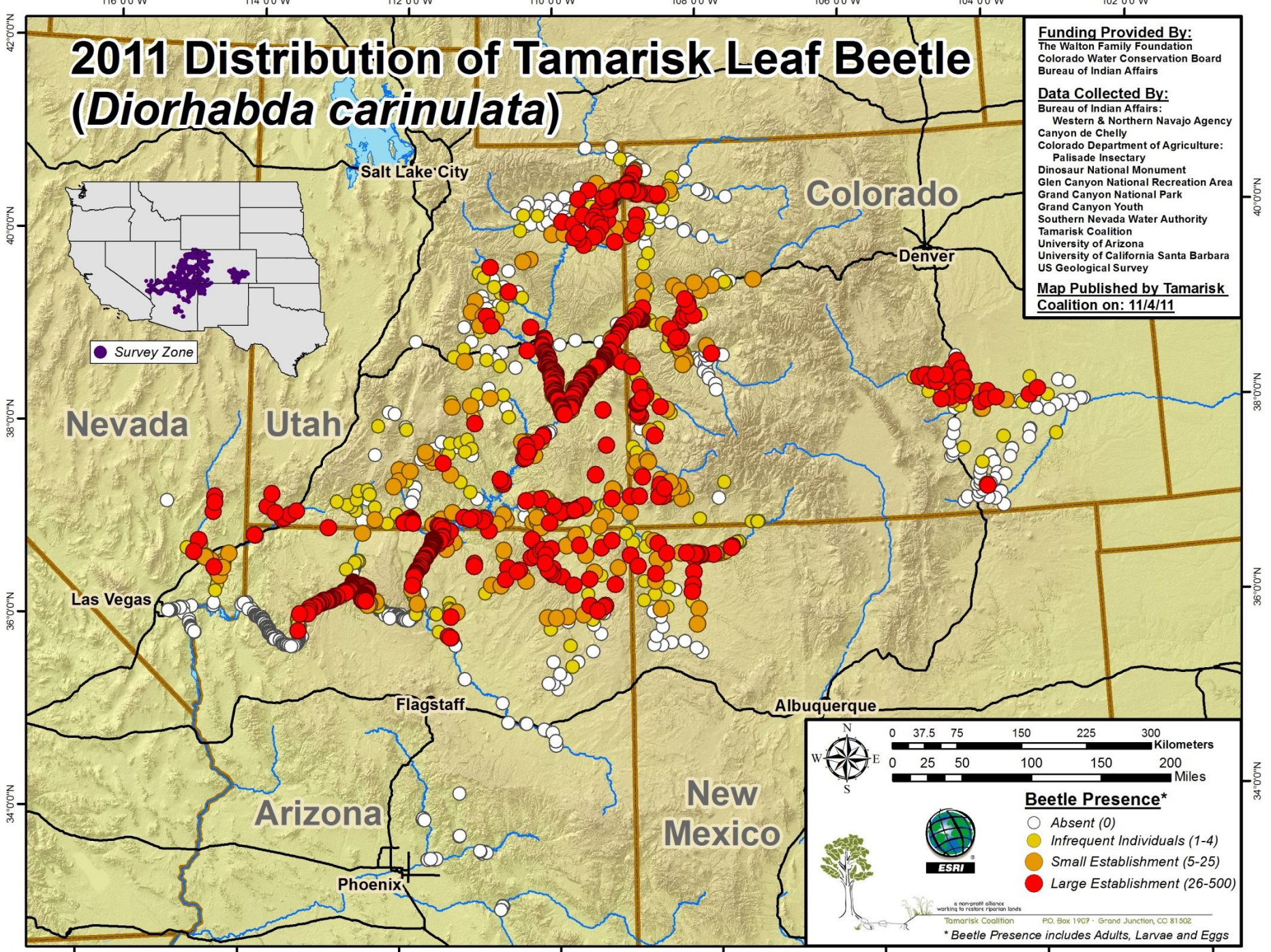


# 2011 Distribution of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

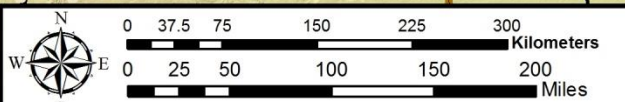
**Funding Provided By:**  
 The Walton Family Foundation  
 Colorado Water Conservation Board  
 Bureau of Indian Affairs

**Data Collected By:**  
 Bureau of Indian Affairs:  
 Western & Northern Navajo Agency  
 Canyon de Chelly  
 Colorado Department of Agriculture:  
 Palisade Insectary  
 Dinosaur National Monument  
 Glen Canyon National Recreation Area  
 Grand Canyon National Park  
 Grand Canyon Youth  
 Southern Nevada Water Authority  
 Tamarisk Coalition  
 University of Arizona  
 University of California Santa Barbara  
 US Geological Survey

**Map Published by Tamarisk Coalition on: 11/4/11**



Survey Zone



- Beetle Presence\***
- Absent (0)
  - Infrequent Individuals (1-4)
  - Small Establishment (5-25)
  - Large Establishment (26-500)



a nonprofit alliance working to restore riparian lands  
 Tamarisk Coalition P.O. Box 1907 • Grand Junction, CO 81502  
 \* Beetle Presence includes Adults, Larvae and Eggs

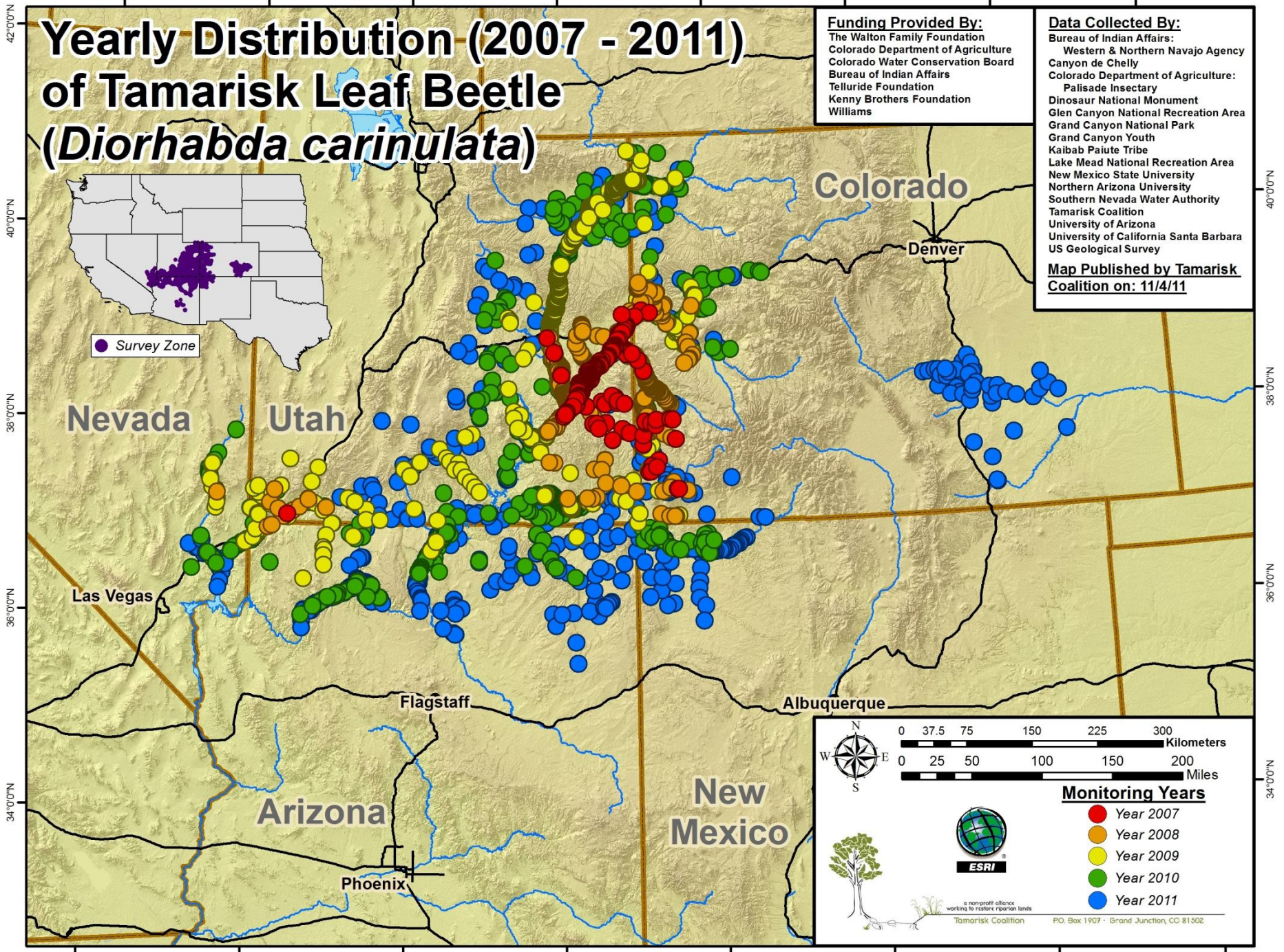
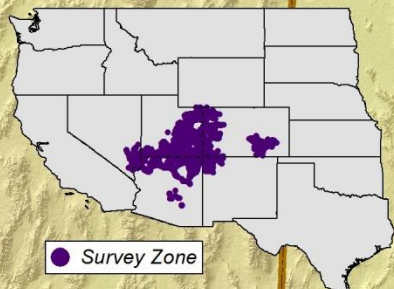


# Yearly Distribution (2007 - 2011) of Tamarisk Leaf Beetle (*Diorhabda carinulata*)

**Funding Provided By:**  
 The Walton Family Foundation  
 Colorado Department of Agriculture  
 Colorado Water Conservation Board  
 Bureau of Indian Affairs  
 Telluride Foundation  
 Kenny Brothers Foundation  
 Williams

**Data Collected By:**  
 Bureau of Indian Affairs:  
 Western & Northern Navajo Agency  
 Canyon de Chelly  
 Colorado Department of Agriculture:  
 Palisade Insectary  
 Dinosaur National Monument  
 Glen Canyon National Recreation Area  
 Grand Canyon National Park  
 Grand Canyon Youth  
 Kaibab Paiute Tribe  
 Lake Mead National Recreation Area  
 New Mexico State University  
 Northern Arizona University  
 Southern Nevada Water Authority  
 Tamarisk Coalition  
 University of Arizona  
 University of California Santa Barbara  
 US Geological Survey

**Map Published by Tamarisk  
Coalition on: 11/4/11**



0 37.5 75 150 225 300 Kilometers

0 25 50 100 150 200 Miles

**Monitoring Years**

- Year 2007
- Year 2008
- Year 2009
- Year 2010
- Year 2011

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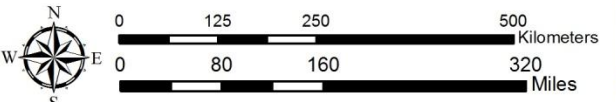
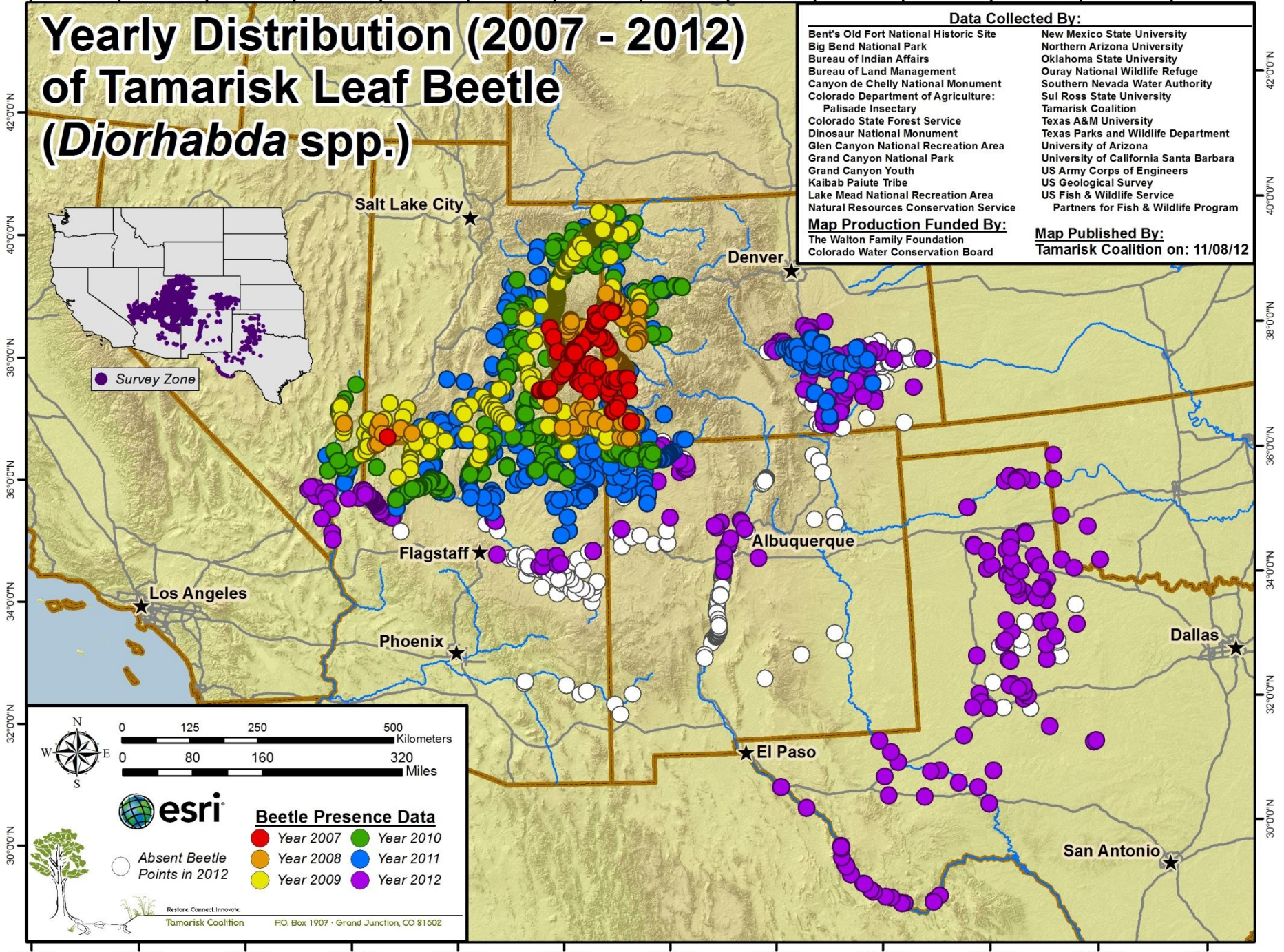
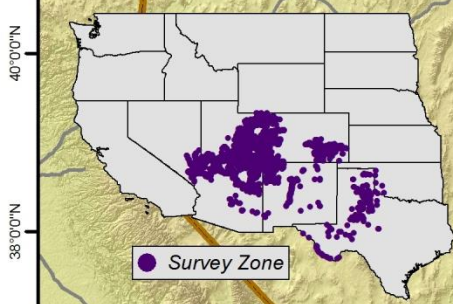
# Yearly Distribution (2007 - 2012) of Tamarisk Leaf Beetle (*Diorhabda* spp.)

**Data Collected By:**

Bent's Old Fort National Historic Site	New Mexico State University
Big Bend National Park	Northern Arizona University
Bureau of Indian Affairs	Oklahoma State University
Bureau of Land Management	Ourray National Wildlife Refuge
Canyon de Chelly National Monument	Southern Nevada Water Authority
Colorado Department of Agriculture:	Sul Ross State University
Palisade Insectary	Tamarisk Coalition
Colorado State Forest Service	Texas A&M University
Dinosaur National Monument	Texas Parks and Wildlife Department
Glen Canyon National Recreation Area	University of Arizona
Grand Canyon National Park	University of California Santa Barbara
Grand Canyon Youth	US Army Corps of Engineers
Kaibab Paiute Tribe	US Geological Survey
Lake Mead National Recreation Area	US Fish & Wildlife Service
Natural Resources Conservation Service	Partners for Fish & Wildlife Program

**Map Production Funded By:**  
The Walton Family Foundation  
Colorado Water Conservation Board

**Map Published By:**  
Tamarisk Coalition on: 11/08/12



**Beetle Presence Data**

● Year 2007	● Year 2010
● Year 2008	● Year 2011
● Year 2009	● Year 2012

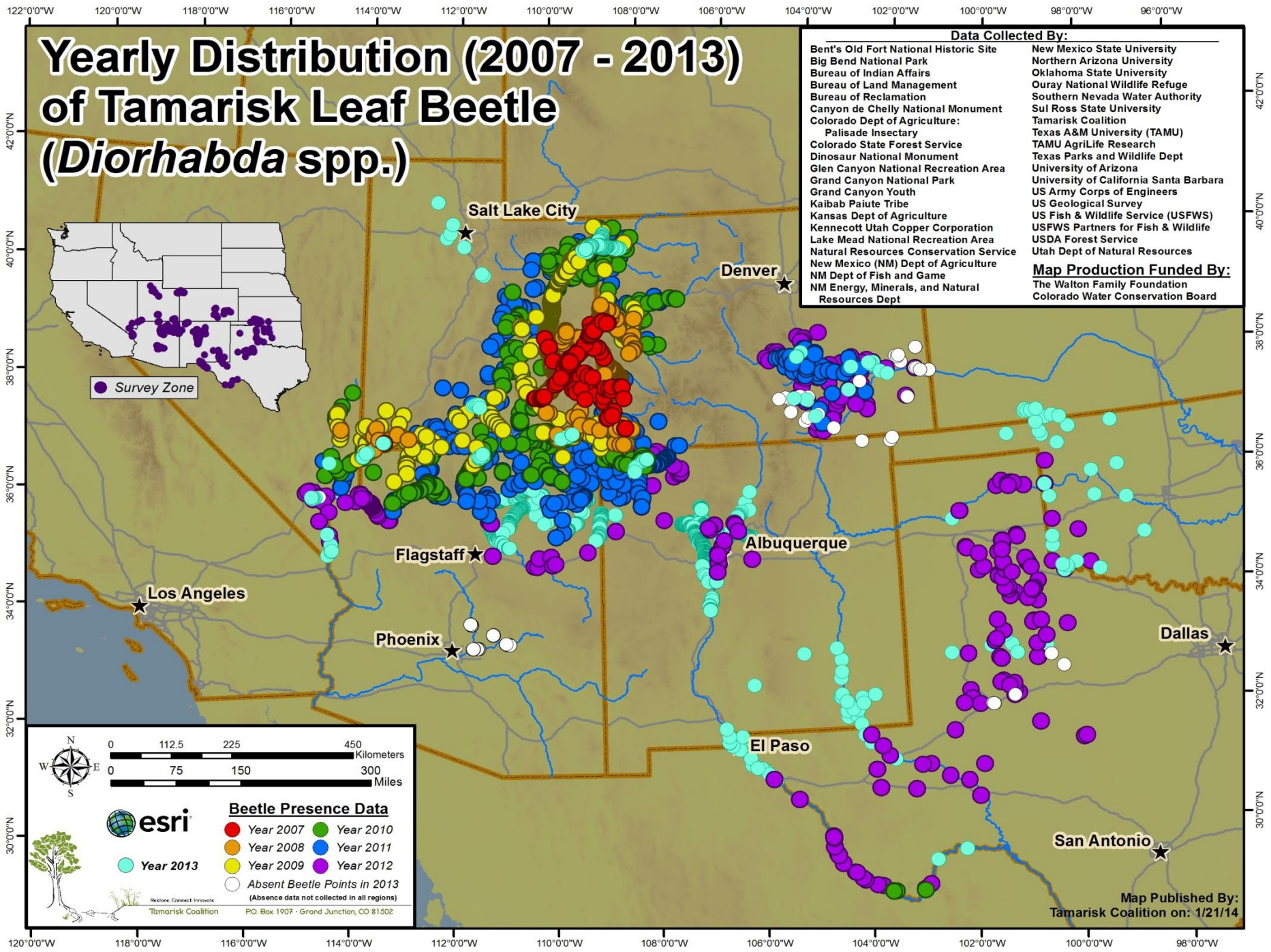
○ Absent Beetle Points in 2012



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# Yearly Distribution (2007 - 2013) of Tamarisk Leaf Beetle (*Diorhabda* spp.)



- Data Collected By:**
- |   |  |
|---|--|
| Bent's Old Fort National Historic Site          | New Mexico State University            |
| Big Bend National Park                          | Northern Arizona University            |
| Bureau of Indian Affairs                        | Oklahoma State University              |
| Bureau of Land Management                       | Ouray National Wildlife Refuge         |
| Bureau of Reclamation                           | Southern Nevada Water Authority        |
| Canyon de Chelly National Monument              | Sul Ross State University              |
| Colorado Dept of Agriculture:                   | Tamarisk Coalition                     |
| Palisade Insectary                              | Texas A&M University (TAMU)            |
| Colorado State Forest Service                   | TAMU AgriLife Research                 |
| Dinosaur National Monument                      | Texas Parks and Wildlife Dept          |
| Glen Canyon National Recreation Area            | University of Arizona                  |
| Grand Canyon National Park                      | University of California Santa Barbara |
| Grand Canyon Youth                              | US Army Corps of Engineers             |
| Kaibab Paiute Tribe                             | US Geological Survey                   |
| Kansas Dept of Agriculture                      | US Fish & Wildlife Service (USFWS)     |
| Kennecott Utah Copper Corporation               | USFWS Partners for Fish & Wildlife     |
| Lake Mead National Recreation Area              | USDA Forest Service                    |
| Natural Resources Conservation Service          | Utah Dept of Natural Resources         |
| New Mexico (NM) Dept of Agriculture             |  |
| NM Dept of Fish and Game                        |  |
| NM Energy, Minerals, and Natural Resources Dept |  |
- Map Production Funded By:**
- The Walton Family Foundation
  - Colorado Water Conservation Board

0 112.5 225 450 Kilometers  
0 75 150 300 Miles

**esri**

**Beetle Presence Data**

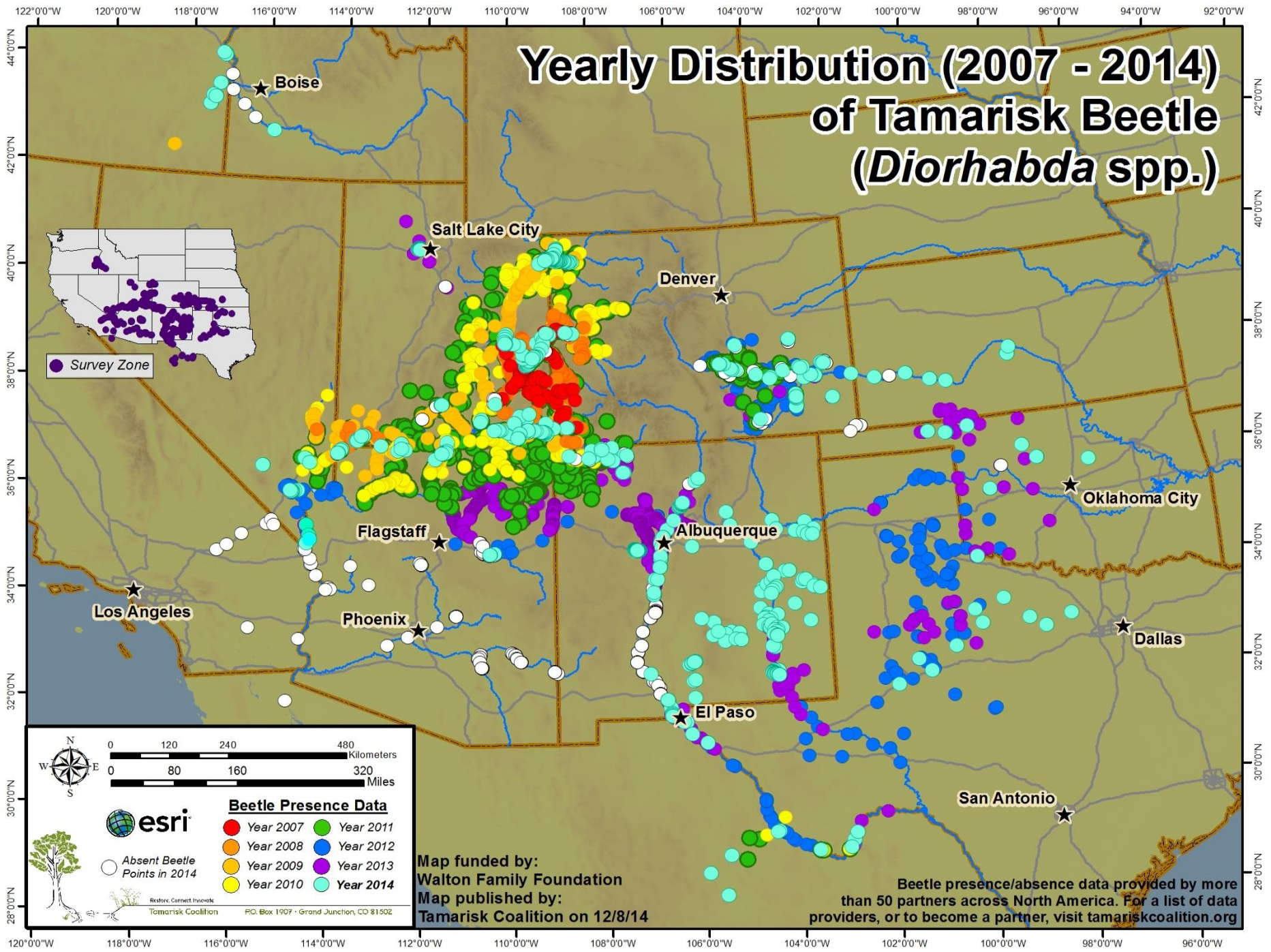
- Year 2007
- Year 2008
- Year 2009
- Year 2010
- Year 2011
- Year 2012
- Year 2013
- Absent Beetle Points in 2013 (Absence data not collected in all regions)

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Map Published By:  
Tamarisk Coalition on: 1/21/14

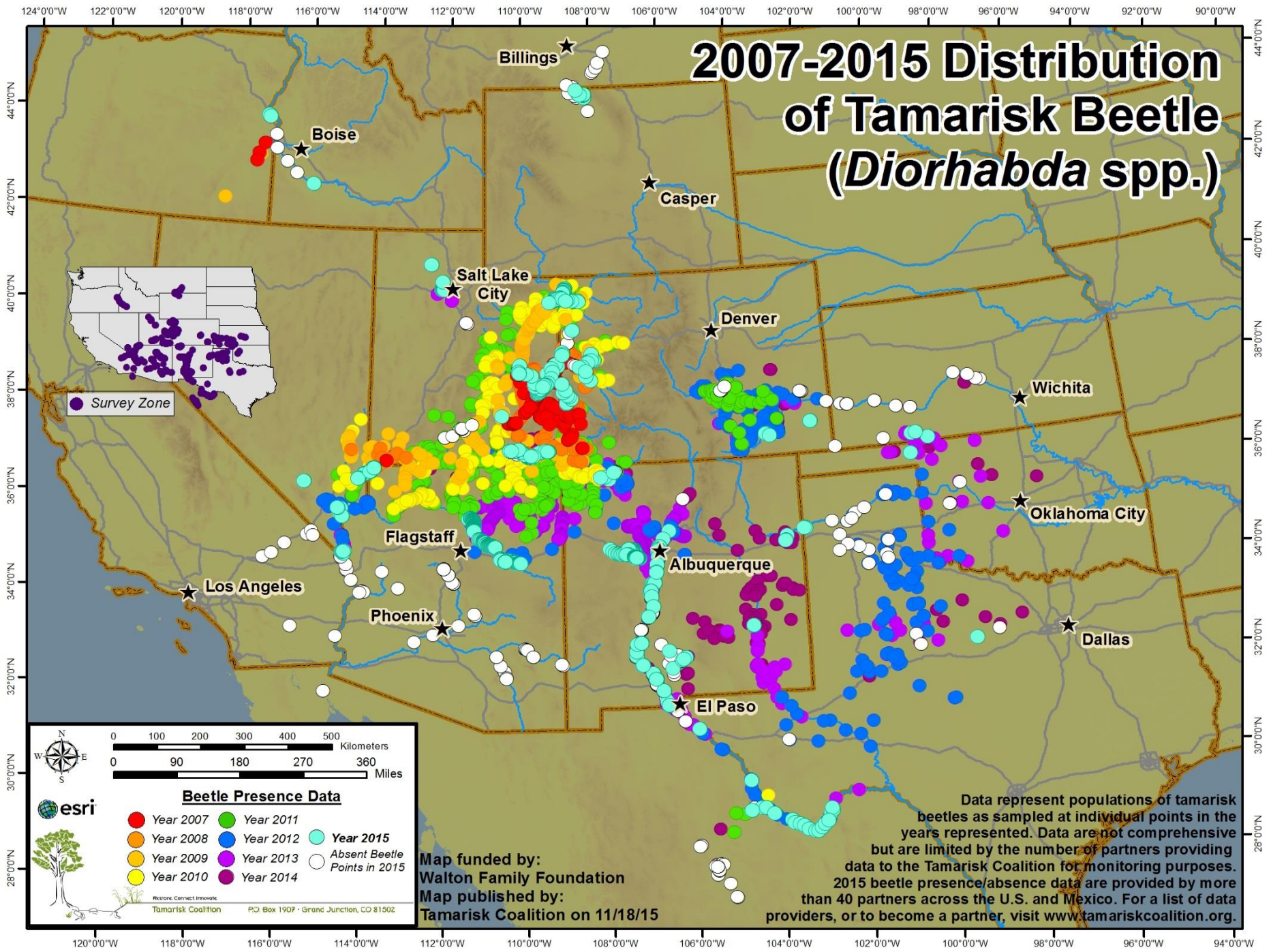


# Yearly Distribution (2007 - 2014) of Tamarisk Beetle (*Diorhabda* spp.)





# 2007-2015 Distribution of Tamarisk Beetle (*Diorhabda* spp.)



**Beetle Presence Data**

- Year 2007
- Year 2008
- Year 2009
- Year 2010
- Year 2011
- Year 2012
- Year 2013
- Year 2014
- Year 2015
- Absent Beetle Points in 2015

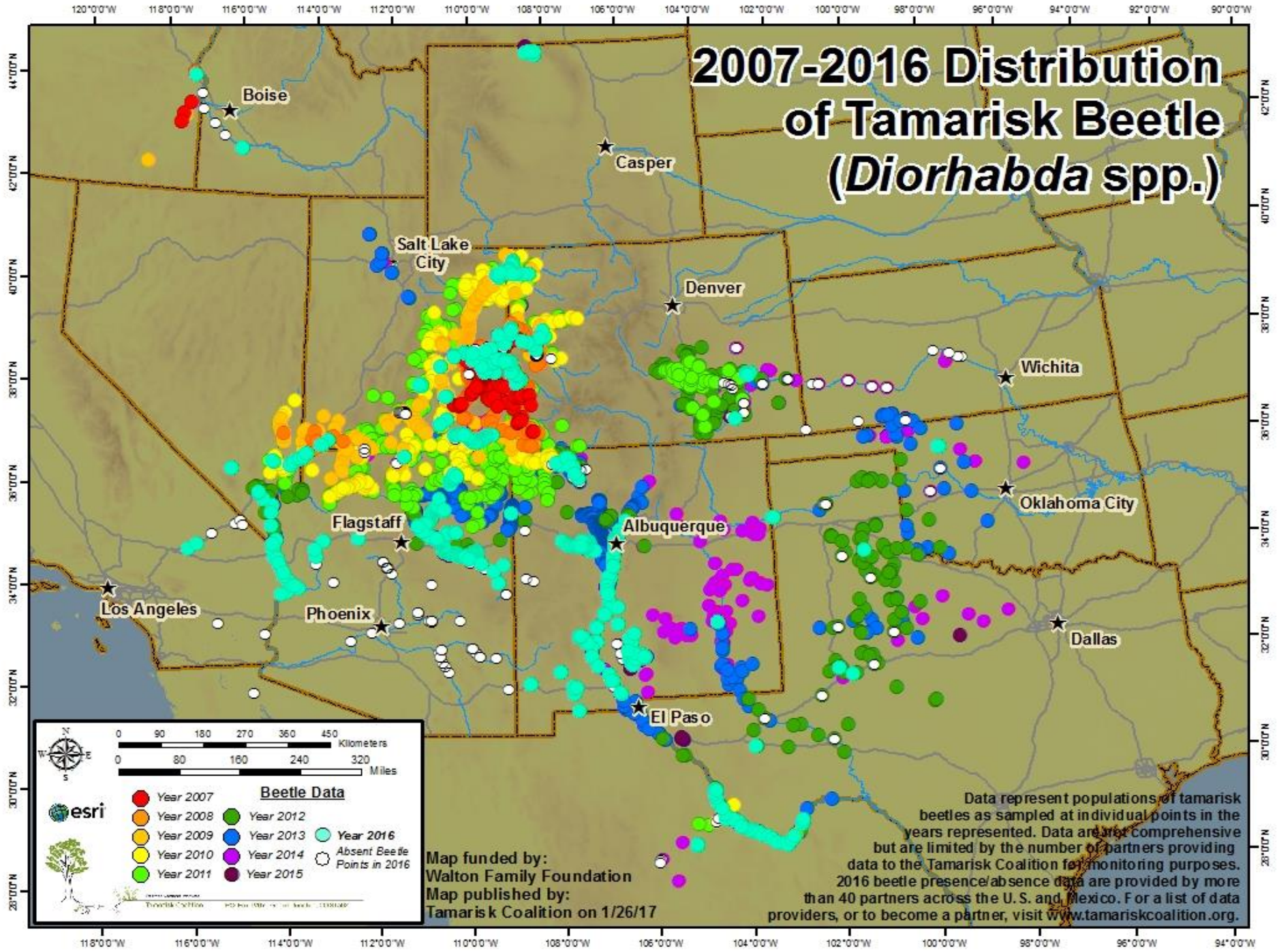
esri  
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Tamarisk Coalition  
P.O. Box 1907 • Grand Junction, CO 81502

Map funded by:  
Walton Family Foundation  
Map published by:  
Tamarisk Coalition on 11/18/15

Data represent populations of tamarisk beetles as sampled at individual points in the years represented. Data are not comprehensive but are limited by the number of partners providing data to the Tamarisk Coalition for monitoring purposes. 2015 beetle presence/absence data are provided by more than 40 partners across the U.S. and Mexico. For a list of data providers, or to become a partner, visit [www.tamariskcoalition.org](http://www.tamariskcoalition.org).



# 2007-2016 Distribution of Tamarisk Beetle (*Diorhabda* spp.)



0 90 180 270 360 450 Kilometers  
0 80 160 240 320 Miles

**Beetle Data**

- Year 2007
- Year 2008
- Year 2009
- Year 2010
- Year 2011
- Year 2012
- Year 2013
- Year 2014
- Year 2015
- Year 2016
- Absent Beetle Points in 2016

esri

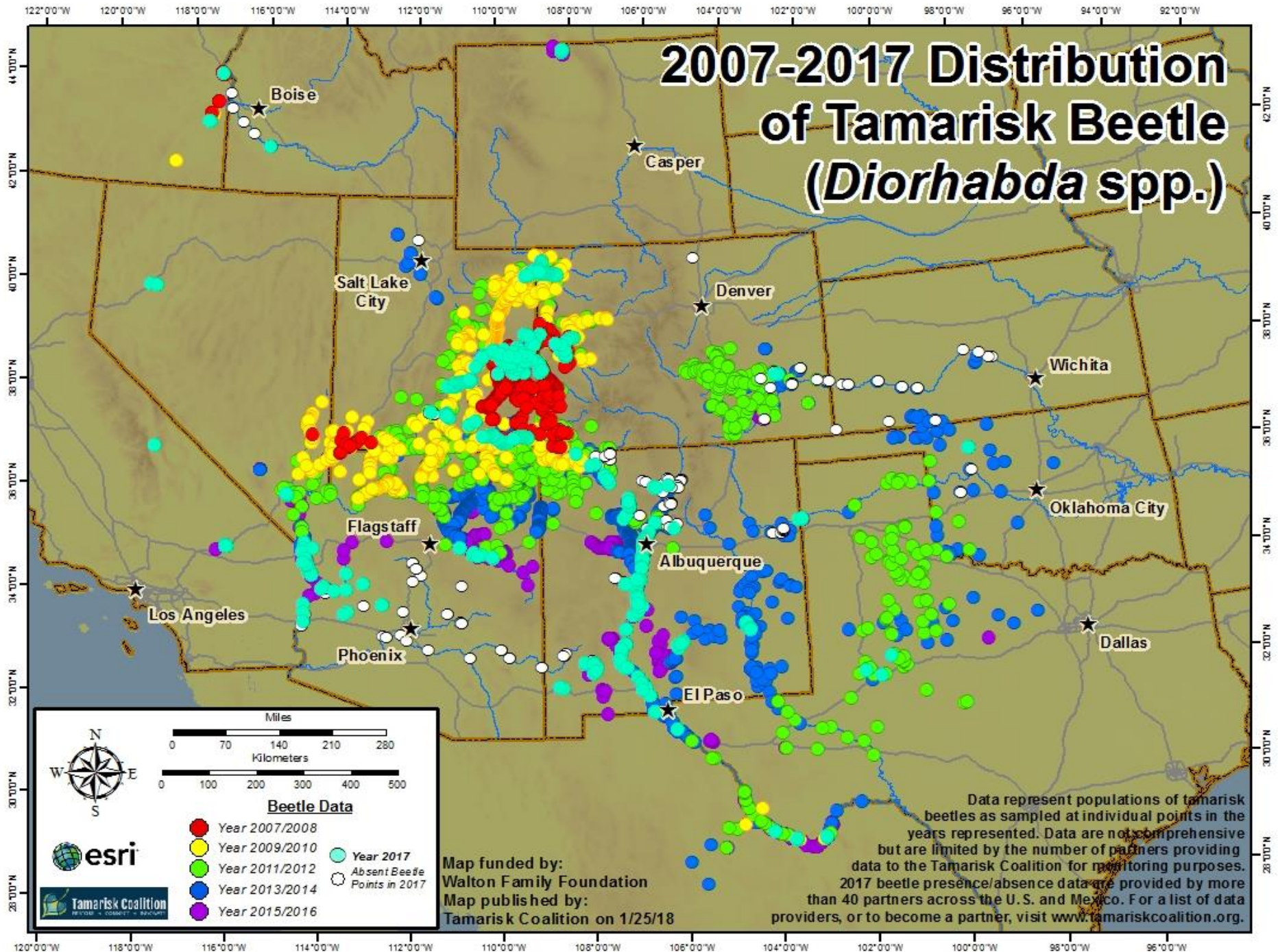
Tamarisk Coalition

Map funded by:  
Walton Family Foundation  
Map published by:  
Tamarisk Coalition on 1/26/17

Data represent populations of tamarisk beetles as sampled at individual points in the years represented. Data are not comprehensive but are limited by the number of partners providing data to the Tamarisk Coalition for monitoring purposes. 2016 beetle presence/absence data are provided by more than 40 partners across the U.S. and Mexico. For a list of data providers, or to become a partner, visit [www.tamariskcoalition.org](http://www.tamariskcoalition.org).

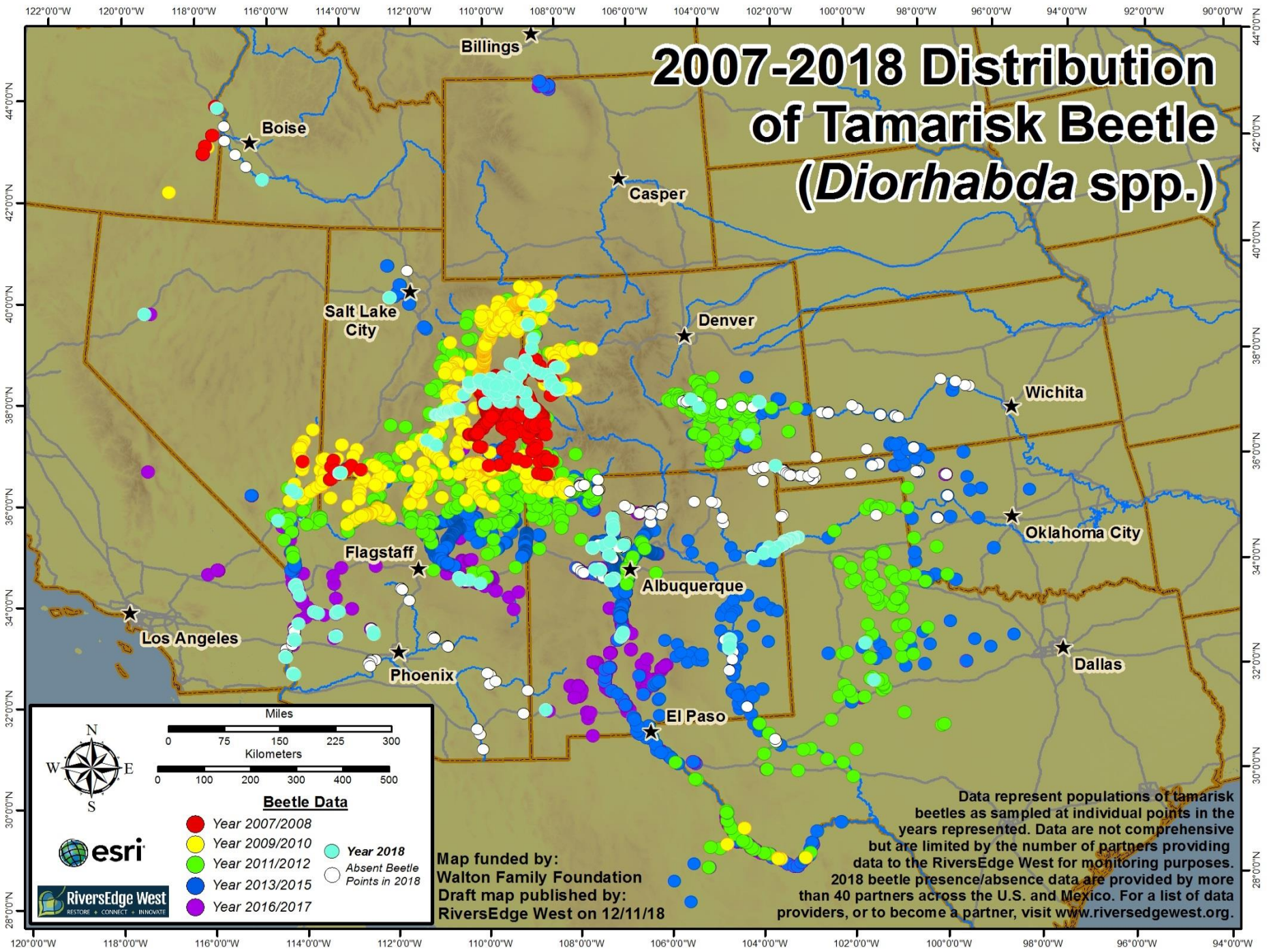


# 2007-2017 Distribution of Tamarisk Beetle (*Diorhabda* spp.)





# 2007-2018 Distribution of Tamarisk Beetle (*Diorhabda* spp.)



- Beetle Data**
- Year 2007/2008
  - Year 2009/2010
  - Year 2011/2012
  - Year 2013/2015
  - Year 2016/2017
  - Year 2018
  - Absent Beetle Points in 2018

Map funded by:  
Walton Family Foundation  
Draft map published by:  
RiversEdge West on 12/11/18

Data represent populations of tamarisk beetles as sampled at individual points in the years represented. Data are not comprehensive but are limited by the number of partners providing data to the RiversEdge West for monitoring purposes. 2018 beetle presence/absence data are provided by more than 40 partners across the U.S. and Mexico. For a list of data providers, or to become a partner, visit [www.riversedgewest.org](http://www.riversedgewest.org).

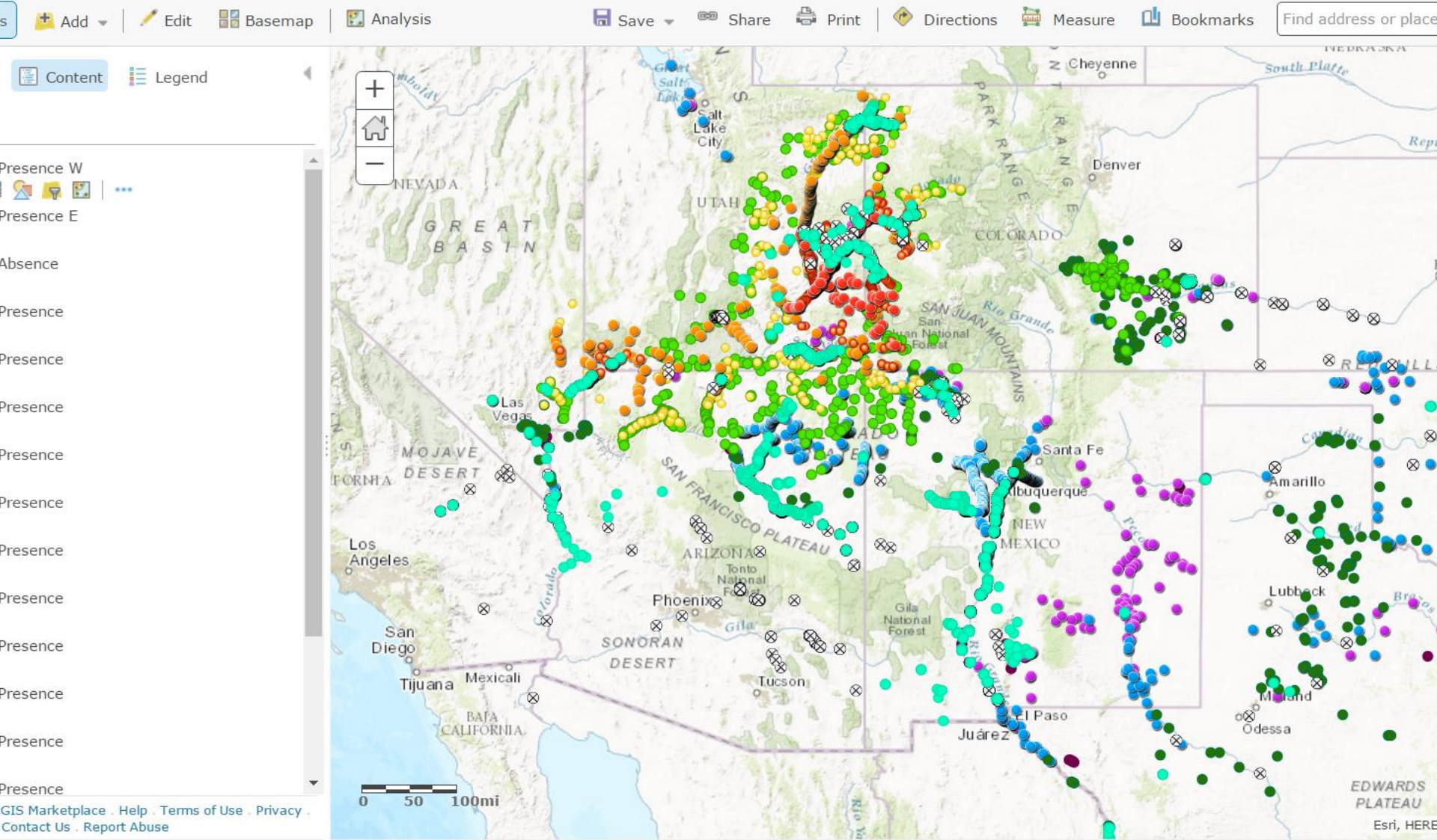


# TC ArcGIS Online Map

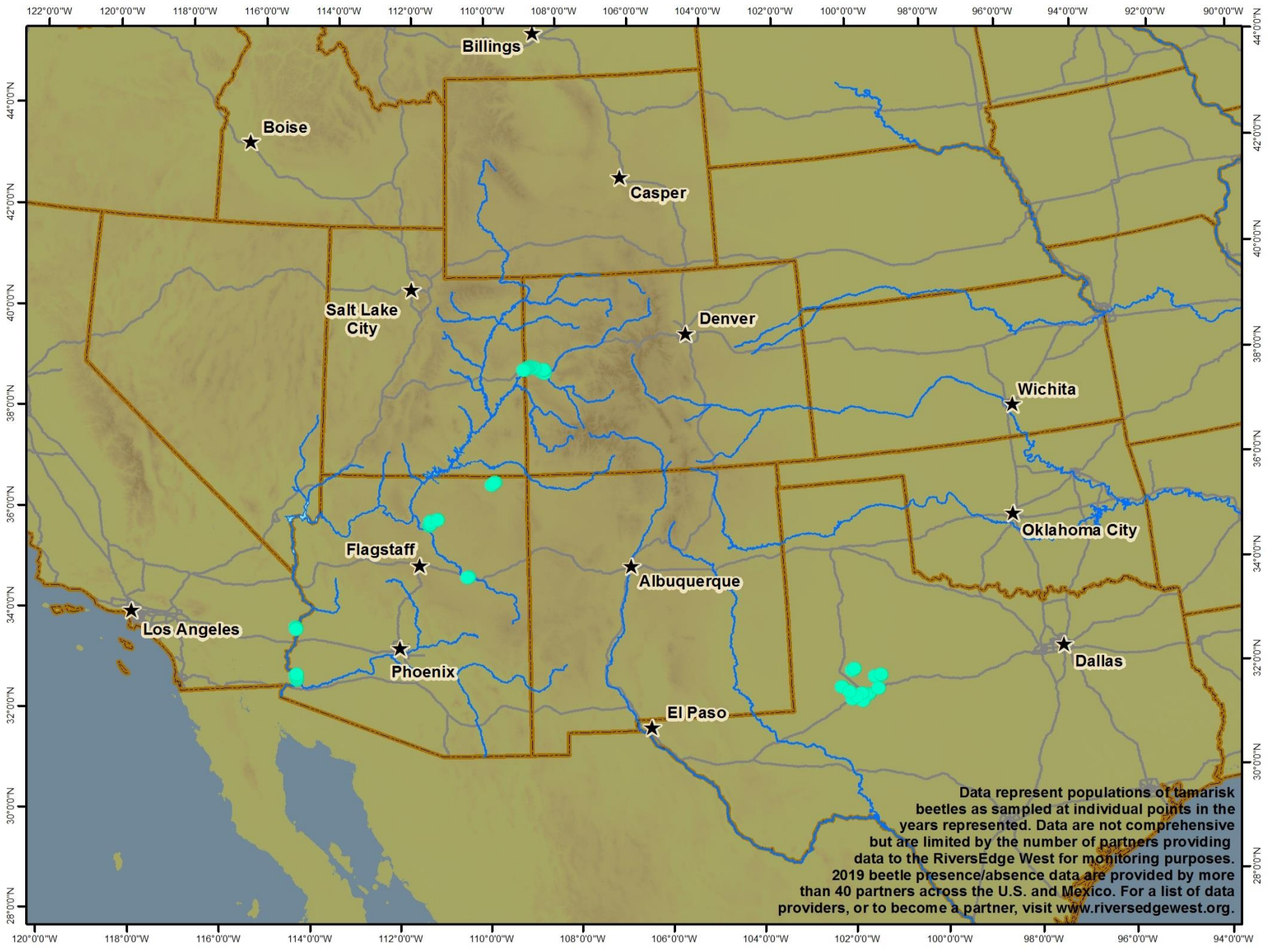
tamariskcltn.maps.arcgis.com/home/webmap/viewer.html?webmap=b6a6028781034008888783d5b47e8c39

Tamarisk Coalition's 2016 Tamarisk Beetle Distribution Map

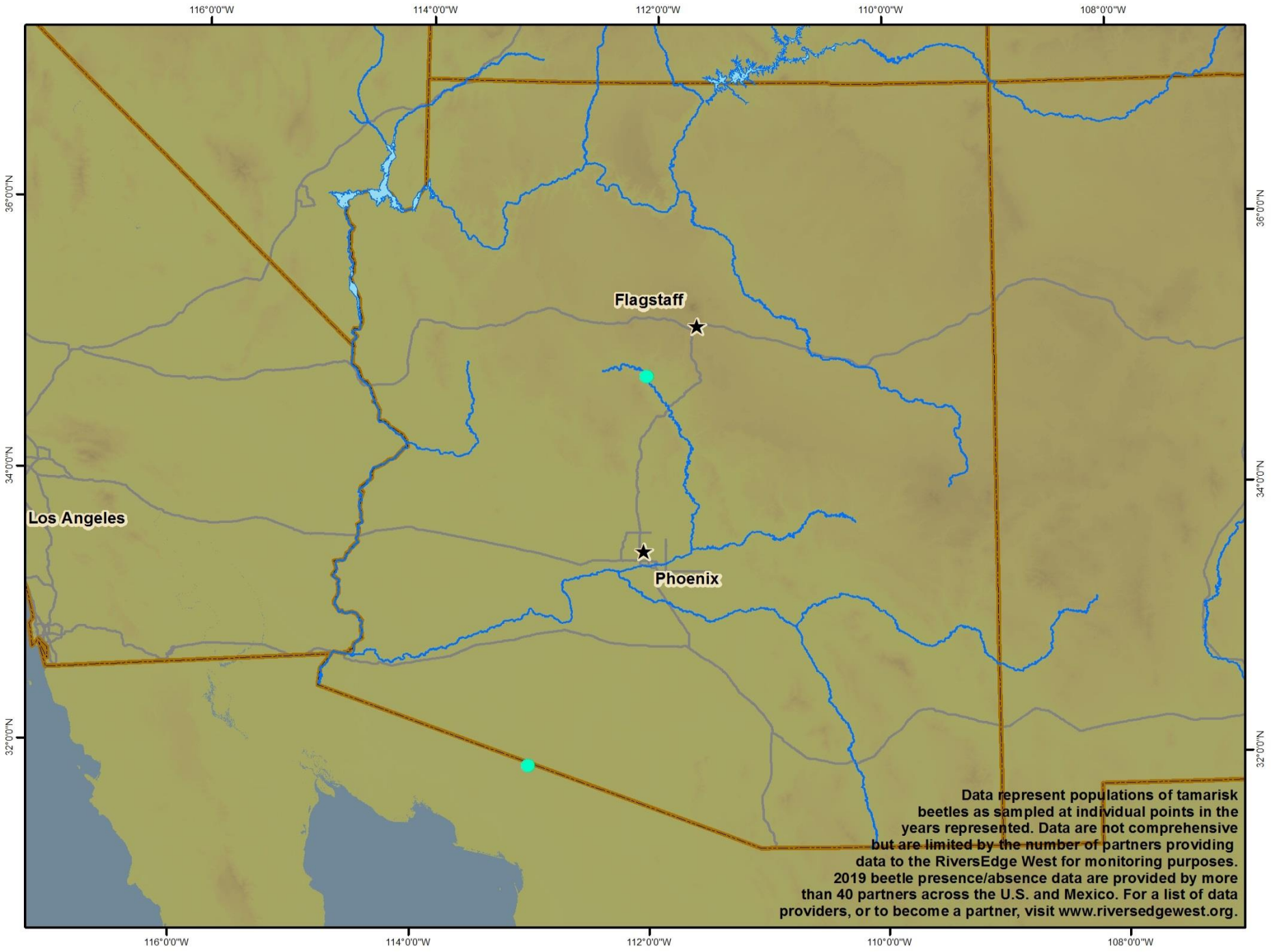
New





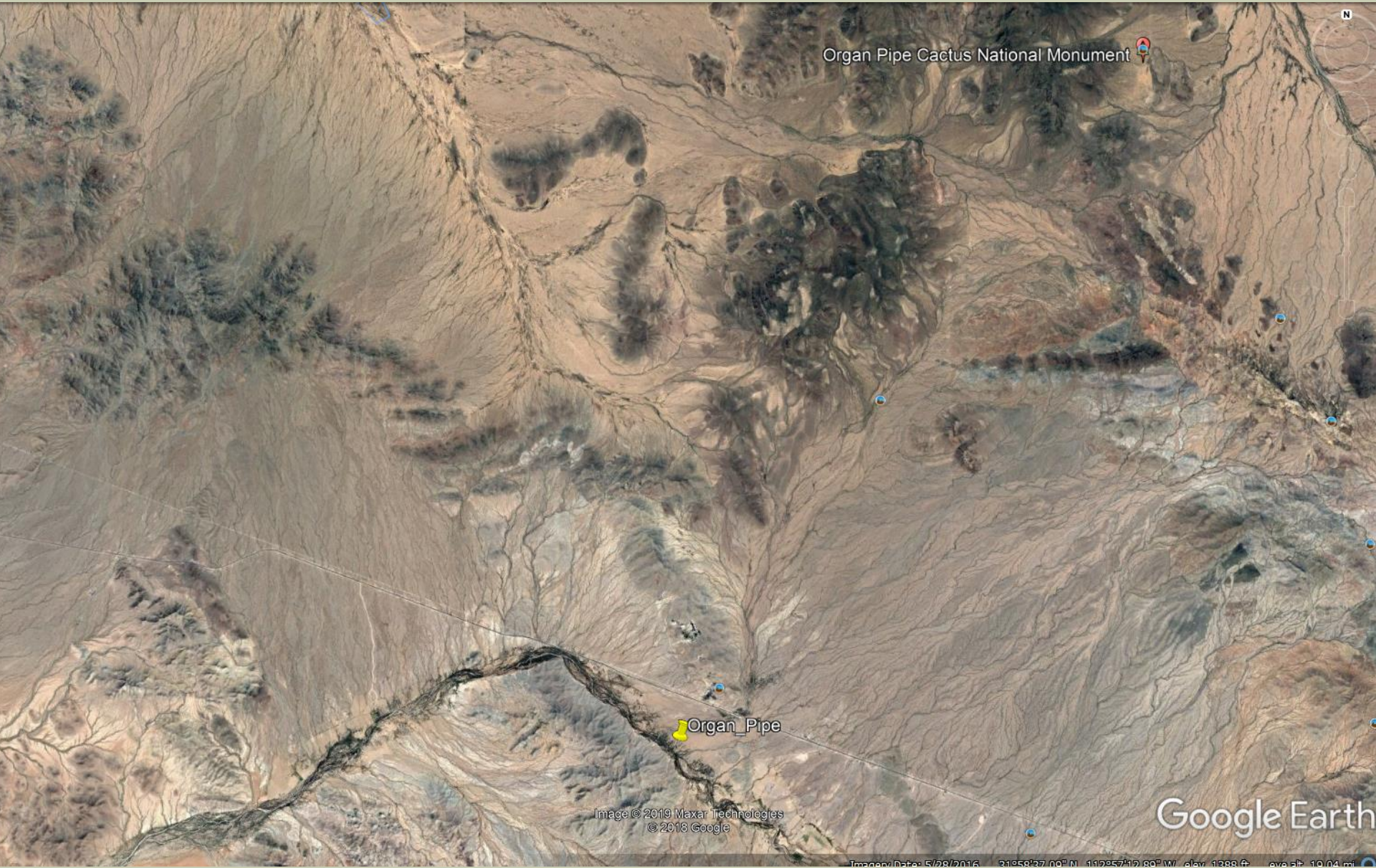






Data represent populations of tamarisk beetles as sampled at individual points in the years represented. Data are not comprehensive but are limited by the number of partners providing data to the RiversEdge West for monitoring purposes. 2019 beetle presence/absence data are provided by more than 40 partners across the U.S. and Mexico. For a list of data providers, or to become a partner, visit [www.riversedgewest.org](http://www.riversedgewest.org).





Organ Pipe Cactus National Monument

Organ Pipe

Image © 2019 Maxar Technologies  
© 2018 Google

Google Earth

Imagery Date: 5/28/2016 31°58'27.00" N 112°57'12.89" W elev: 1388 ft eye alt: 19.04 mi



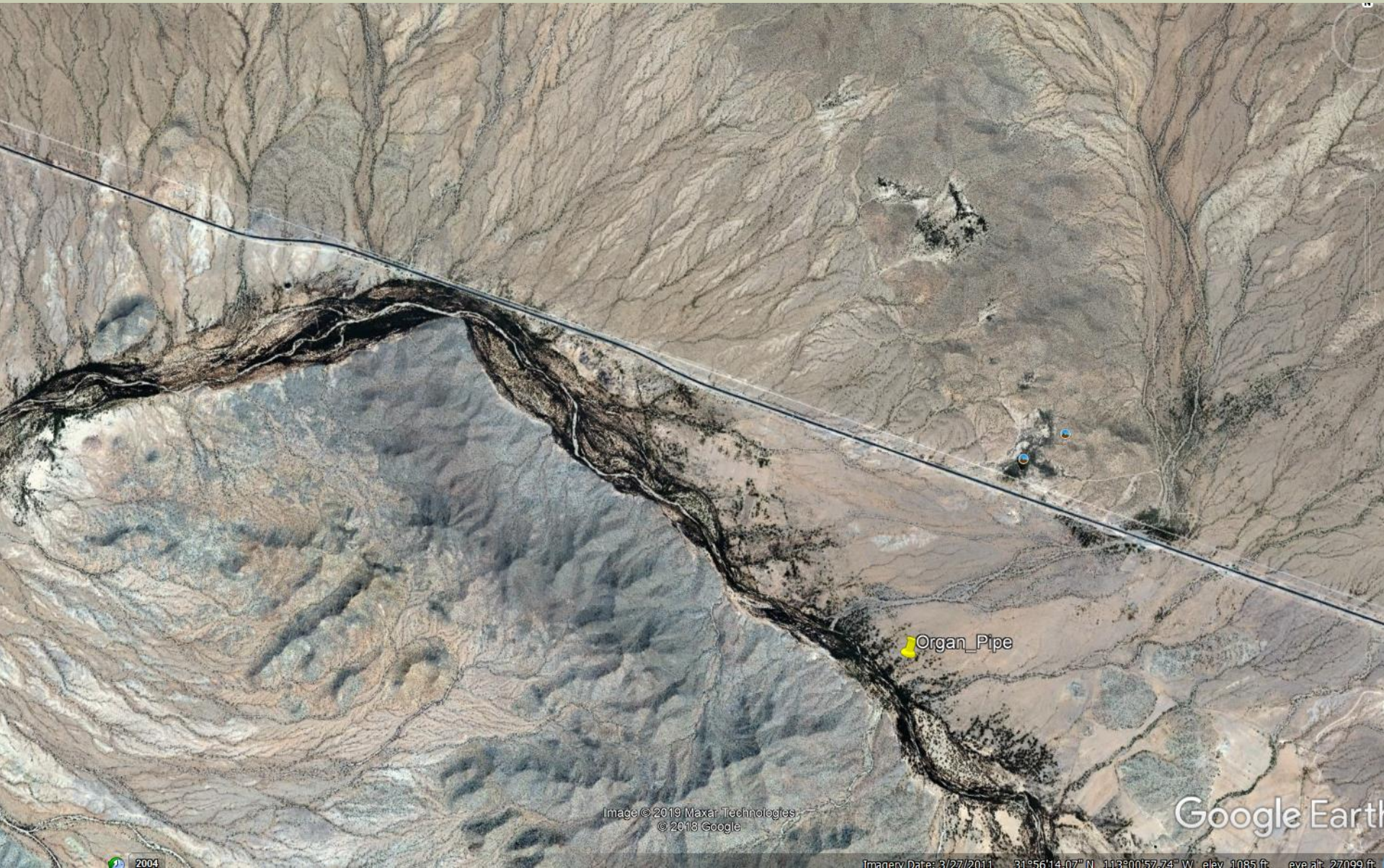


Image © 2019 Maxar Technologies  
© 2018 Google

Google Earth

2004

Imagery Date: 3/27/2011 31°56'14.07" N 113°00'57.74" W elev 1085 ft eye alt 27099 ft





Imperial\_NWR  
Imperial\_NWR  
Imperial\_NWR  
Imperial\_NWR  
Imperial\_NWR  
Imperial\_NWR

Organ Pipe Cactus National Monument

Organ\_Pipe

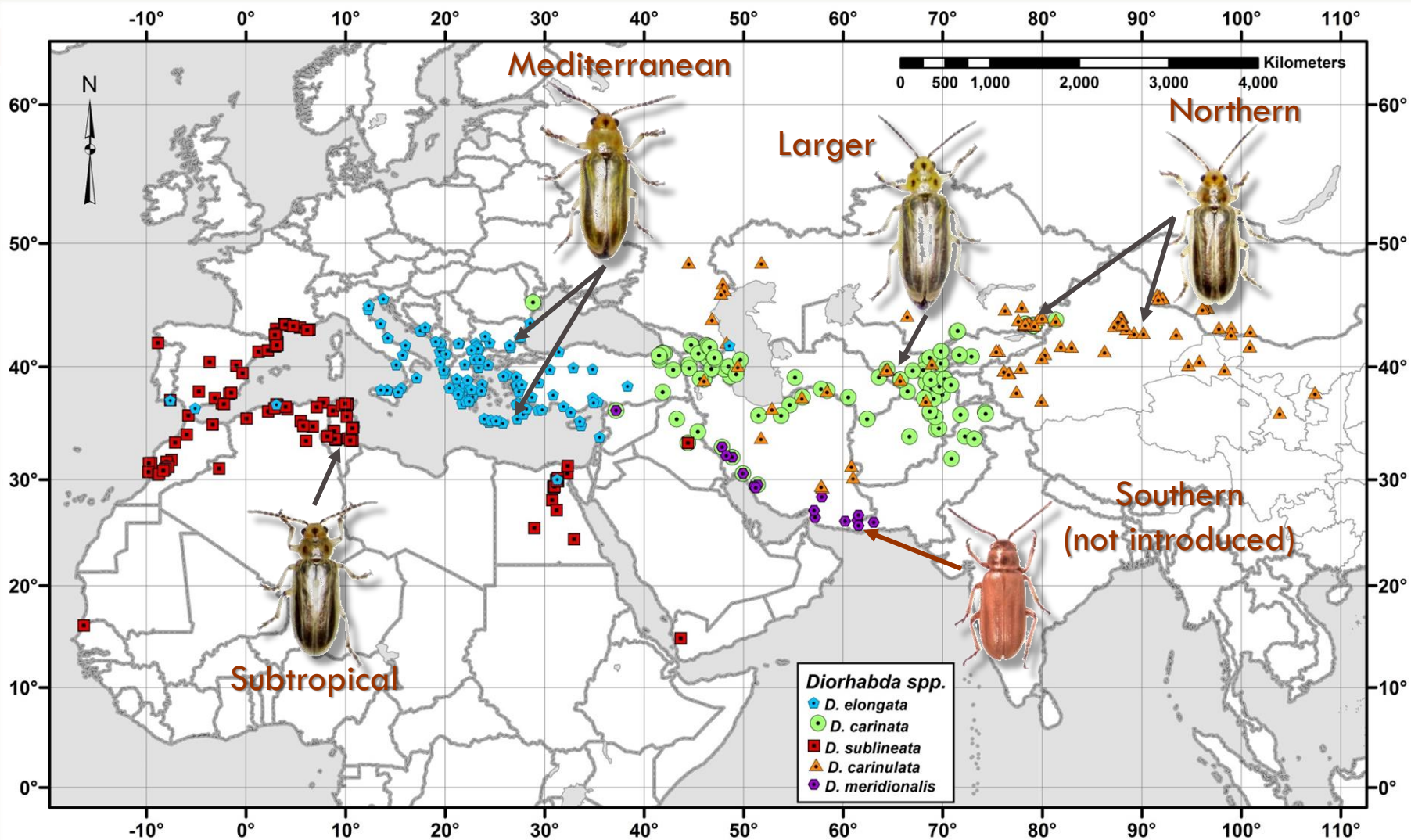
© 2018 Google  
Image Landsat / Copernicus  
© 2018 INEGI

Google Earth

32°31'20.45" N 112°40'56.46" W, elev: 1916 ft, eye alt: 132.83 mi



# Tamarisk beetle Old World distributions





# Four Old World *Diorhabda* spp. tamarisk beetles introduced into western North America from 2001–2009

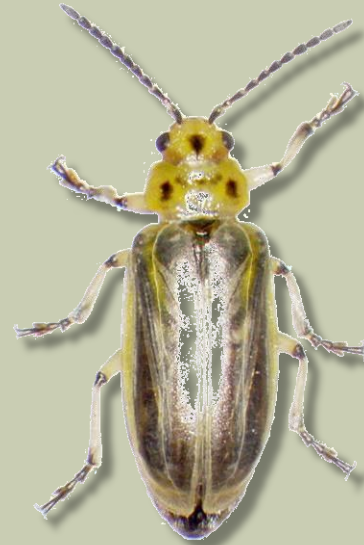
5 mm



Northern TB  
*D. carinulata*  
E. (ex: CN, KZ)  
2001-NV, UT, WY,  
CO, AZ, NM, CA



Mediterranean TB  
*D. elongata*  
(ex: GR)  
2004-CA, TX



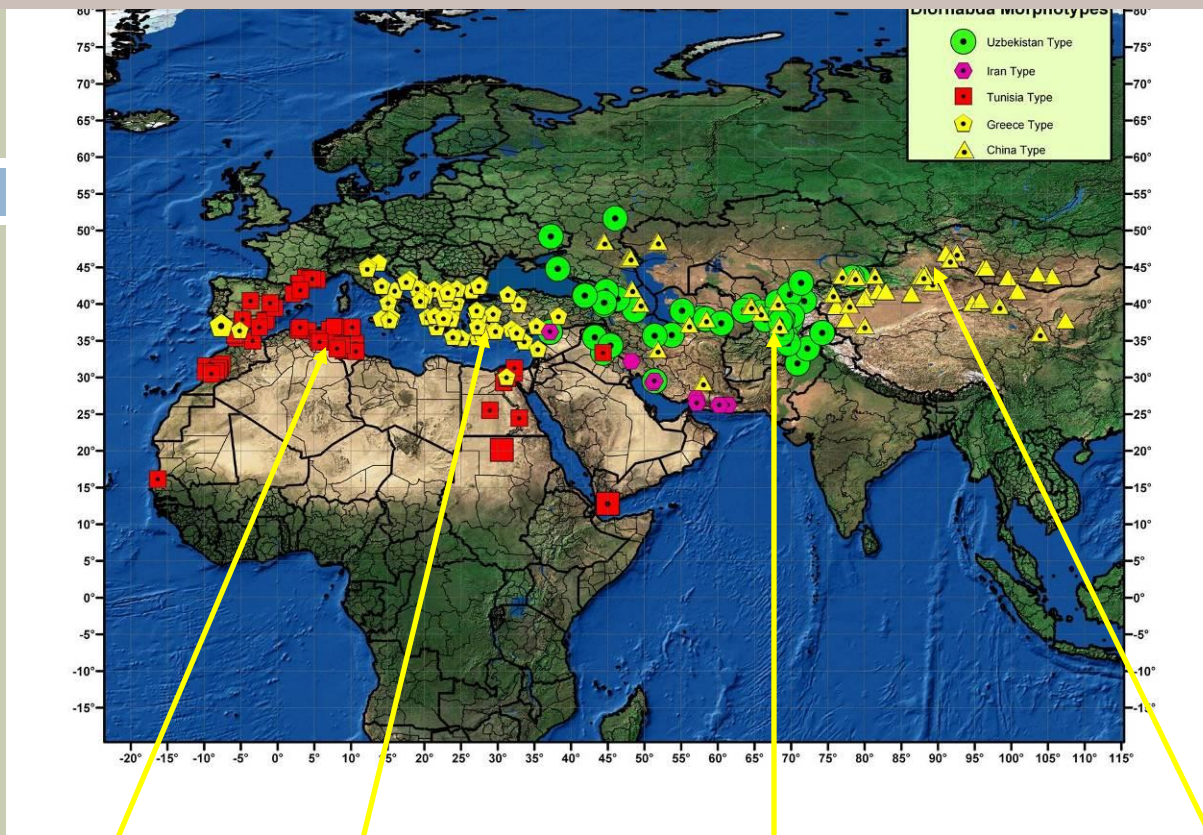
Larger TB  
*D. carinata*  
(ex: UZ)  
2007-TX



Subtropical TB  
*D. sublineata*  
(ex: TN)  
2009-TX



# The genus *Diorhabda* comprises five tamarisk feeding species, four of which are now found in NA



*Diorhabda sublineata*



Tunisia

*Diorhabda elongata*



Crete

*Diorhabda carinata*



Uzbekistan

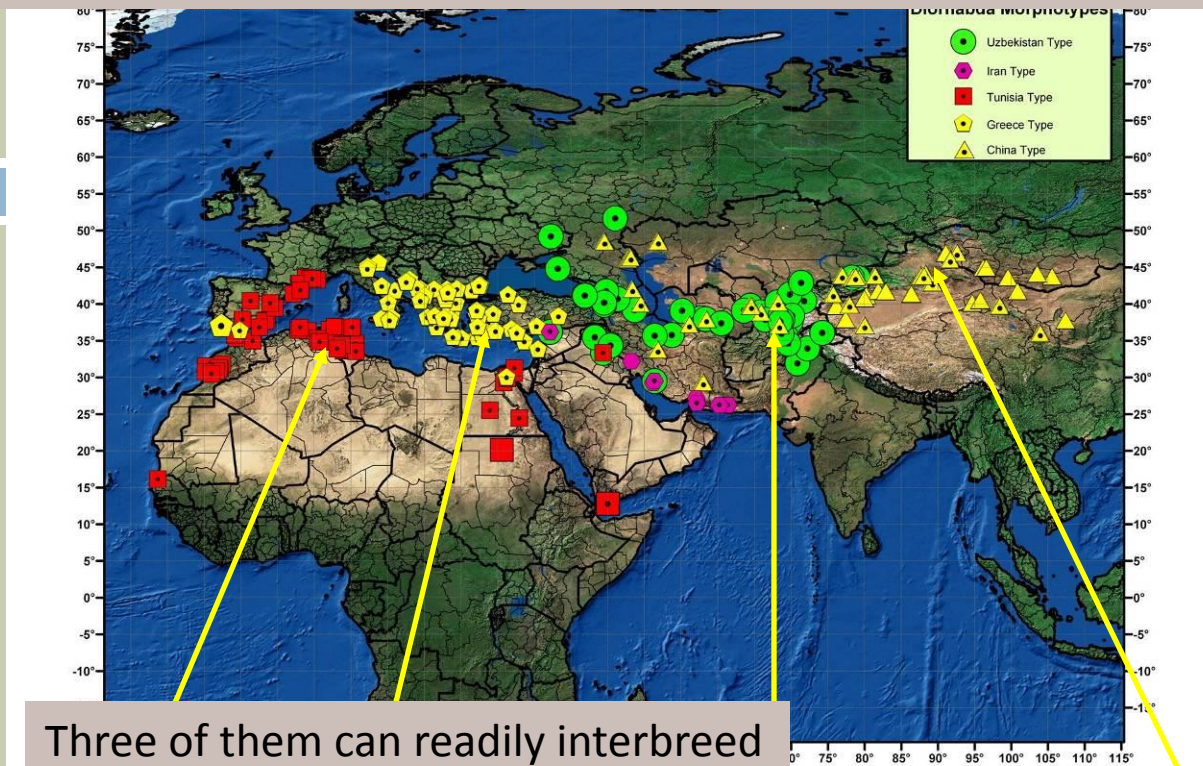
*Diorhabda carinulata*



Chilik, Fukang, Turpan



The genus *Diorhabda* comprises five tamarisk feeding species, four of which are now found in NA



Three of them can readily interbreed

*Diorhabda sublineata*



Tunisia

*Diorhabda elongata*



Crete

*Diorhabda carinata*



Uzbekistan

*Diorhabda carinulata*




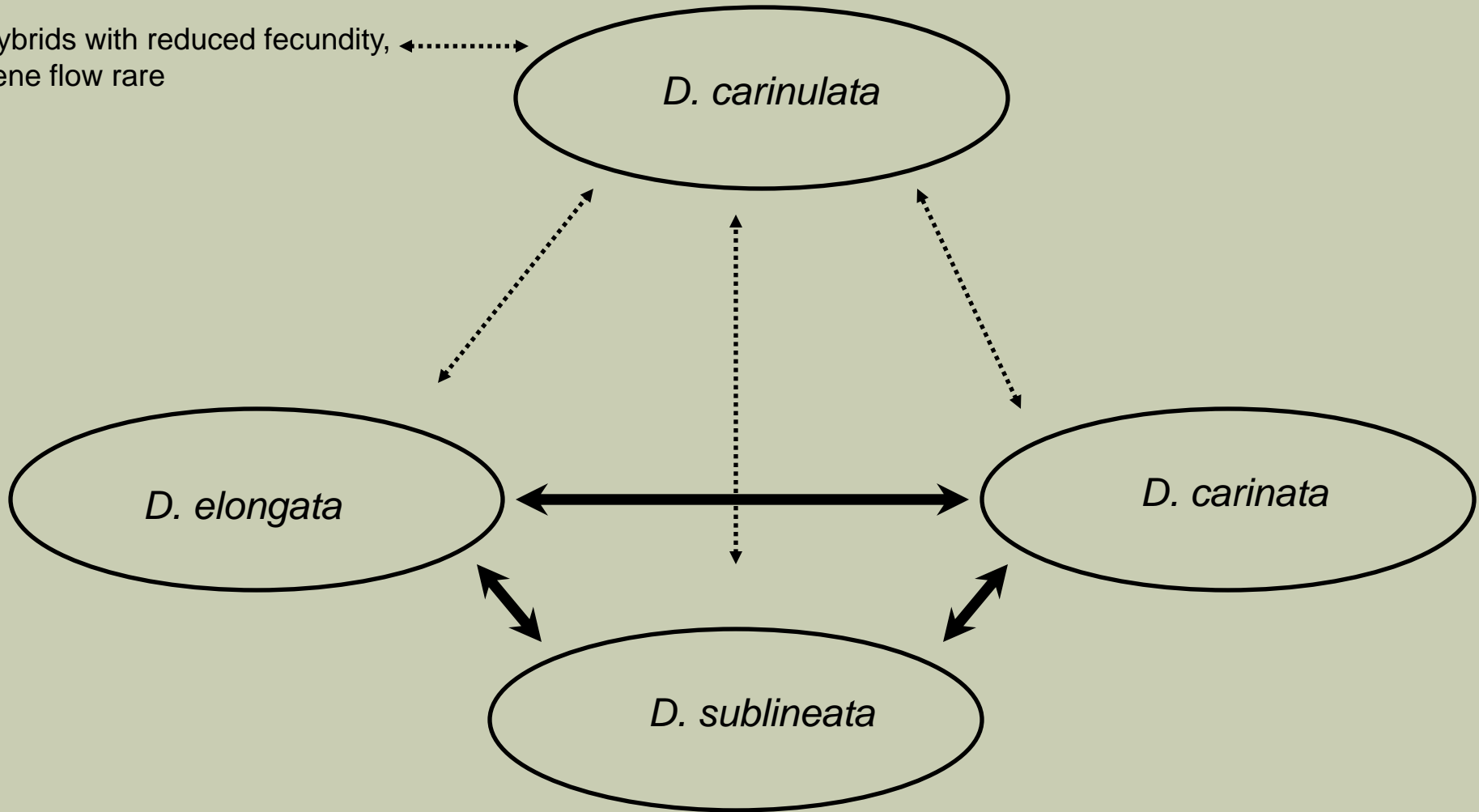
Chilik, Fukang, Turpan



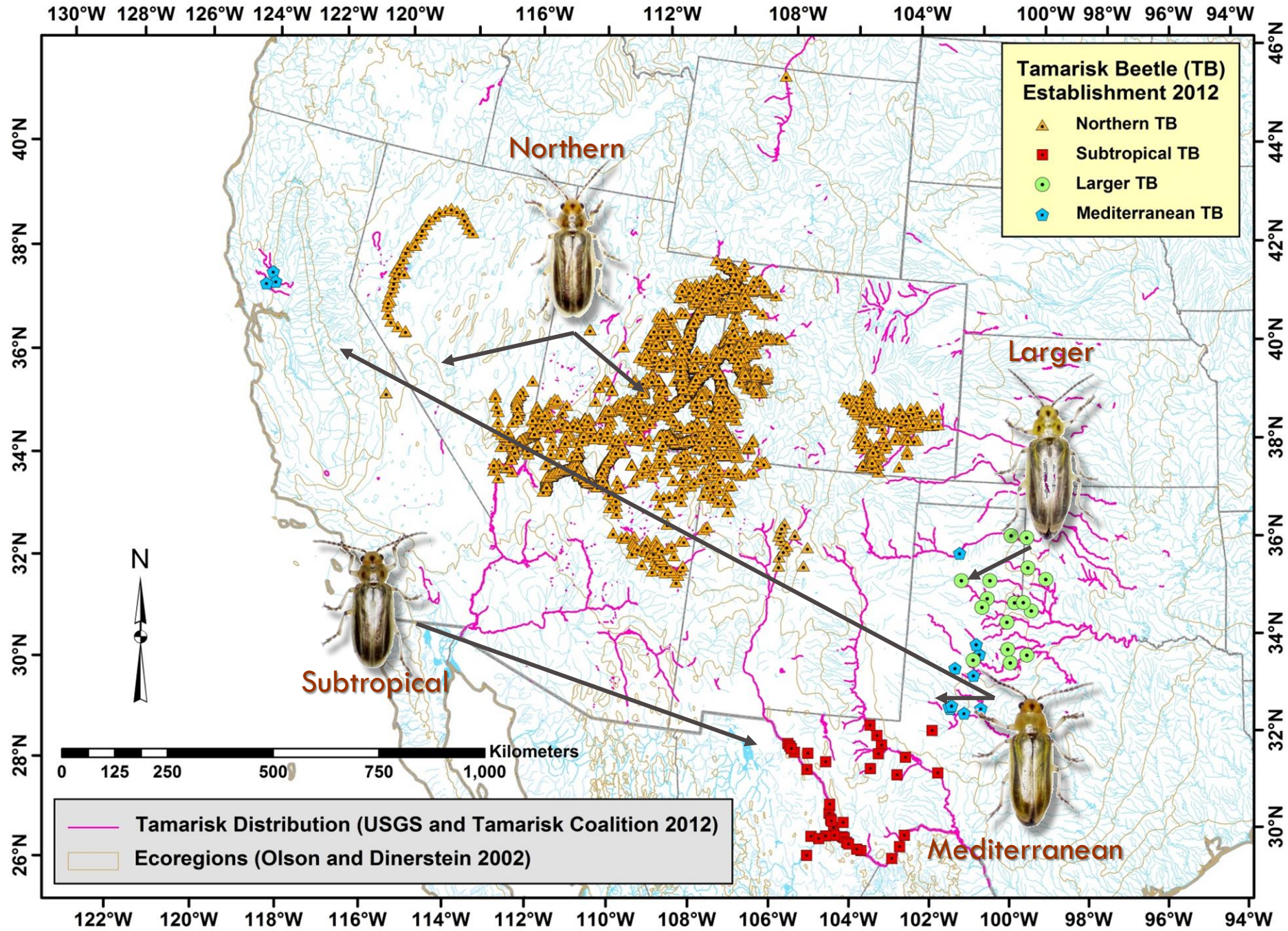
# *Diorhabda* hybridization

Hybrids possible, gene flow likely 

Hybrids with reduced fecundity, gene flow rare 



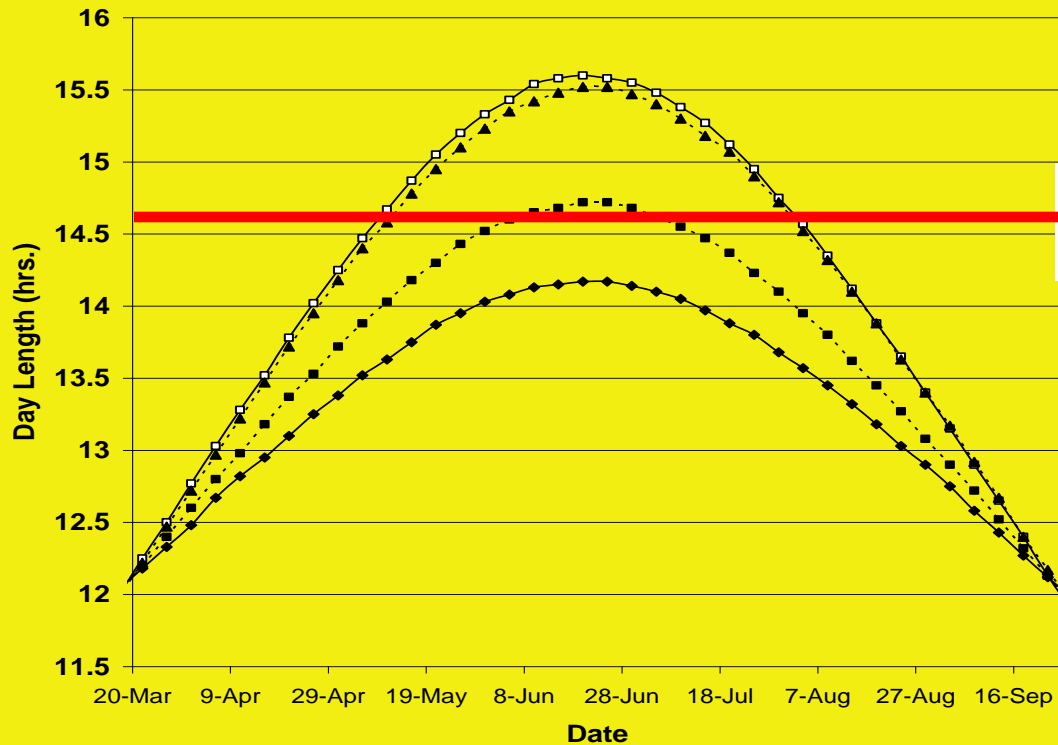




North America Albers Equal-Area Conic Projection, GCS North American 1983 Datum



# Over-wintering induced by shortening daylengths – Go to sleep in middle of summer in southern areas



Lovell, WY – 44.5°N  
Xinjiang, China – 44.1°N

Owens Valley, CA – 37.1°N

Temple, TX – 31.1°N

*New Diorhabda:*

*D. carinata* - 38.9° (Uzbek.)

*D. elongata* – 35.1° (Greece)

*D. sublineata* - 34.7° (Tunisia)

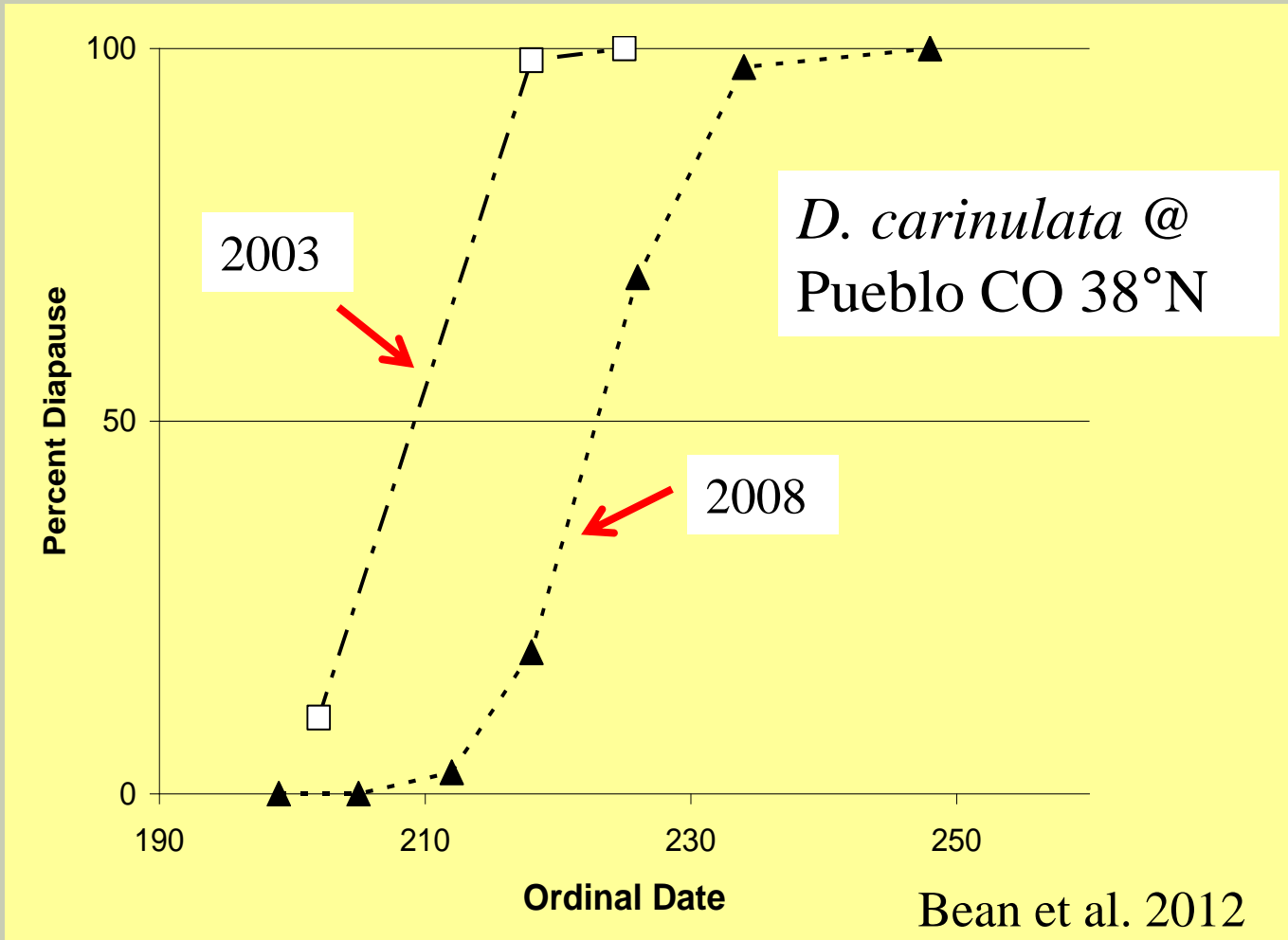
All in Texas

Narrow reproductive window in Pueblo, CO and did not reproduce during the summer in Texas.



# Evolution Happens...!

## Diapause dates at 37°N





# SW Willow Flycatcher & tamarisk beetle ranges- 2014



Northern



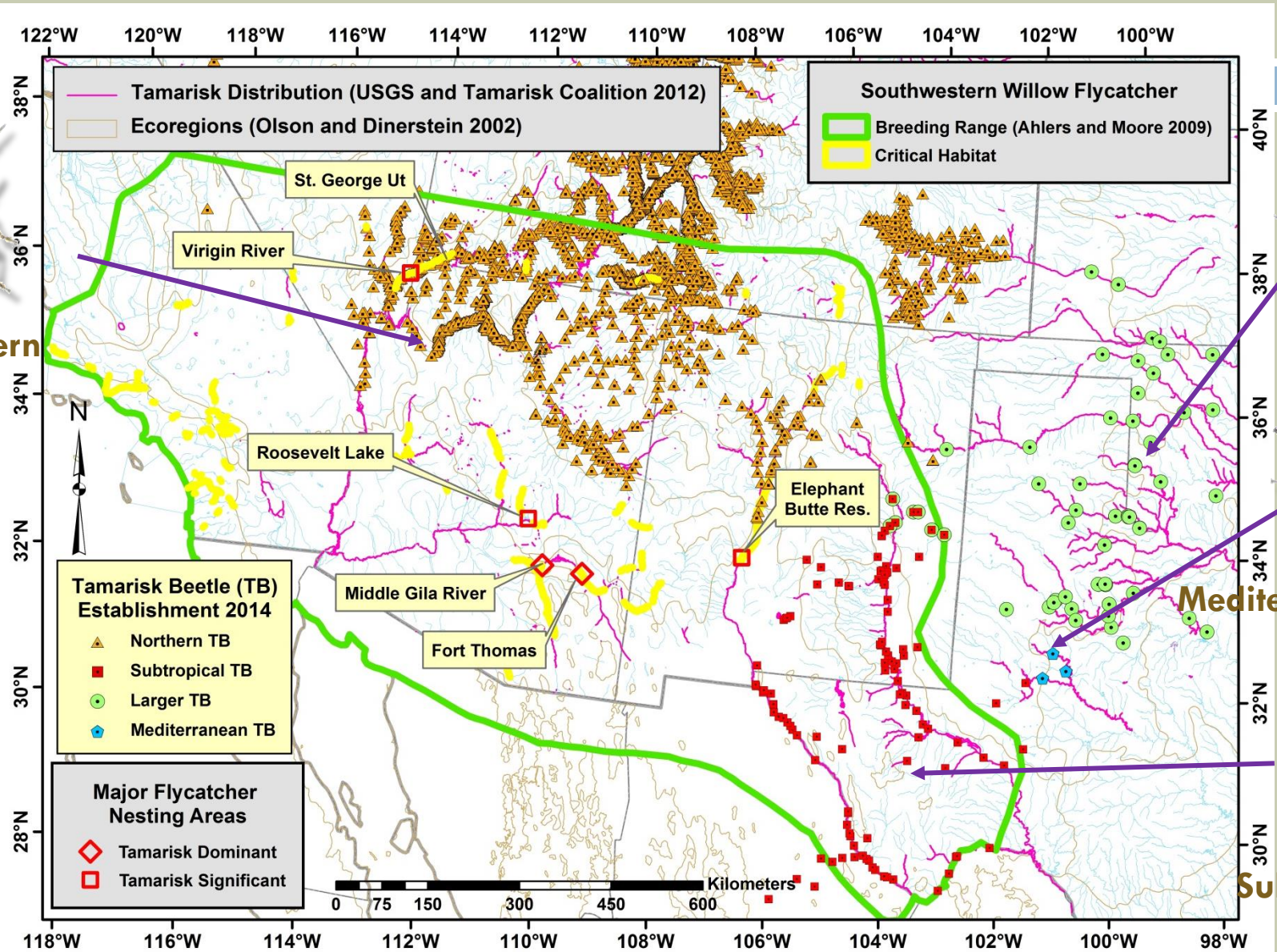
Larger



Mediterranean



Subtropical



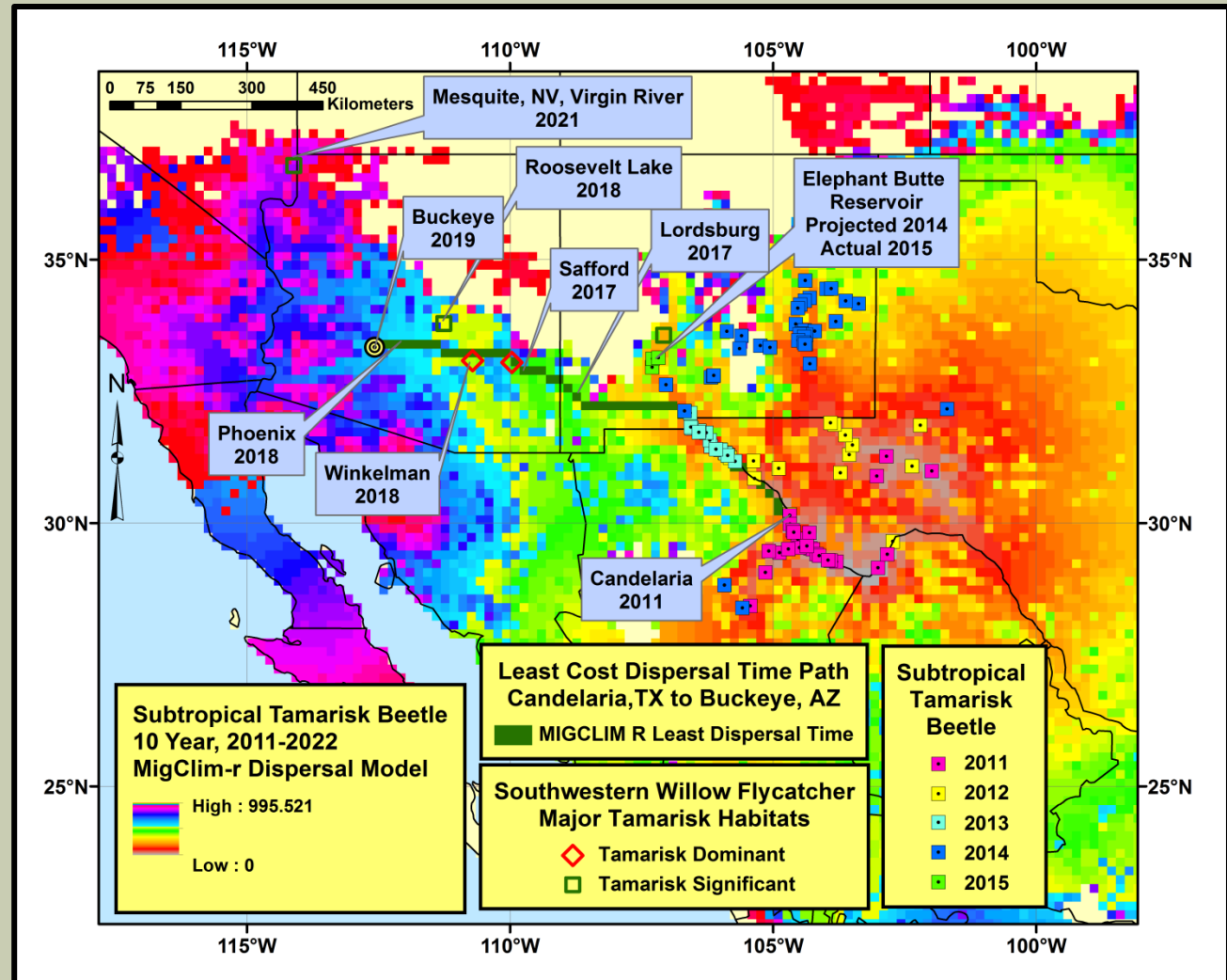
North America Albers Equal-Area Conic Projection, GCS North American 1983 Datum



# Subtropical tamarisk beetle dispersal projected from 2011- 2022



- Final model incorporates functional connectivity and represents mean of 10 individual model runs using optimal dispersal kernel yielding maximum of ca. 210 km dispersal per year.





# *Coniatus splendidulus* – Splendid tamarisk weevil



A)



B)

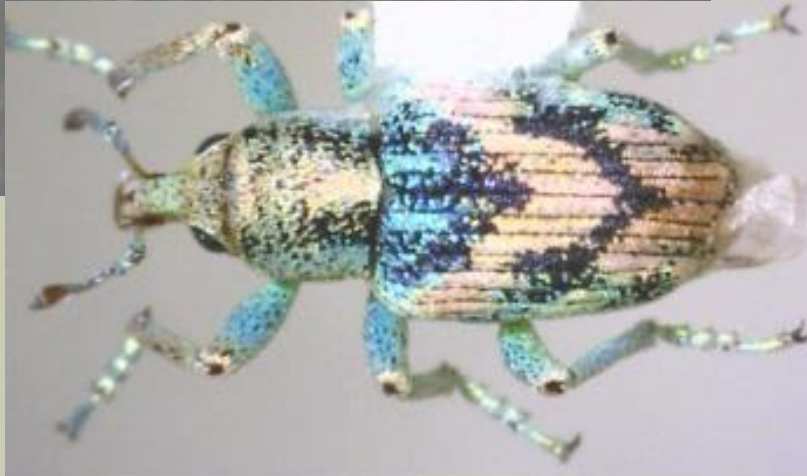


C)



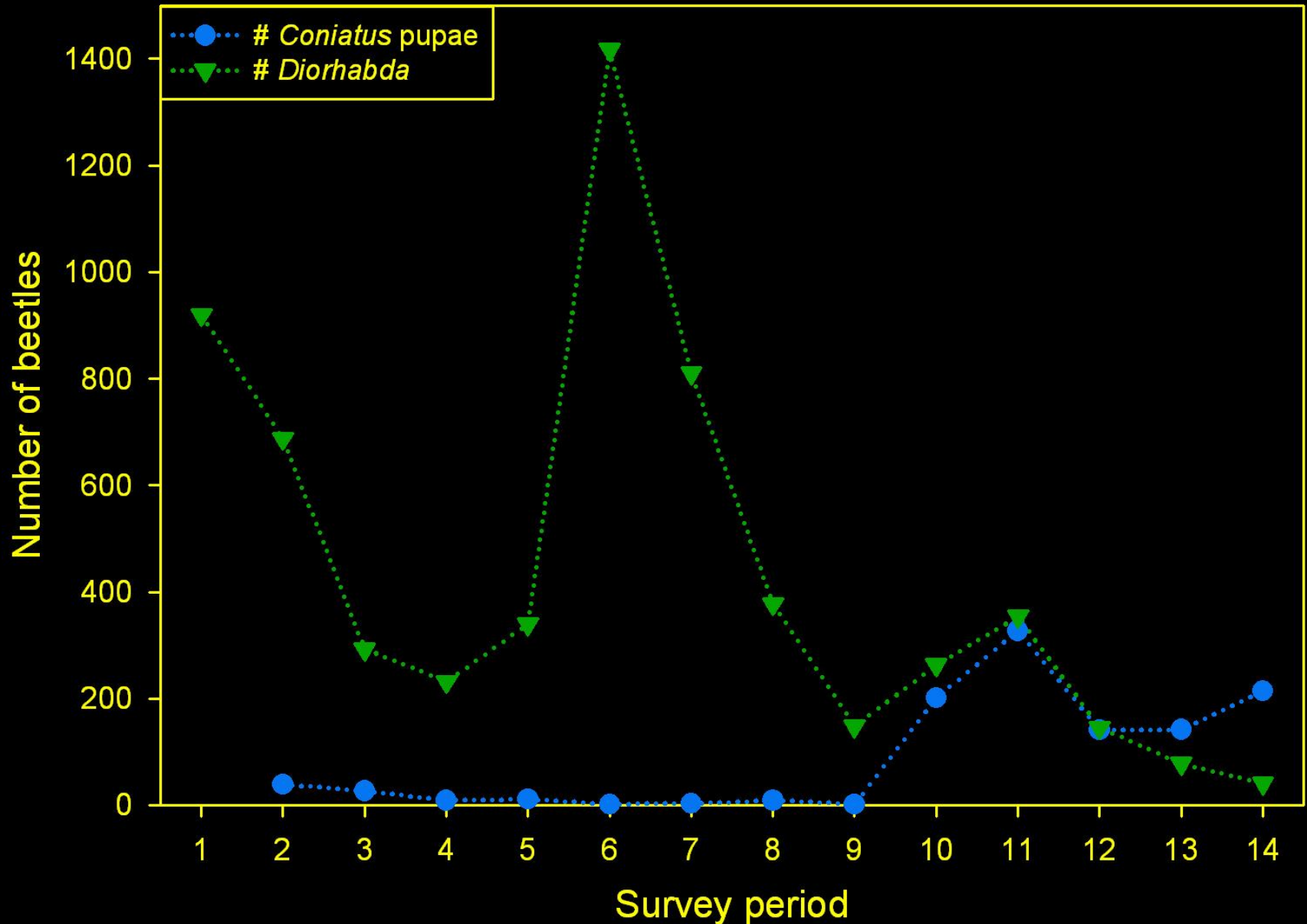
D)





*Coniatus splendidulus*

Number of *Coniatus splendidulus* pupal cases and number of *Diorhabda carinulata* at each site during 2012 beetle monitoring season.





*Coniatus* begin feeding earlier in the spring and remain active later in the summer/fall than *Diorhabda*



Tamarisk branch collected September 28. *Diorhabda* have been in diapause for about 30 days, *Coniatus* populations have exploded on the regrowth. Adults abundant, baskets abundant on branches with regrowth.



*Coniatus splendidulus*

