River flooding and its impacts on large-scale biocontrol of Tamarix along the Virgin River: moving targets and trajectories

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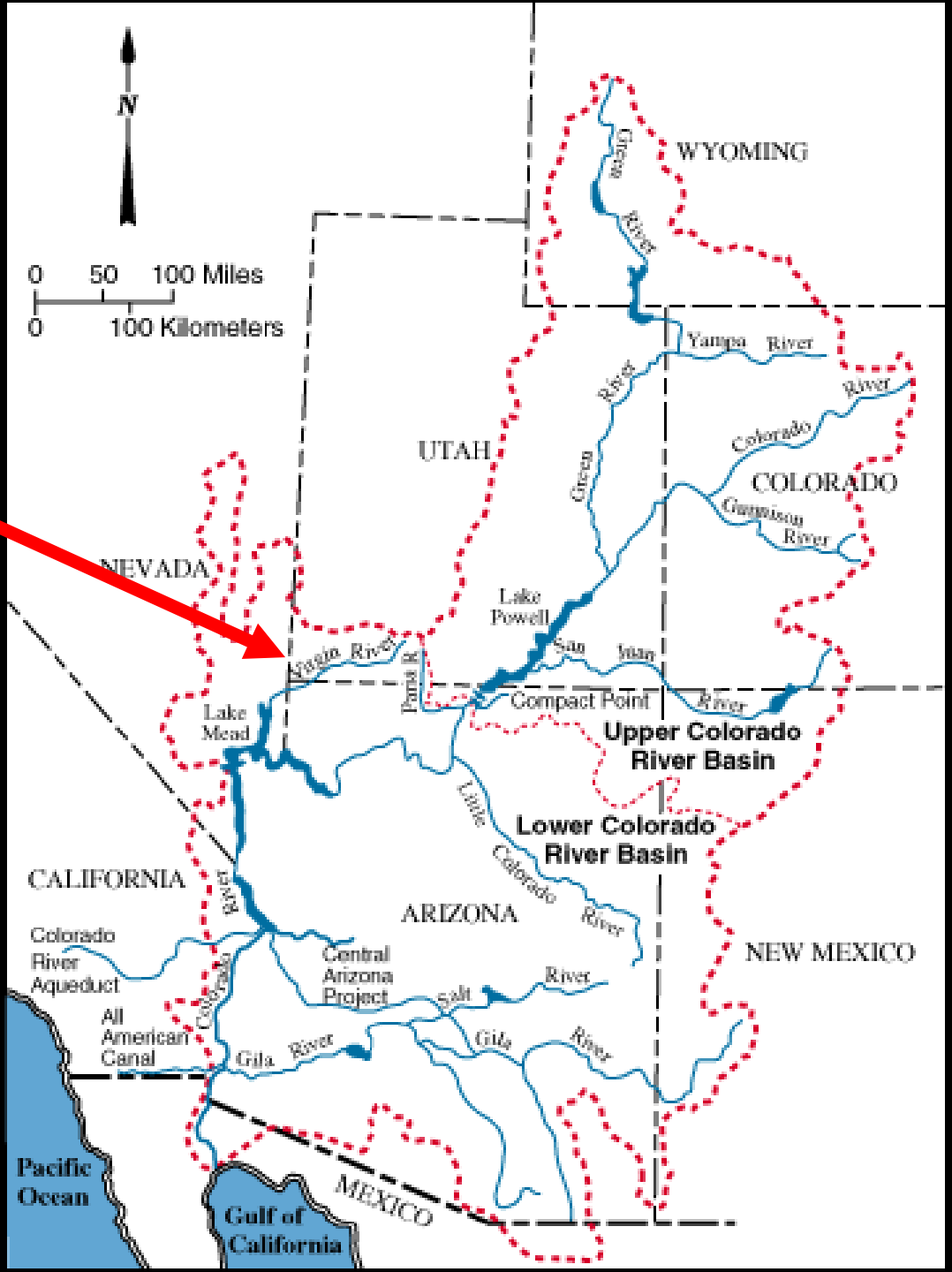
Steven M. Ostoja[3], Matthew L. Brooks[1]

Virgin River

Last major river above Lake Mead




USGS

Habitat

Photo: https://ecos.fws.gov/

USGS

X

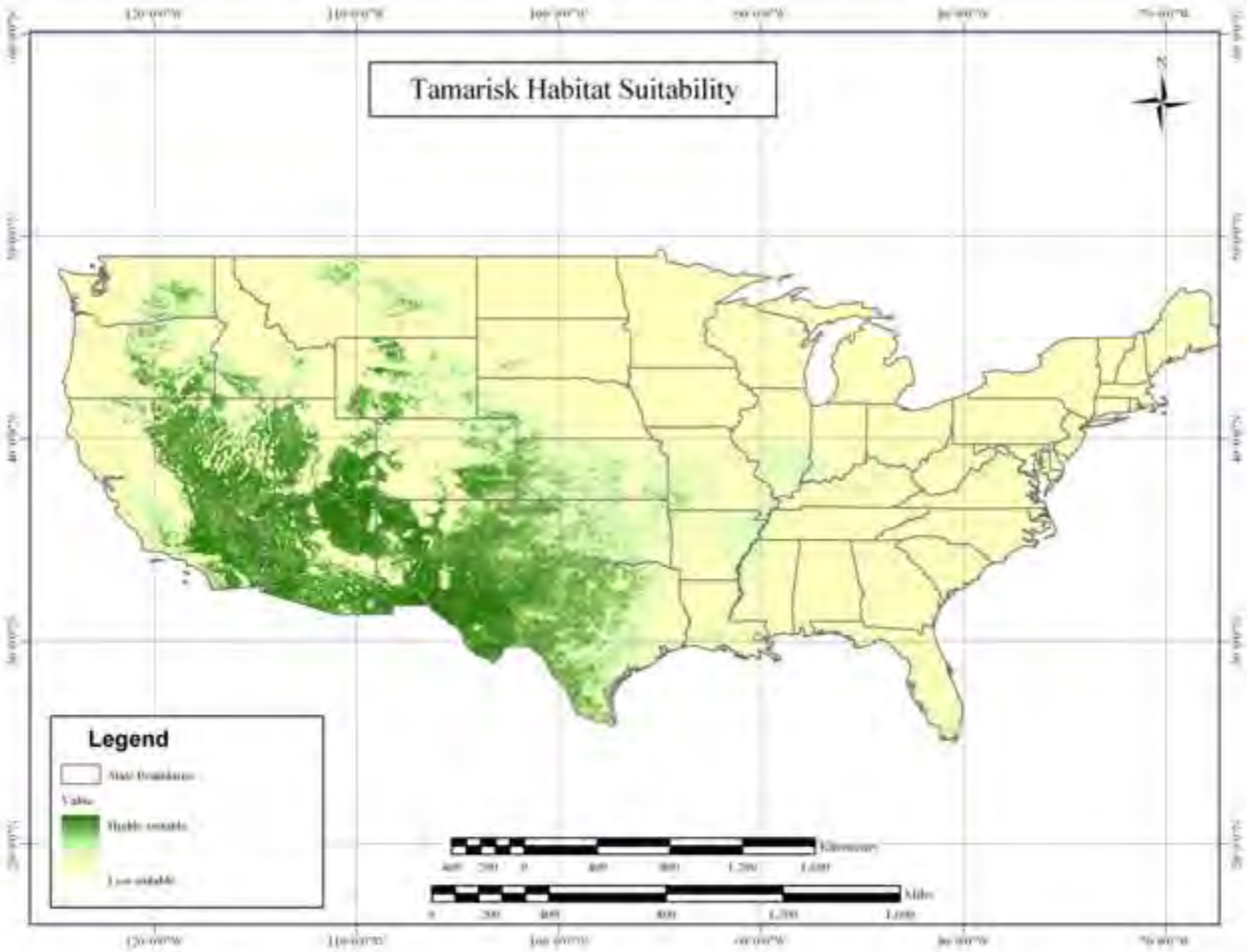
Tamarix ramossissima

Diorhabda sp.

USGS

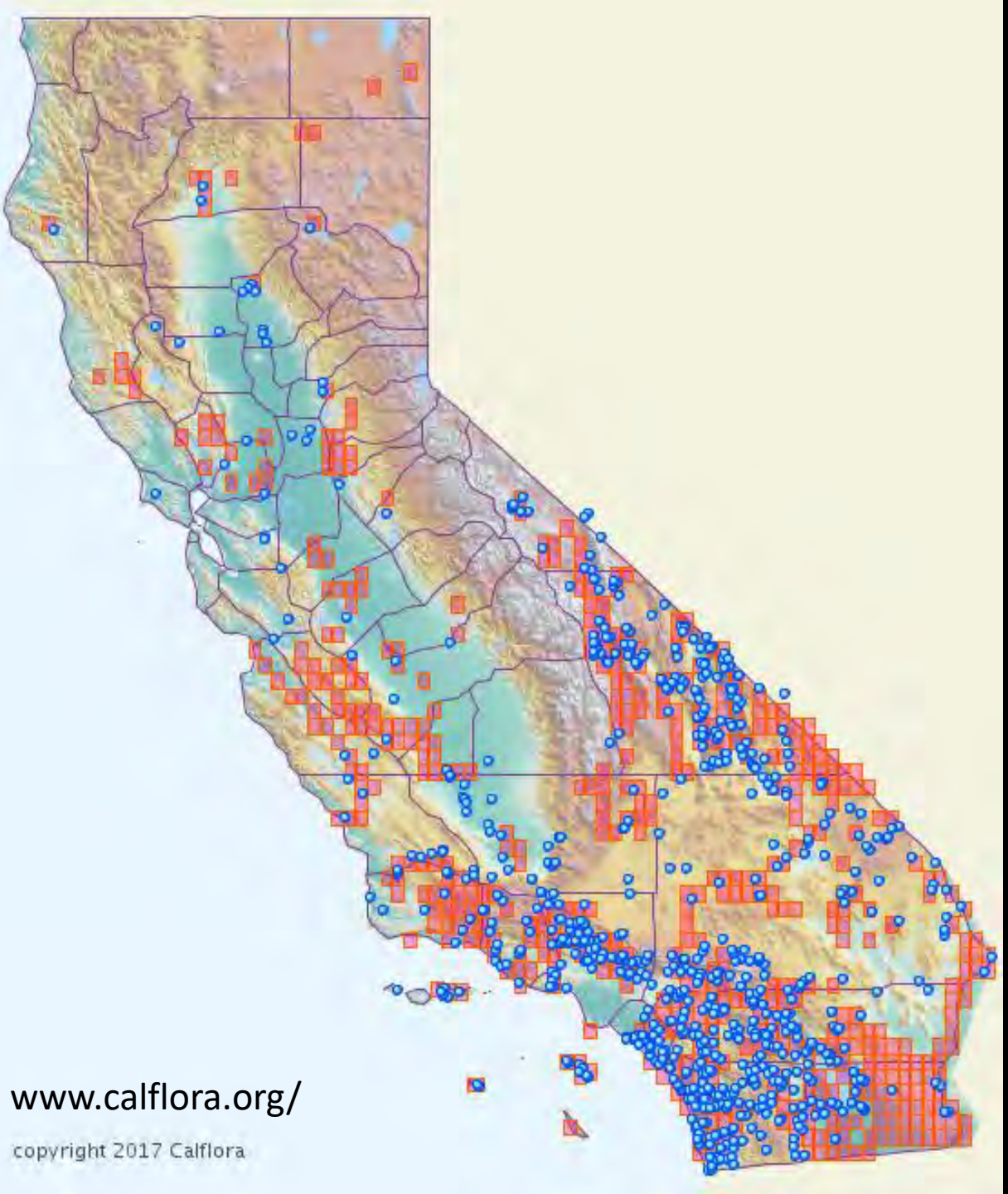
National Tamarisk Habitat Map

- This national map of habitat suitability for tamarisk was developed to aid land managers in early detection of this invasive plant species
- The map produced by combining MODIS satellite products (vegetation indices and land cover type) with field observations to predict suitable habitat for tamarisk.



Morisette, J.T., C. S. Jernevich, A. Ullah, W. Cai, J.A. Pedelty, J. Gentle, T.J.Stohlgren, J.L. Schnase, A tamarisk habitat suitability map for the continental US., *Frontiers in Ecology and the Environment*, Volume 4, Issue 1 (February 2006) pp. 11–17

https://www.fort.usgs.gov/sites/default/files/RAM/slide.html


www.calflora.org/
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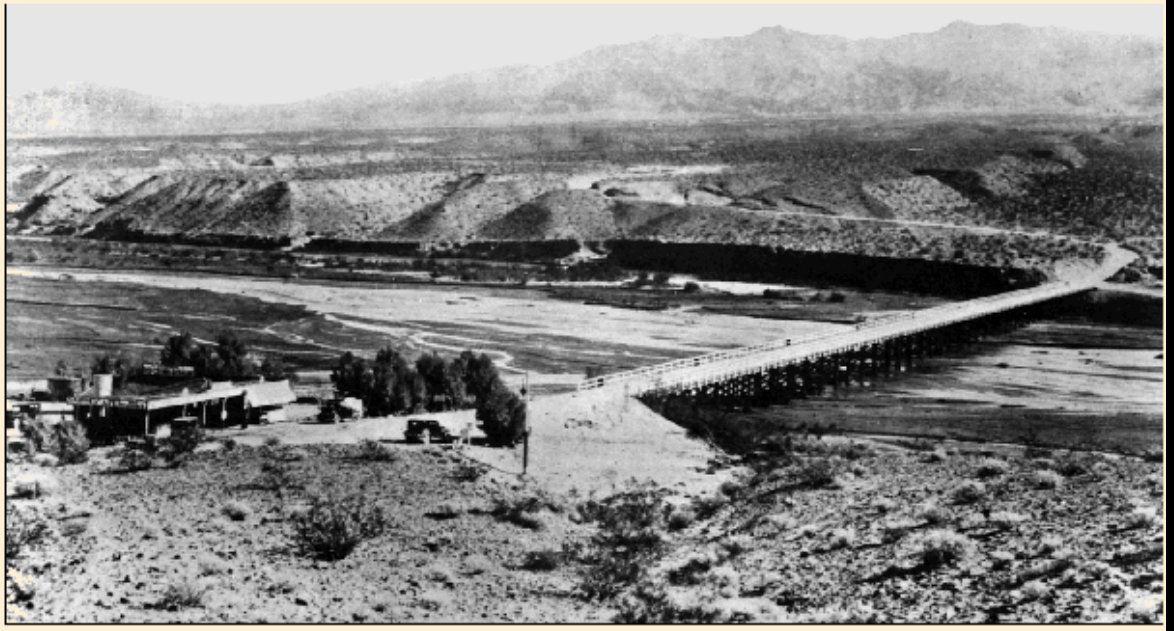
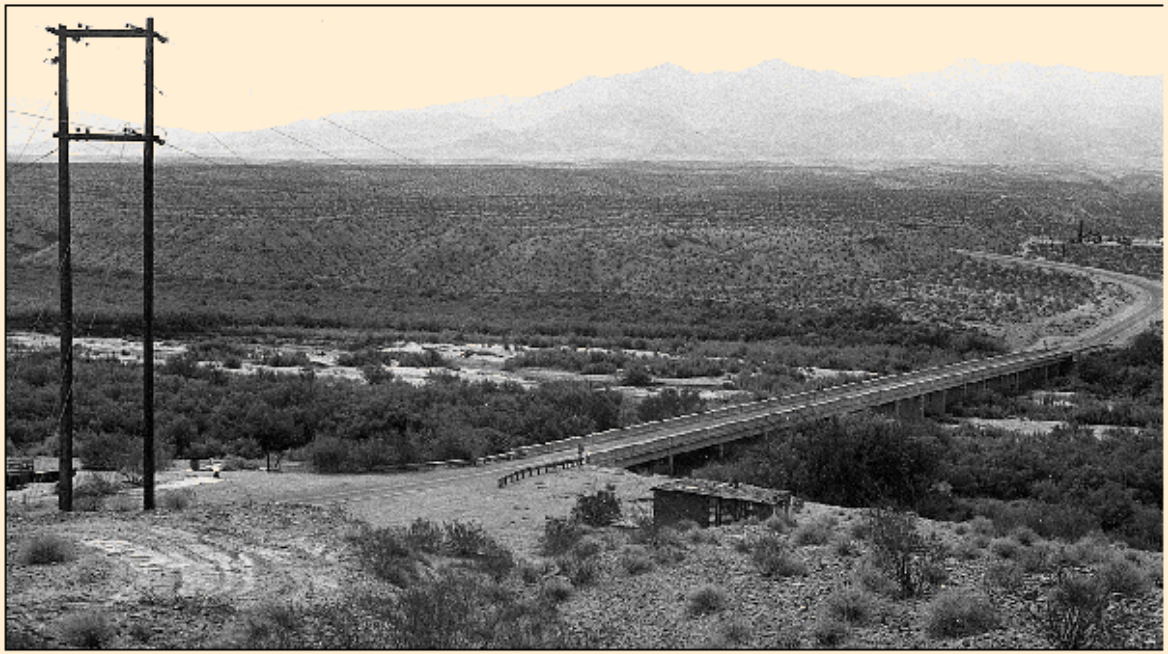
1920's

No Tamarix

A.



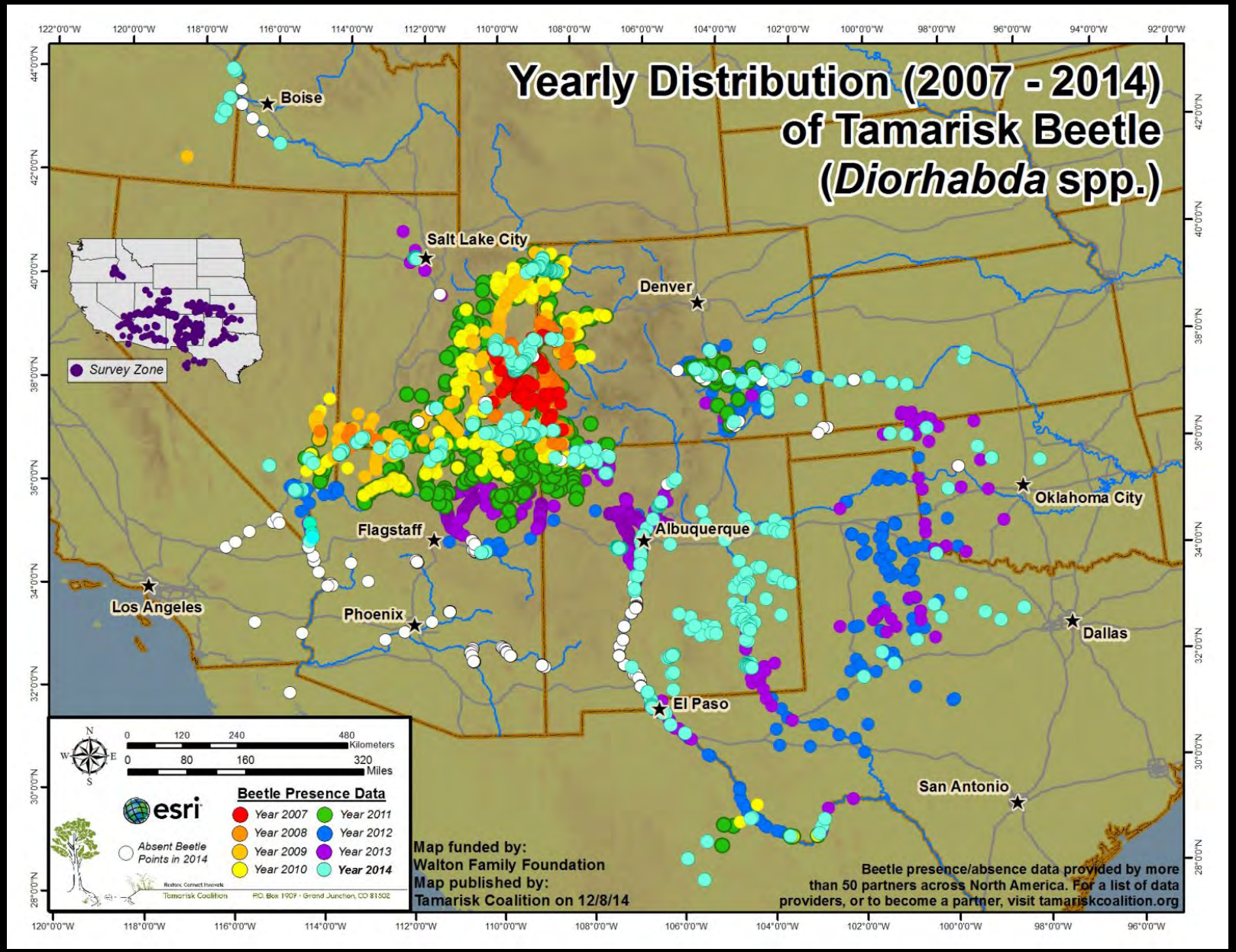
B.



1996

Tamarix

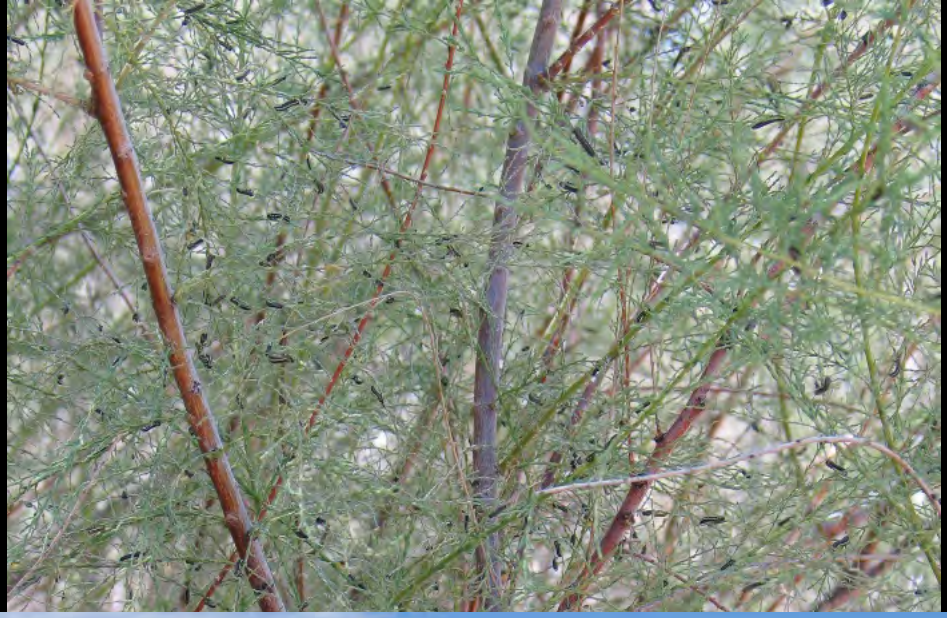
USGS



http://www.tamariskcoalition.org/events/tamarisk-beetle-maps

Biological control

- Defoliation; branch or tree mortality
- Reduced competition for above and belowground resources
- changes to litter
- changes to seed supply



X

Tamarix ramossissima

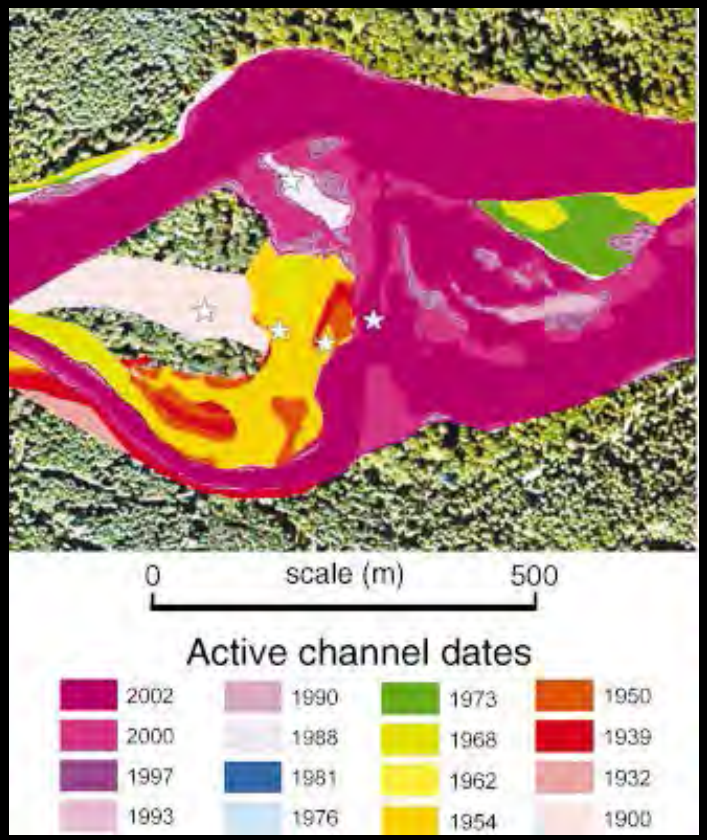
Diorhabda sp.

USGS

?

Drivers of riparian vegetation dynamics:

- Biological processes (e.g., succession, herbivory, pathogens)
- Physical processes (e.g., floods, and associated fluvial processes)



Floods

- Drive fluvial processes
  - > meandering
  - > widening, narrowing

- sediment deposition, erosion
- create physical disturbance

- moisten sediments
- flush salts
- remove vegetation
- magnitude, frequency, duration, timing, change
- sequencing of floods is important

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Large flood – December 2010

- Peak discharge: 31,000 f^3/s (878 m^3/s)
- ~ 20-25 year recurrence interval

USGS

X

X

USGS

Something new

USGS

Something new

Something new

Objectives – Virgin River riparian vegetation

1) understand effects of a large flood

2) understand effects of biological control

3) explore interactive effects of flooding and biological control

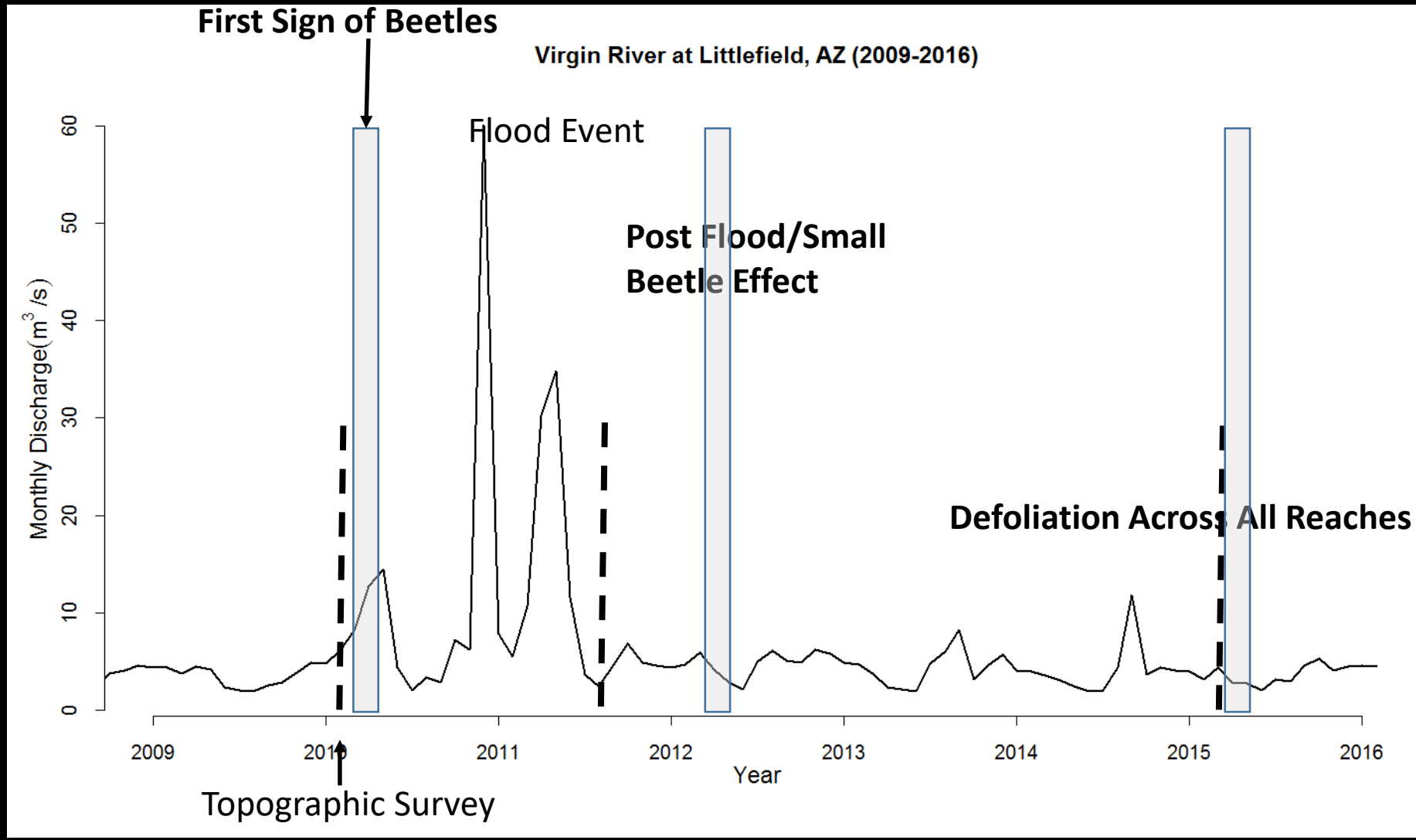
Biological control – 2010 - 2017

- Effects most pronounced after 2012

- Arrived in 2010, small/moderate effect by late 2012, large effect by 2014 (Hultine et al. 2015)

Timeline of events and field work

- *2009-2010* – pre-beetle, pre-flood
- *2011-2012* – post-flood, small beetle effect
- *2015* – after large beetle effect


First Sign of Beetles
Virgin River at Littlefield, AZ (2009-2016)
Flood Event
Post Flood/Small Beetle Effect
Defoliation Across All Reaches
Monthly Discharge(m3/s)
0
10
20
30
40
50
60
2009
2010
2011
2012
2013
2014
2015
2016
Year
Topographic Survey

METHODS

- 24 transects, 5 reaches, ~60 river km

- transect length between190 and 665 m; extend from upland to channel.

- 2x5m plots every 20m. 511 plots total

- Cover estimated for every species in plots (2010, 2012, 2015, 2017)

- Soil samples collected near each plot in 2010 and in 2012. Analyzed for electrical conductivity (EC, a measure of salinity), and soil texture (% sand, silt, and clay).

- Elevation and topographic position of transects and plots measured in 2010 (before flood), 2011 (after flood), and 2015.

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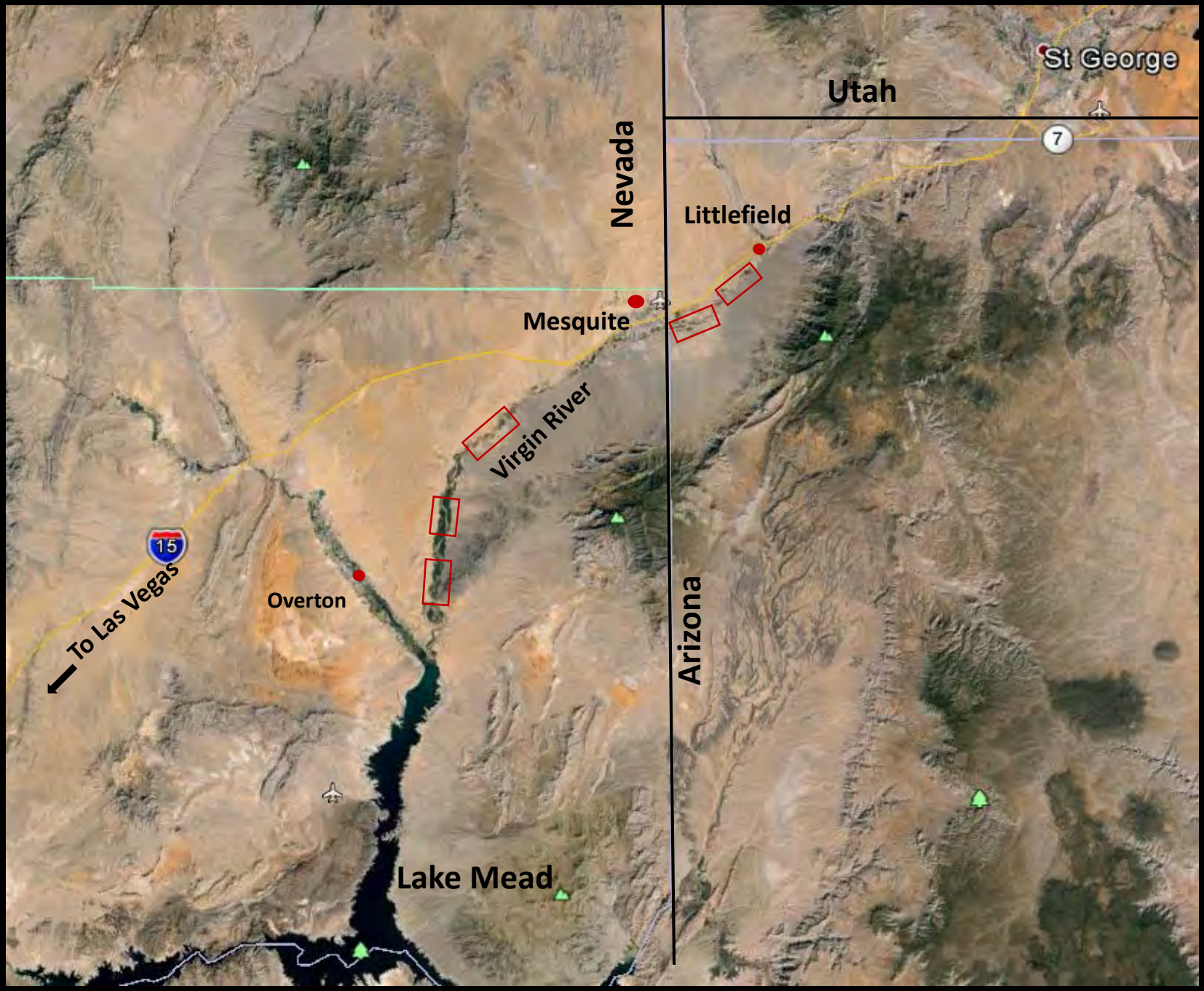
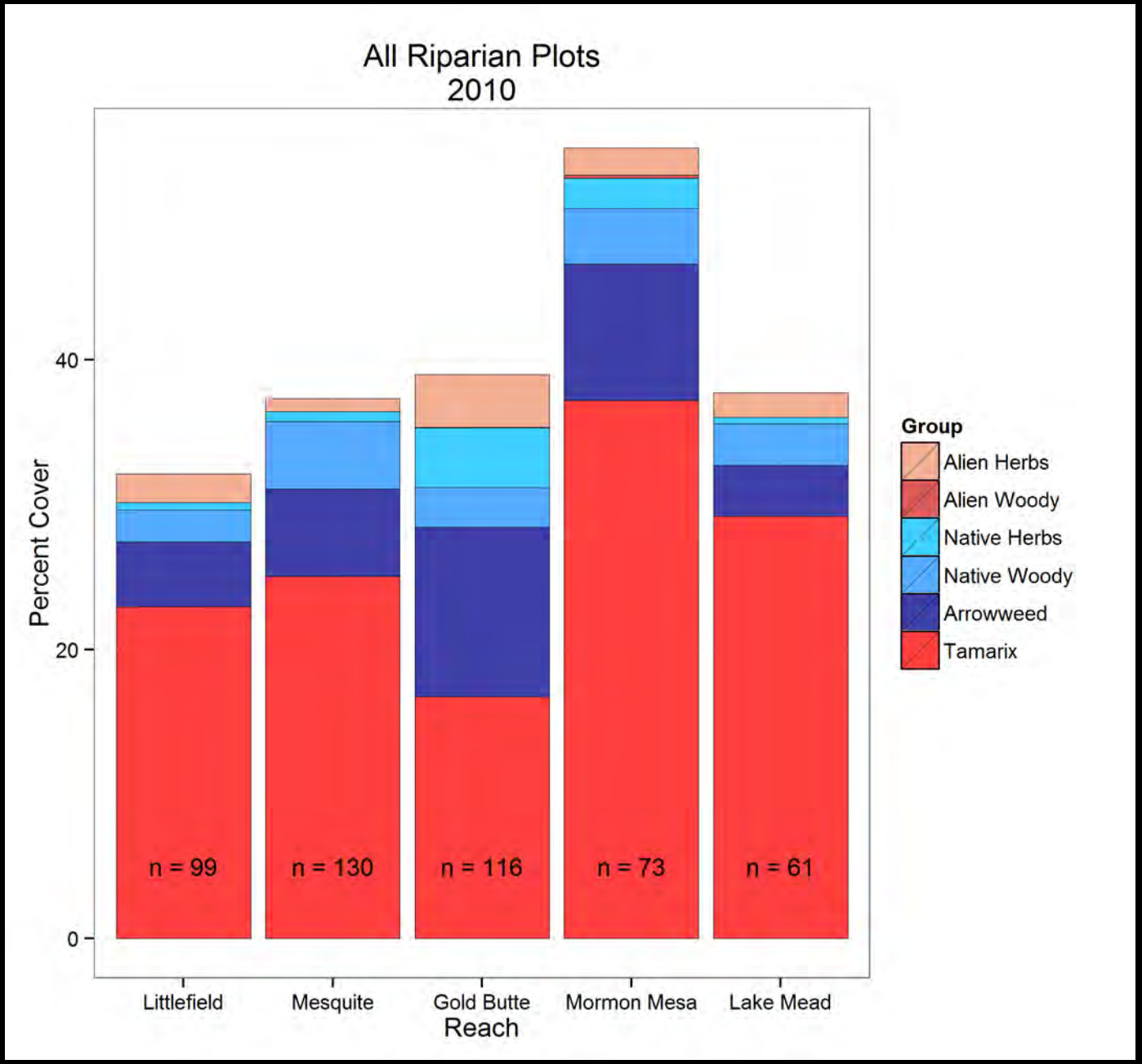
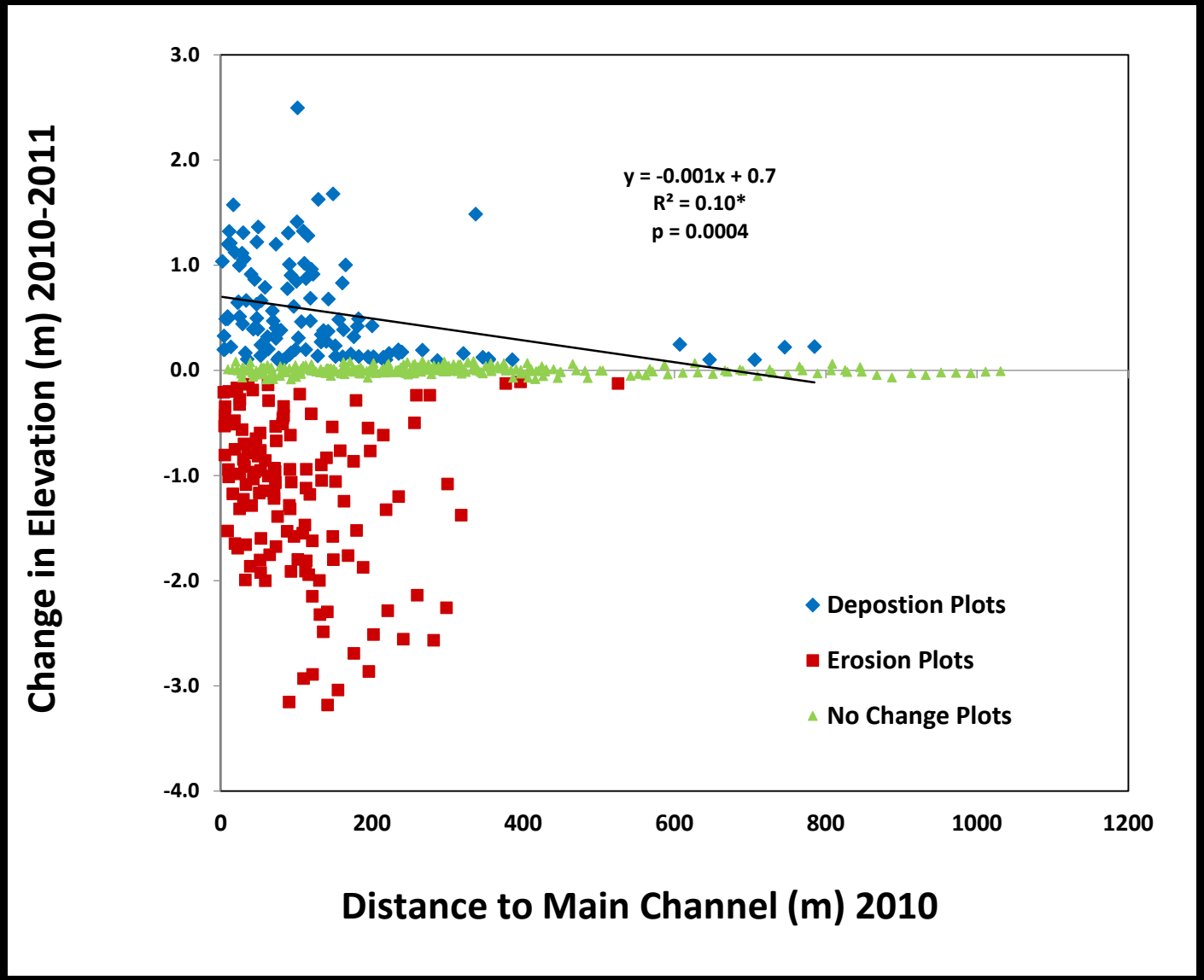
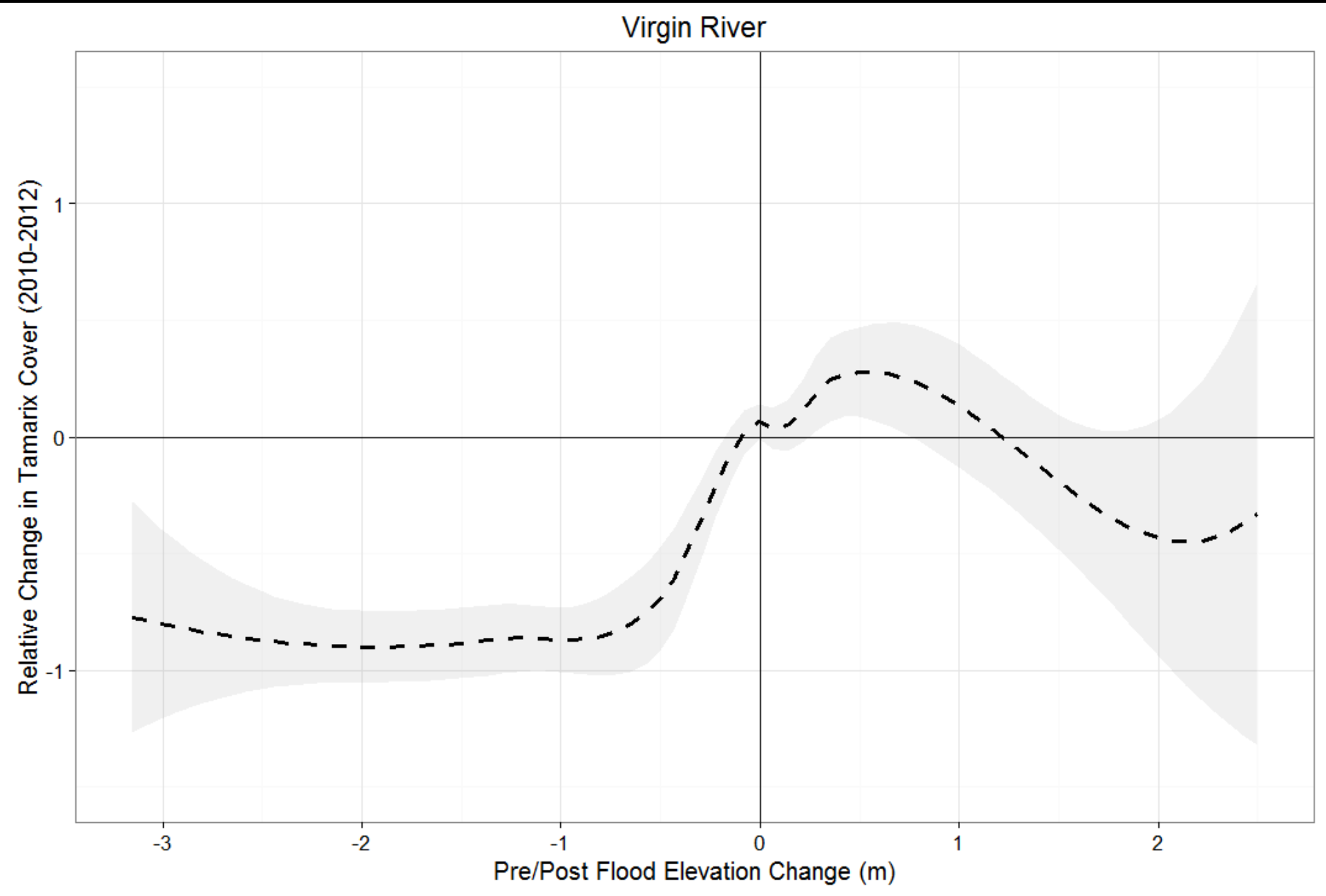

St George
Utah
Nevada
7
Littlefield
Mesquite
Virgin River
15
To Las Vegas
Overton
Arizona
Lake Mead


All Riparian Plots
2010
Percent Cover
40
20
0
n = 99
n = 130
n = 116
n = 73
n = 61
Littlefield
Mesquite
Gold Butte
Mormon Mesa
Lake Mead
Reach
Group
Alien Herbs
Alien Woody
Native Herbs
Native Woody
Arrowweed
Tamarix

Effects of flood – topographic change

- Plots classified as “erosion”, “deposition”, or “no change”
- 10 cm +/- vertical change

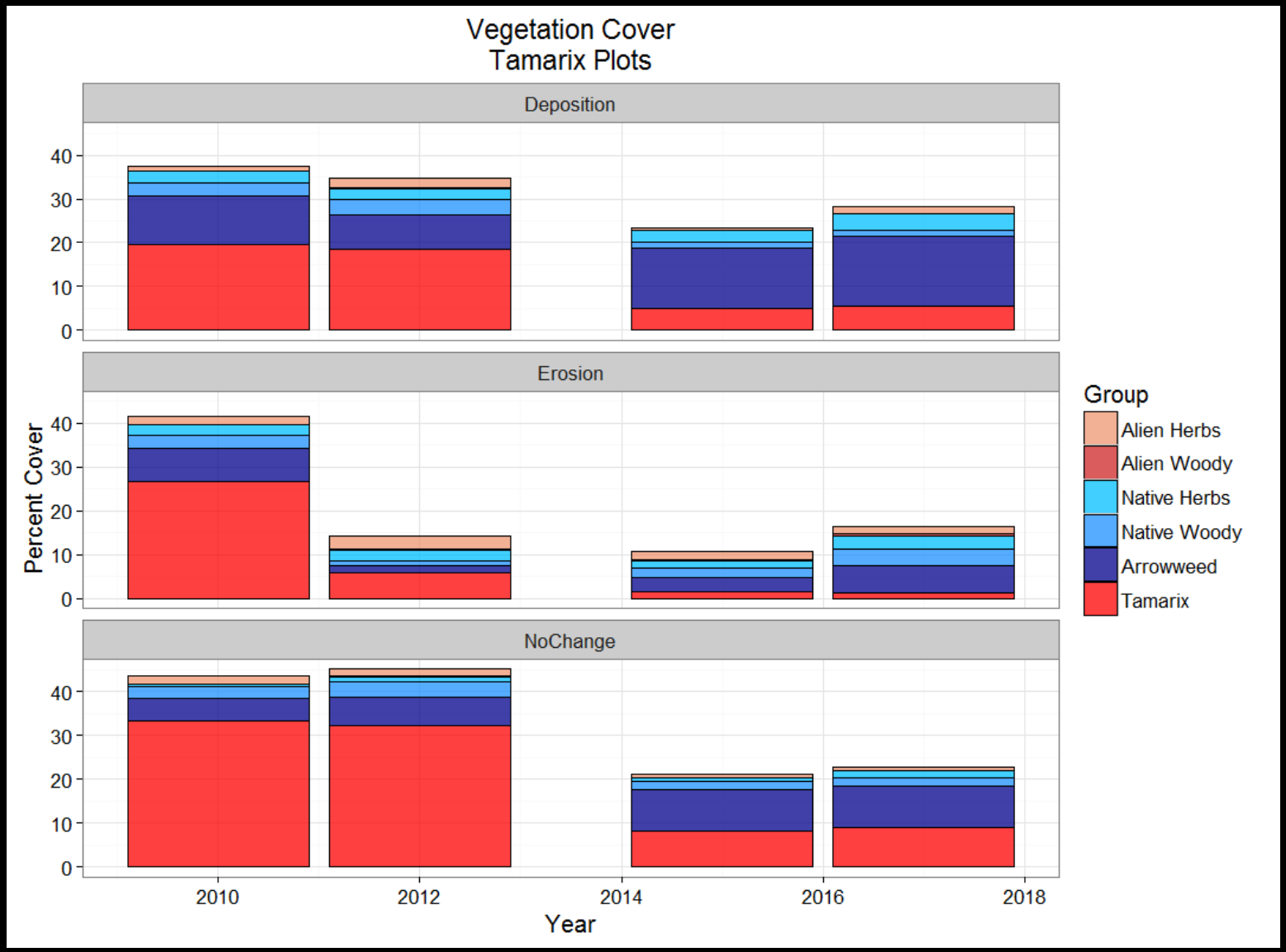

Change in Elevation (m) 2010-2011
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
0
200
400
600
800
1000
1200
Distance to Main Channel (m) 2010
y = -0.001x + 0.7
R² = 0.10*
p = 0.0004
Depostion Plots
Erosion Plots
No Change Plots


Virgin River
Relative Change in Tamarix Cover (2010-2012)
1
0
-1
-3
-2
-1
0
1
2
Pre/Post Flood Elevation Change (m)

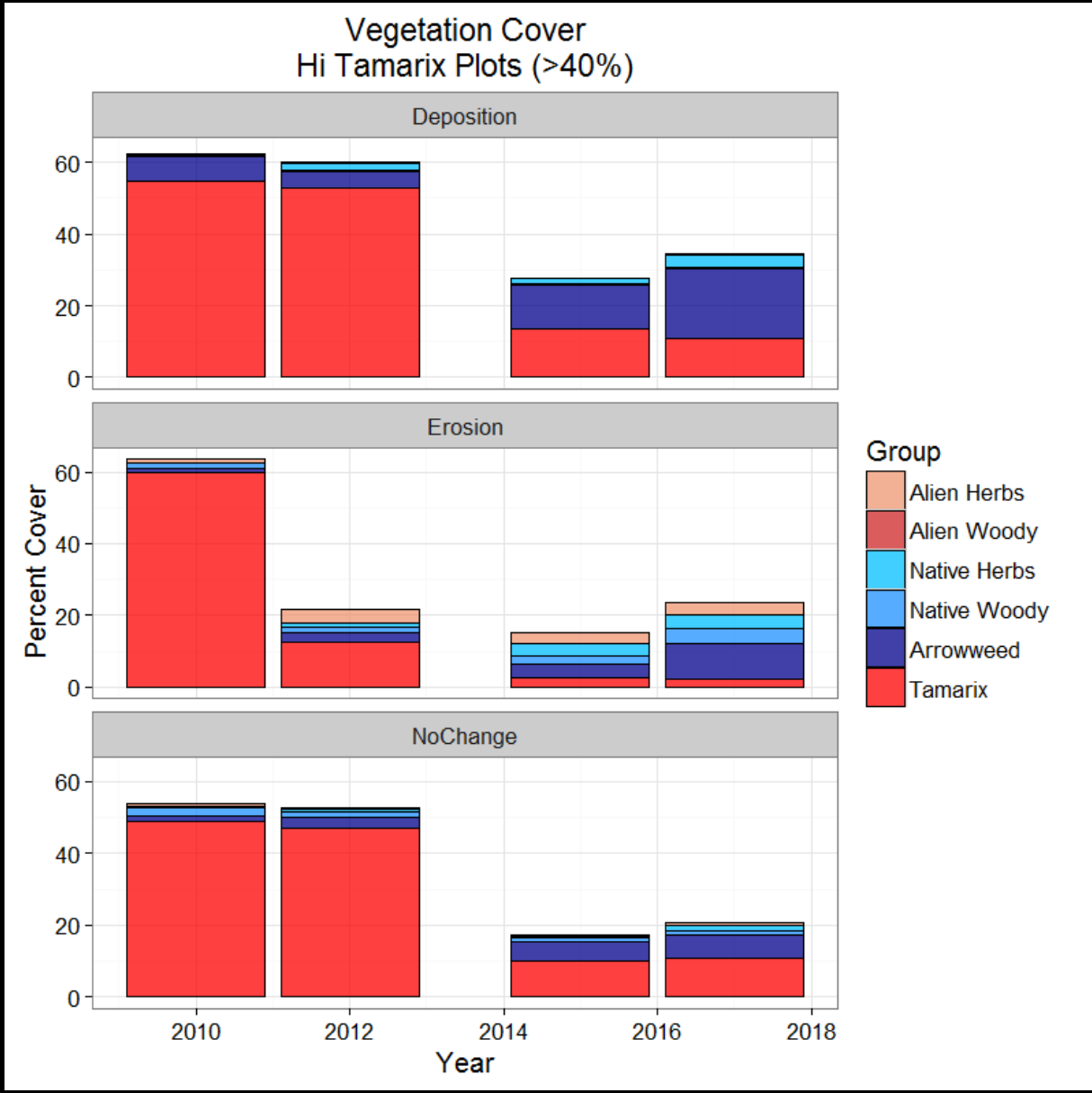
Effects of flood and biocontrol on vegetation cover

Effects of flood and biocontrol on vegetation cover

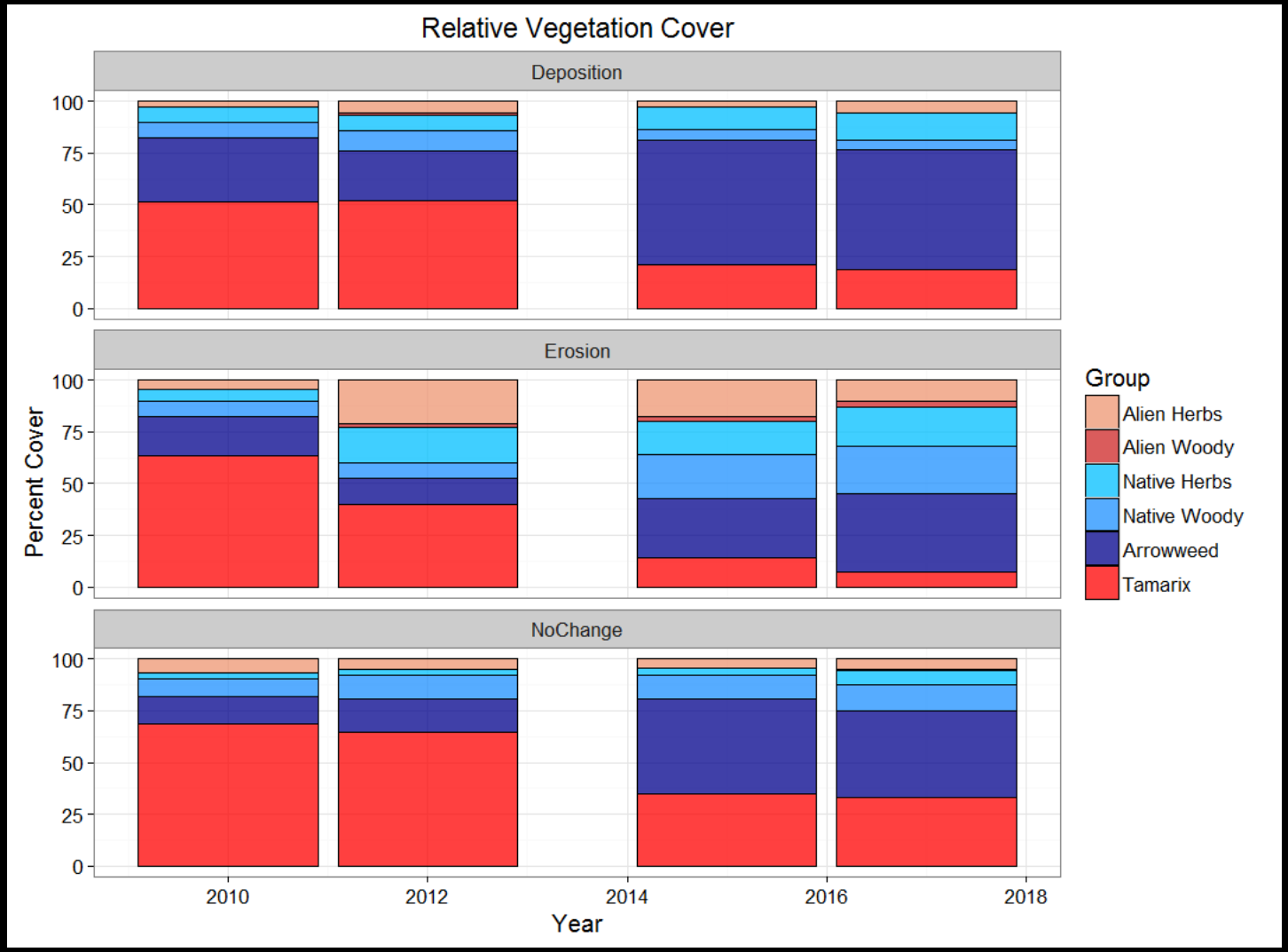
All *Tamarix* plots, absolute cover



Dense stands of Tamarix, absolute cover



All *Tamarix* plots, relative cover



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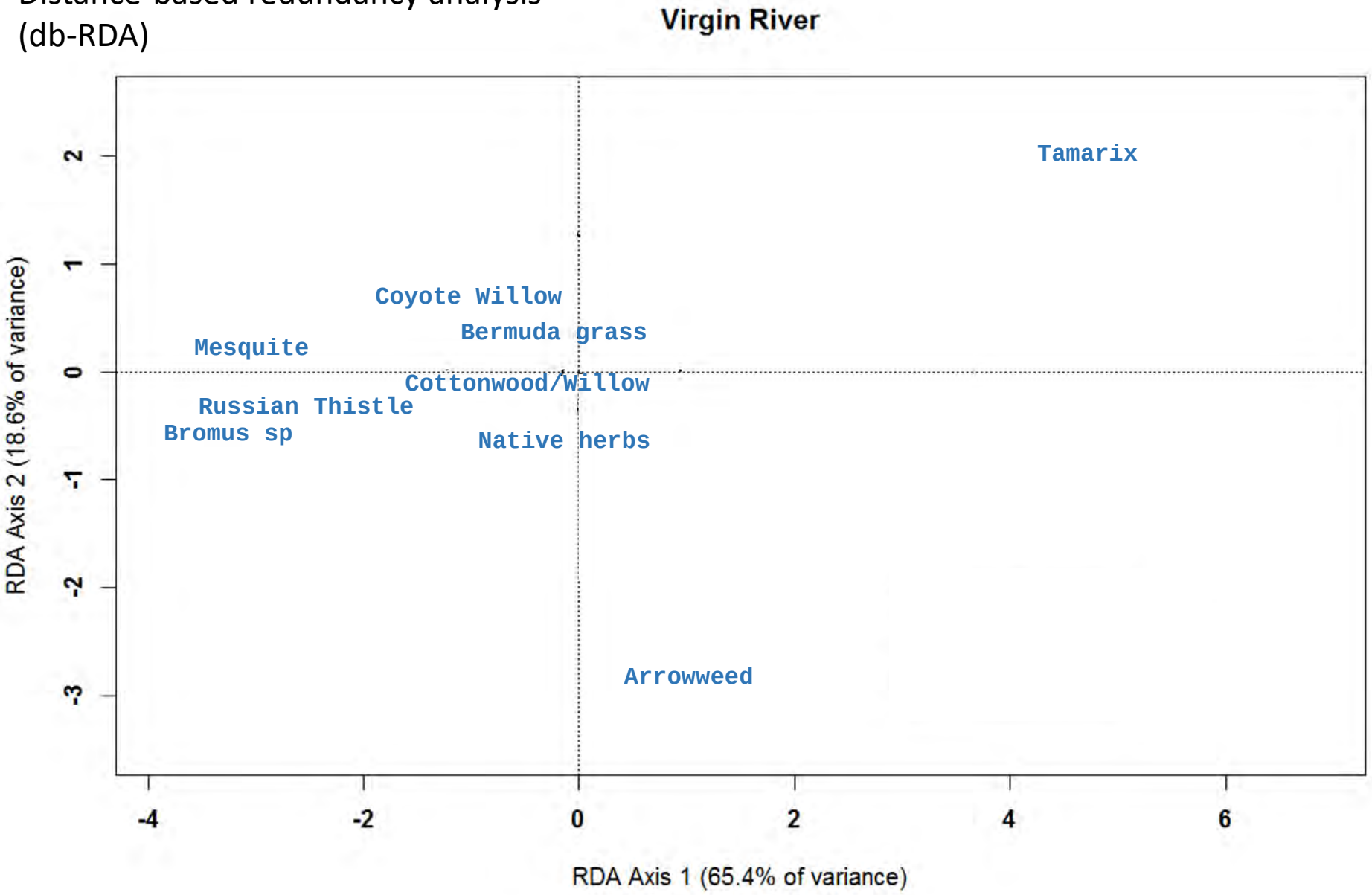
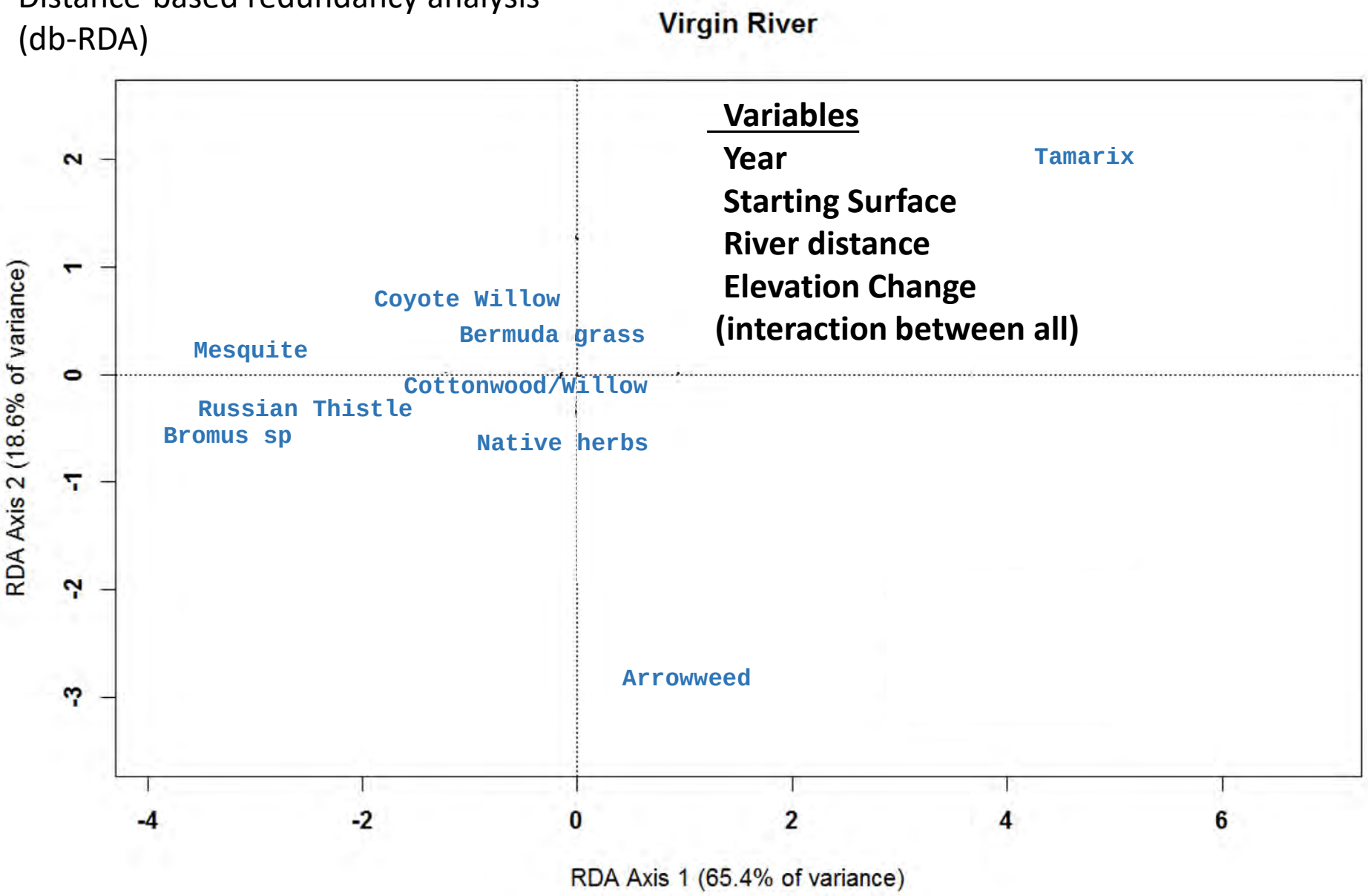
Where is it going?


Lower
Floodplain
Terrace
Floodplain

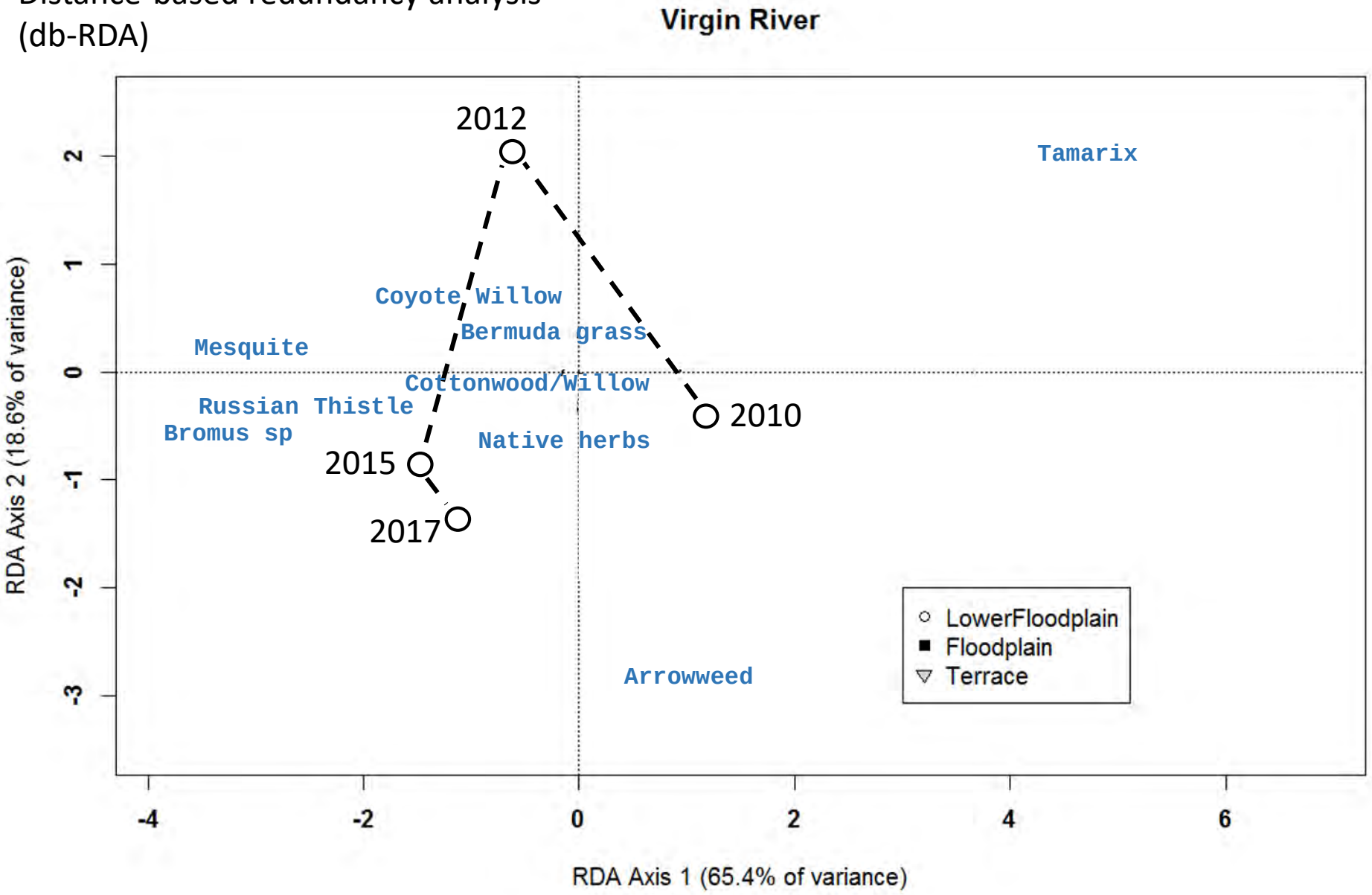
Distance-based redundancy analysis (db-RDA)



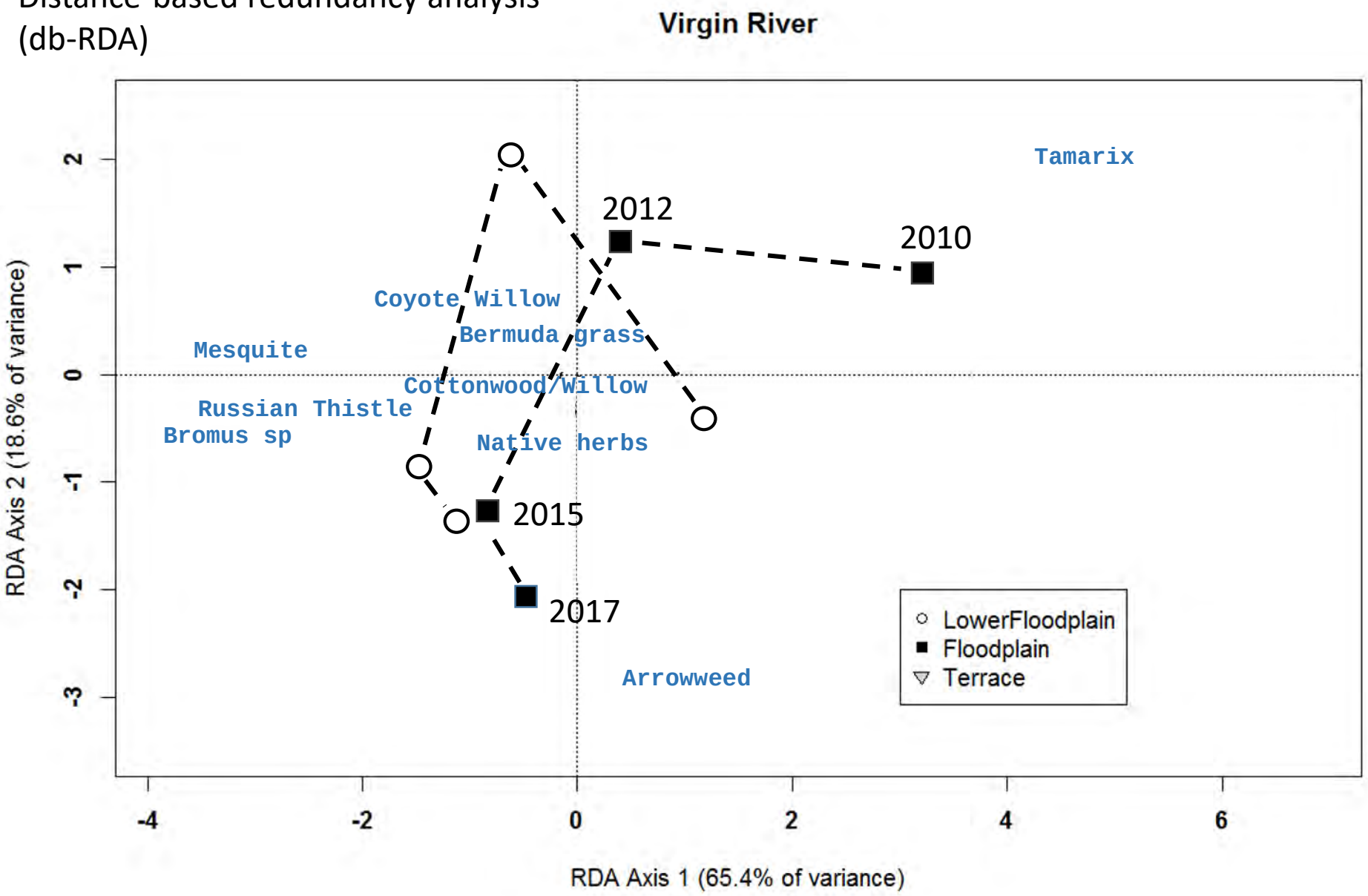
Distance-based redundancy analysis (db-RDA)



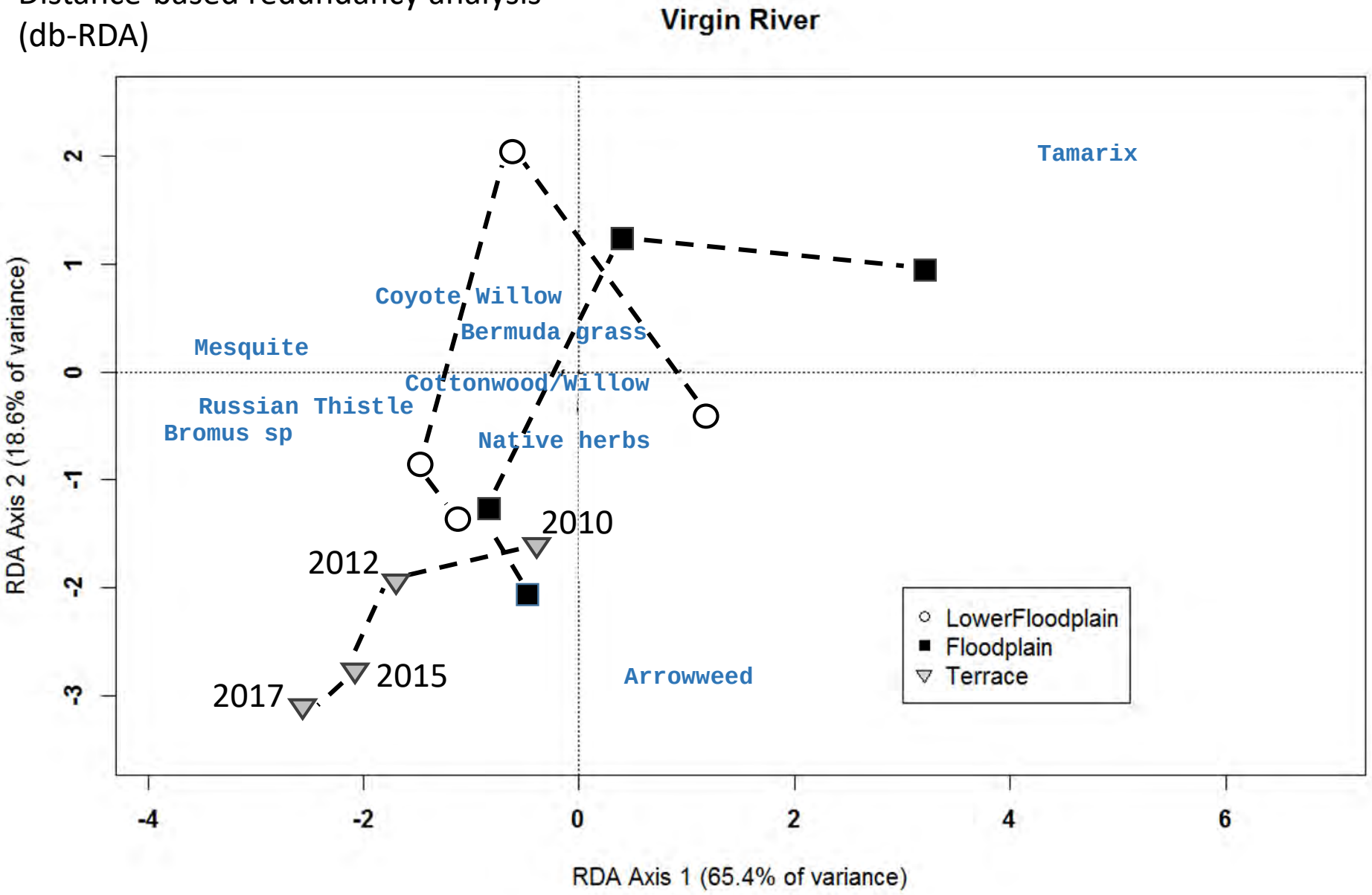
Distance-based redundancy analysis (db-RDA)



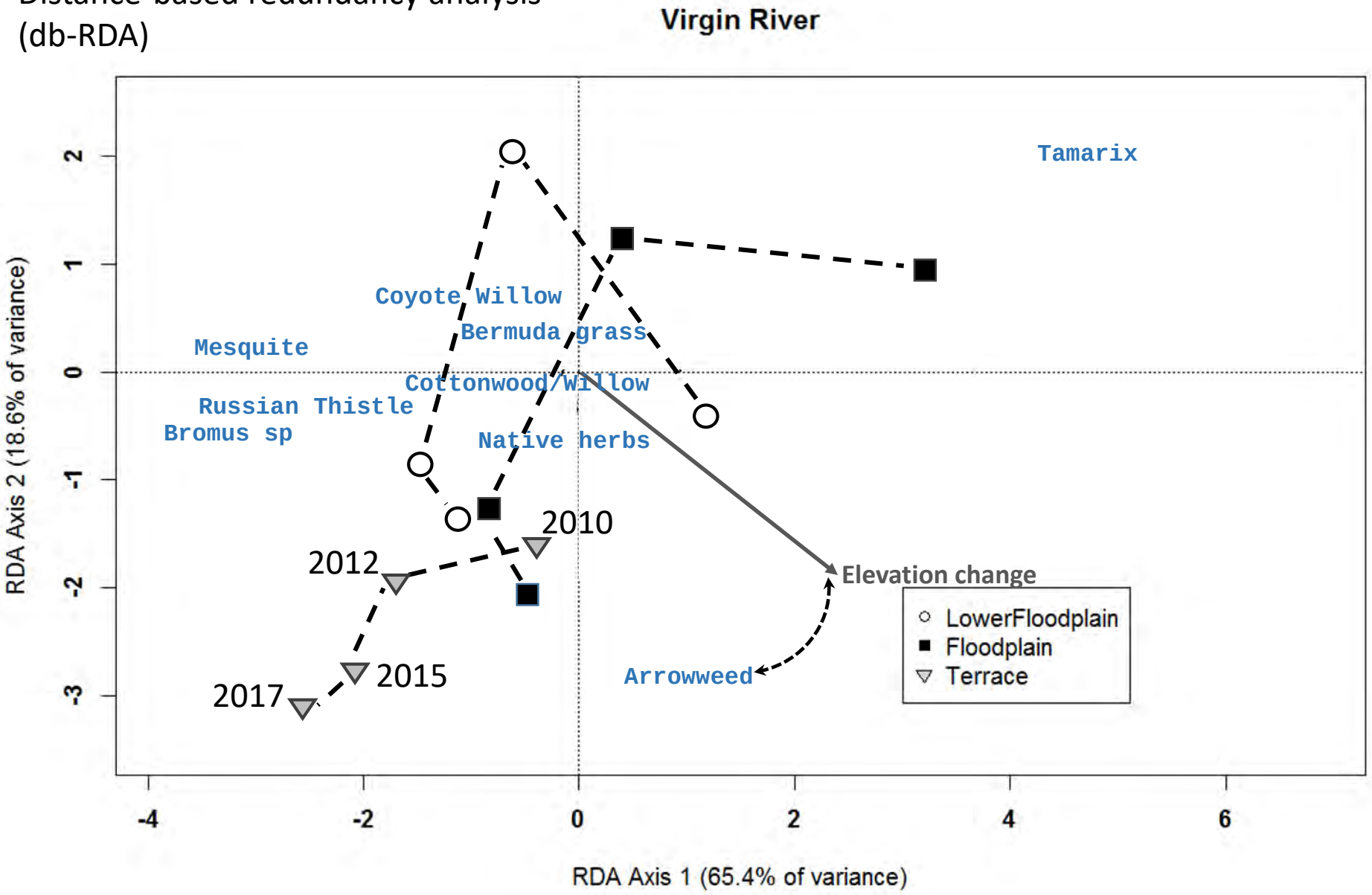
Distance-based redundancy analysis (db-RDA)



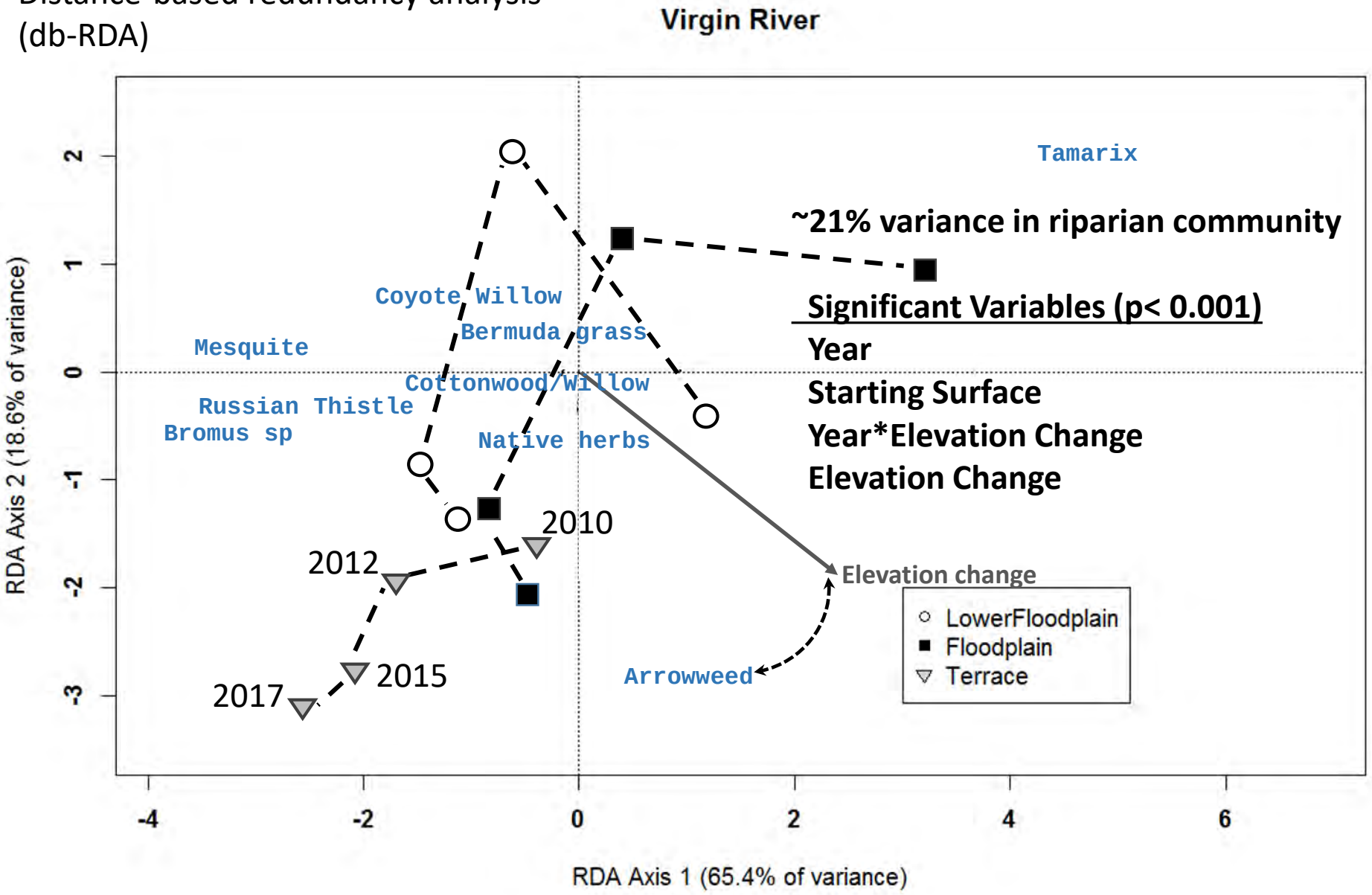
Distance-based redundancy analysis (db-RDA)



Distance-based redundancy analysis (db-RDA)



Distance-based redundancy analysis (db-RDA)



More mixed community

Slow recruitment of woody species in densest stands

Some invasive herbs and grasses

Water use?

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

Vol. 49, No. 3

AMERICAN WATER RESOURCES ASSOCIATION

June 2013

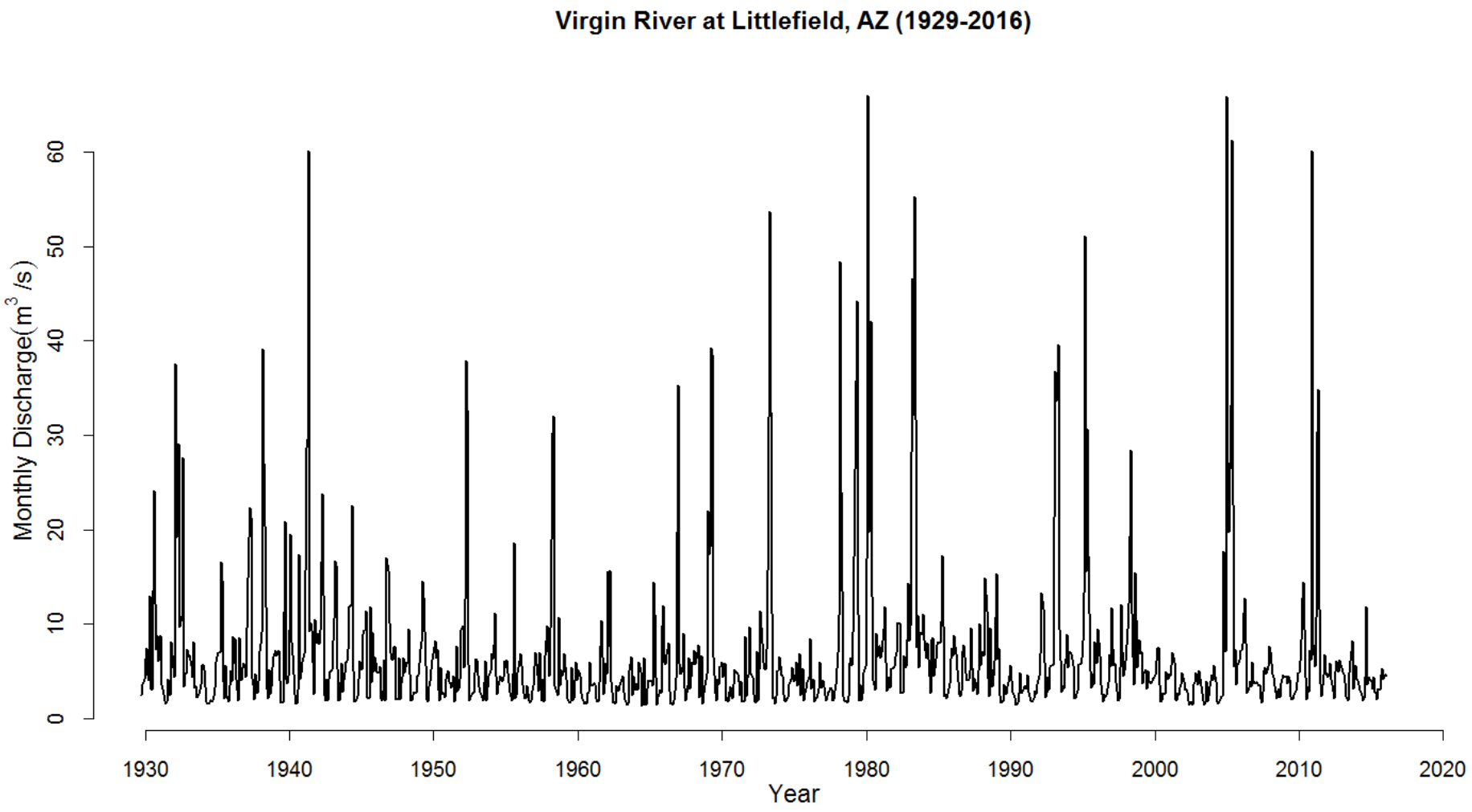
TAMARIX AND *DIORHABDA* LEAF BEETLE INTERACTIONS: IMPLICATIONS FOR *TAMARIX* WATER USE AND RIPARIAN HABITAT[1]

Pamela Nagler and Edward Glenn[2]

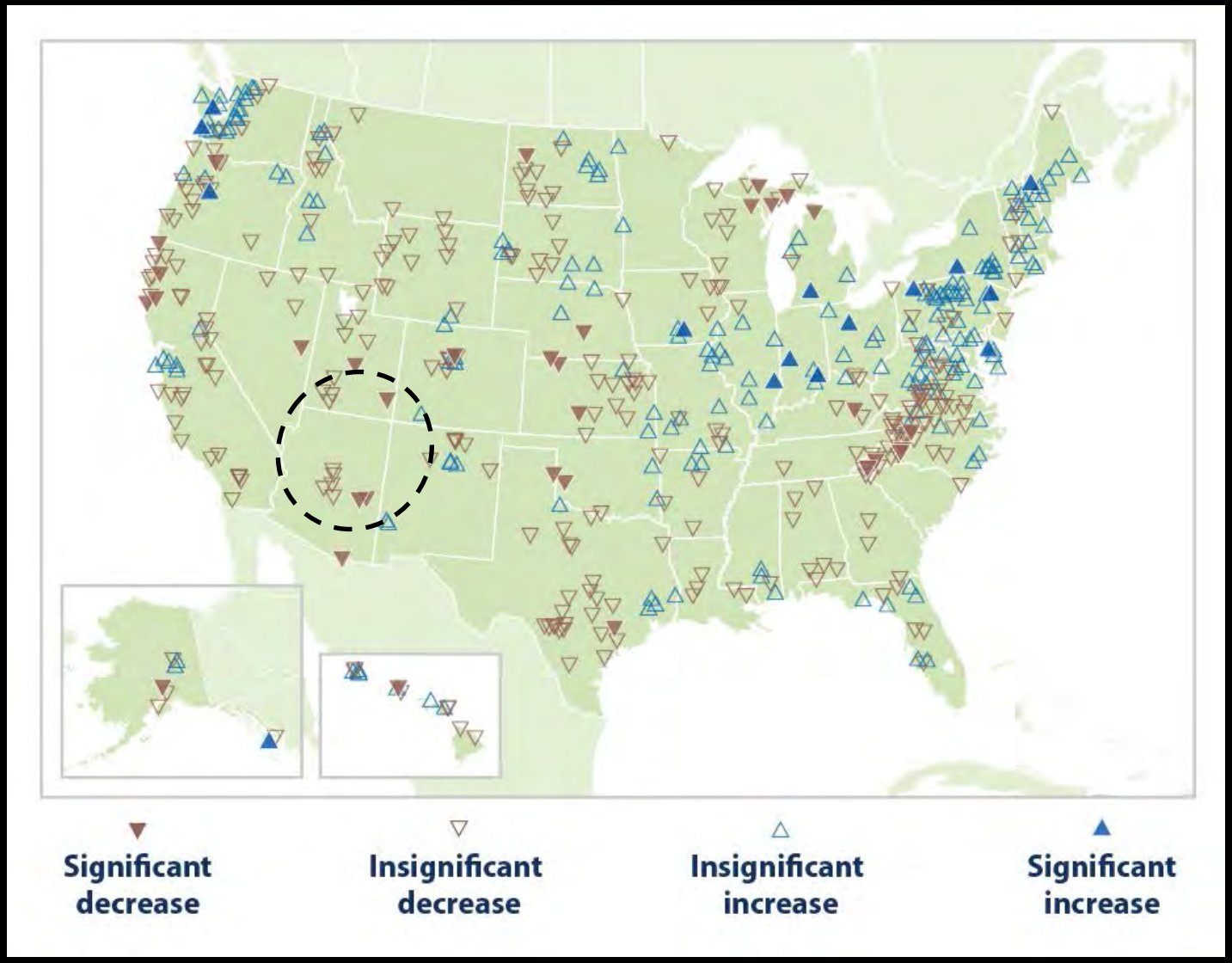
ABSTRACT: *Tamarix* leaf beetles (*Diorhabda carinulata*) have been widely released on western United States rivers to control introduced shrubs in the genus *Tamarix*, with the goals of saving water through removal of an assumed high water-use plant, and of improving habitat value by removing a competitor of native riparian trees. We review recent studies addressing three questions: (1) to what extent are *Tamarix* weakened or killed by recurrent cycles of defoliation; (2) can significant water salvage be expected from defoliation; and (3) what are the effects of defoliation on riparian ecology, particularly on avian habit? Defoliation has been patchy at many sites, and shrubs at some sites recover each year even after multiple years of defoliation. *Tamarix* evapotranspiration (ET) is much lower than originally assumed in estimates of potential water savings, and are the same or lower than possible replacement plants. There is concern that the endangered southwestern willow flycatcher (*Empidonax trailli extimus*) will be negatively affected by defoliation because the birds build nests early in the season when *Tamarix* is still green, but are still on their nests during the period of summer defoliation. Affected river systems will require continued monitoring and development of adaptive management practices to maintain or enhance riparian habitat values. Multiplatform remote sensing methods are playing an essential role in monitoring defoliation and rates of ET on affected river systems.

"Tamarix evapotranspiration (ET) is much lower than originally assumed in estimates of potential water savings"

Floods are important

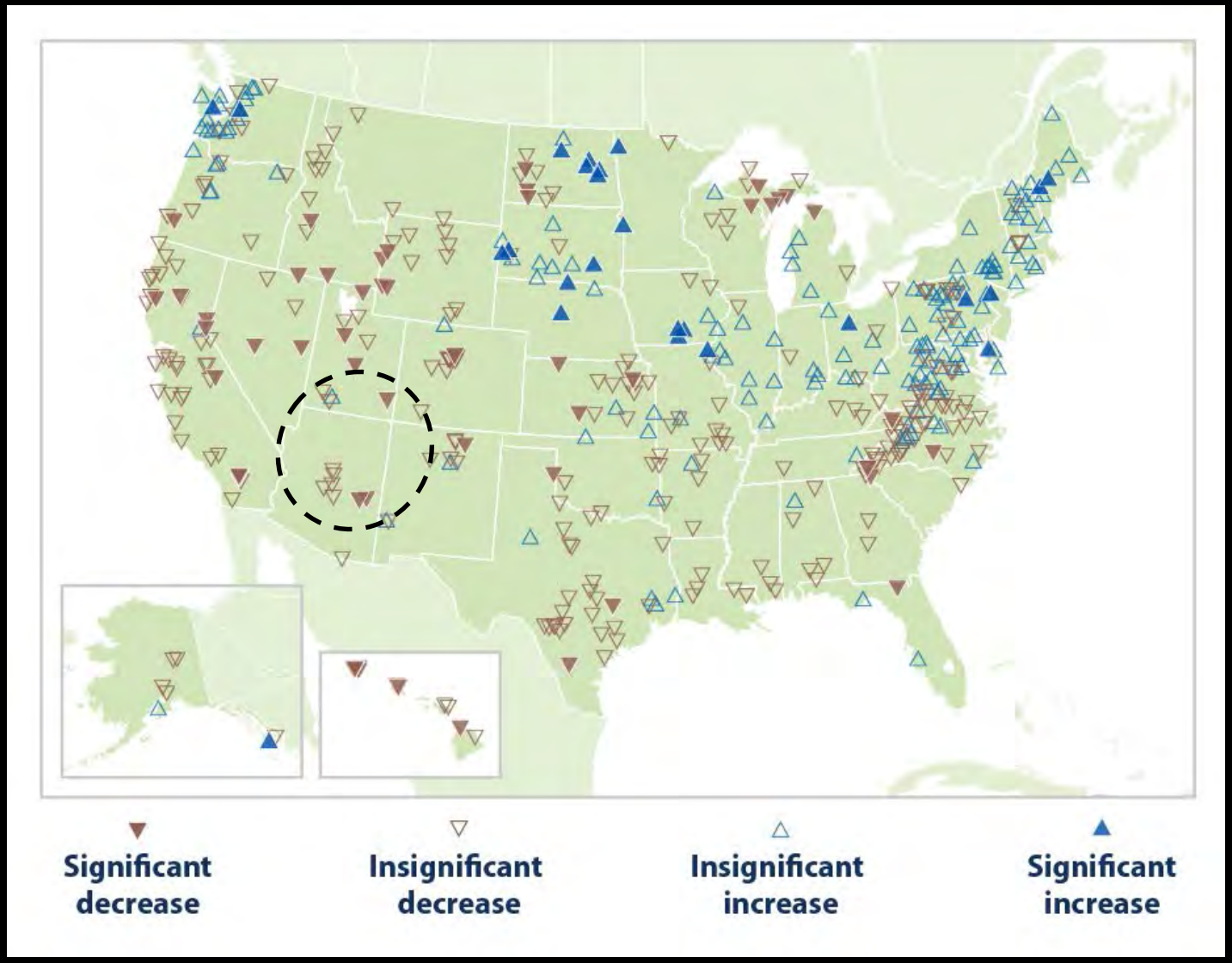


Change in flood magnitude 1965 - 2015



From:https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding

Change in flood frequency 1965 - 2015



From:https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding

Summary – Virgin River riparian vegetation

1) *understand effects of a large flood*

> flood resulted in > 10cm deposition or erosion in half of all vegetation plots. Sometimes > 3m of topographic change.

> many "erosion" plots were completely re-set and showed greatest change in vegetation

2) *understand effects of biological control*

> dramatic reduction in *Tamarix* cover between 2012-2015

> arrowweed had the greatest increase in cover

3) *explore interactive effects of flooding and biological control*

> "deposition" plots appear to have tendency for expansion of arrowweed.

> "erosion" plots show greatest potential for new plant community development

USGS

Unique Interactions

Acknowledgements

U.S. Geological Survey, Ecosystems Mission Area,
Invasive Species Program

All of the dedicated field crew!!!