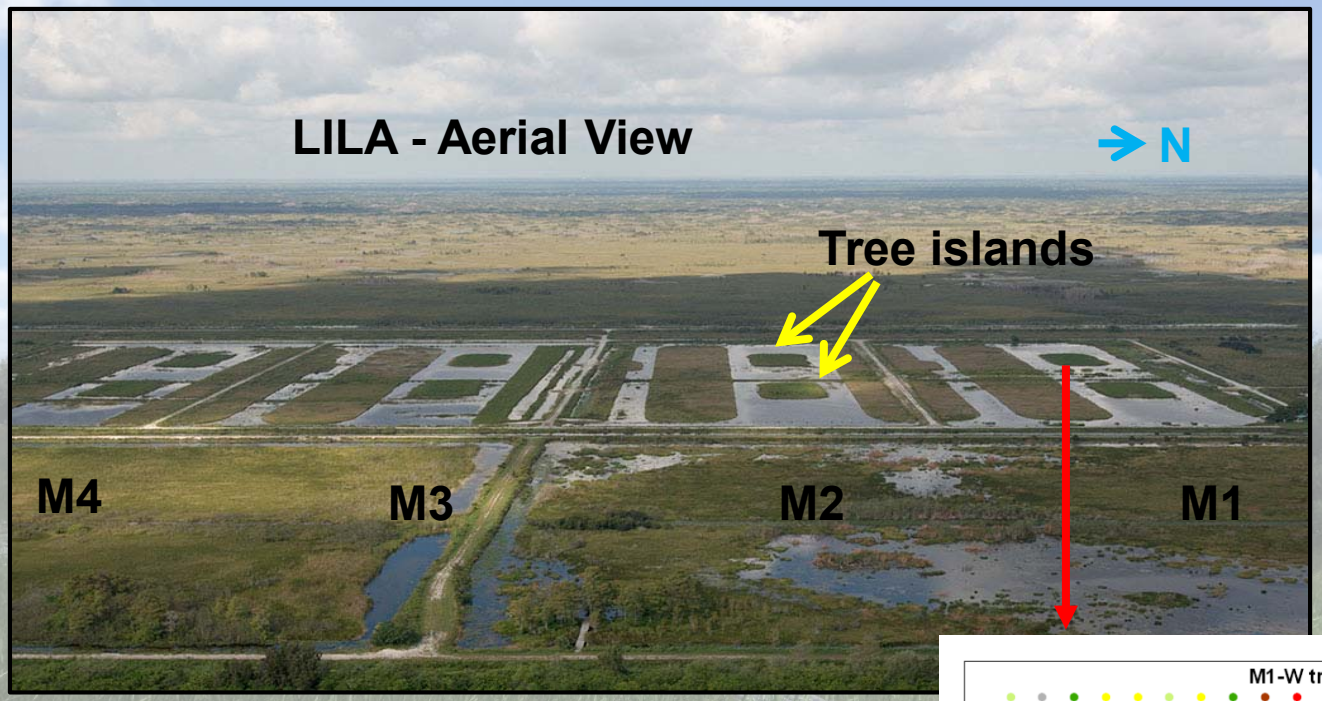
An experimental assessment of neighborhood interference on Everglades' tree species growth along a flooding gradient in constructed tree islands

Susana L. Stoffella, Michael S. Ross & Jay P. Sah.

Tree islands play a pivotal role in the Everglades system:

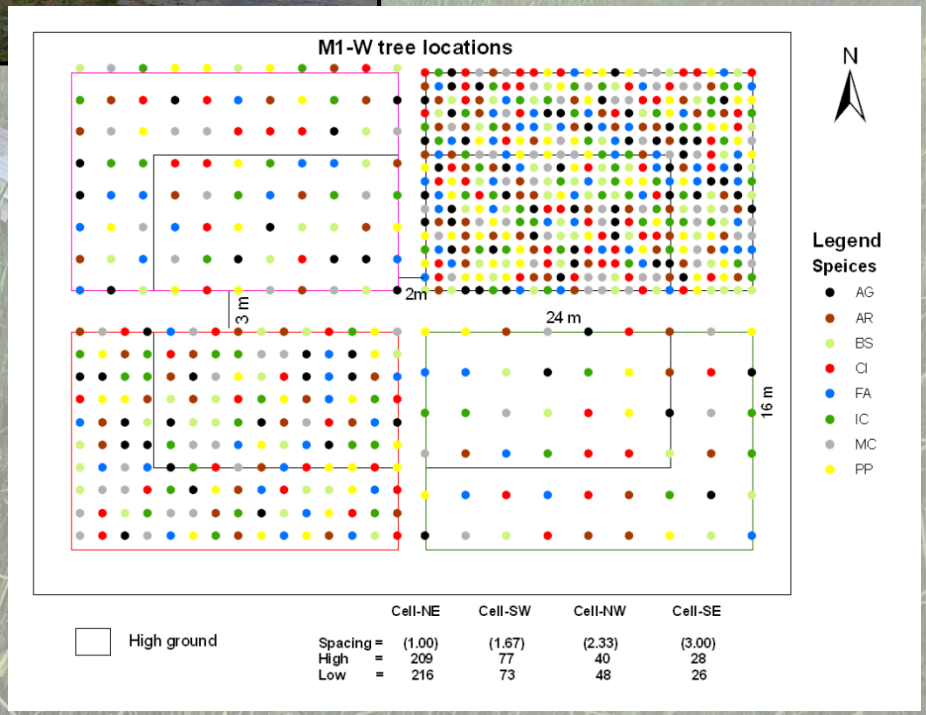
- Biogeochemistry of the Everglades landscape
- Keystone habitats that increase overall biodiversity
- Important anthropological sites

In spite of their importance, over the twentieth century, the number and total area of tree islands have been roughly halved in Everglades National Park

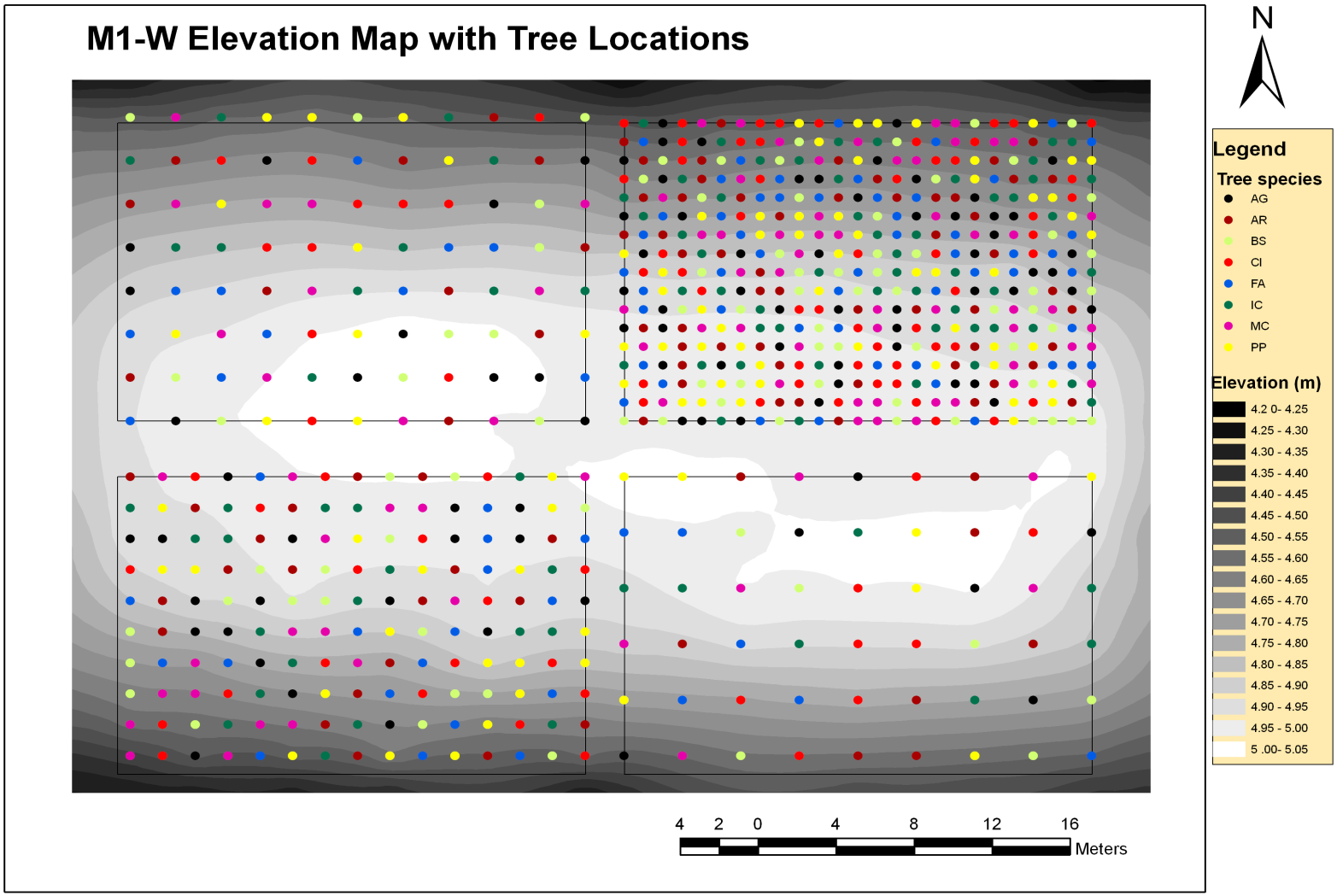


Arrangements of trees by species on the western tree island in cell M1

AG: *Annona glabra*: pond apple
AR: *Acer rubrum*: sugar maple
BS: *Bursera simaruba*: gumbo limbo
CI: *Chrysobalanus icaco*: cocoplum
EA: *Eugenia axillaris*: spanish stopper
FA: *Ficus aurea*: strangler fig
IC: *Ilex cassine*: dahoon holly
MC: *Morella cerifera*: wax myrtle
MFl: Myrsine floridana: myrsine
PP: *Persea palustris*: swamp red bay

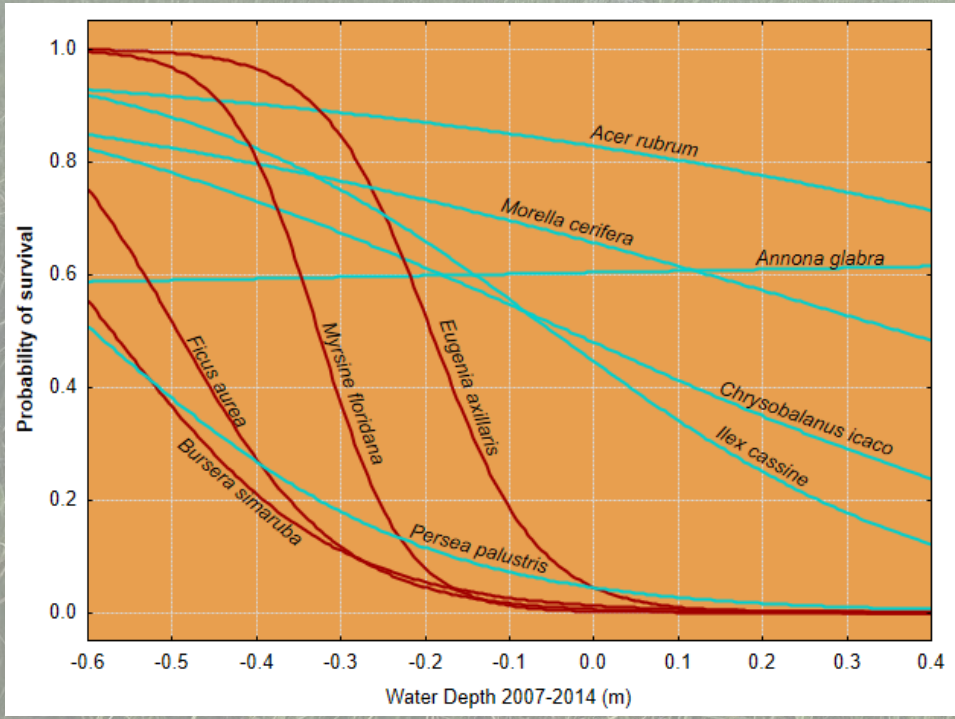


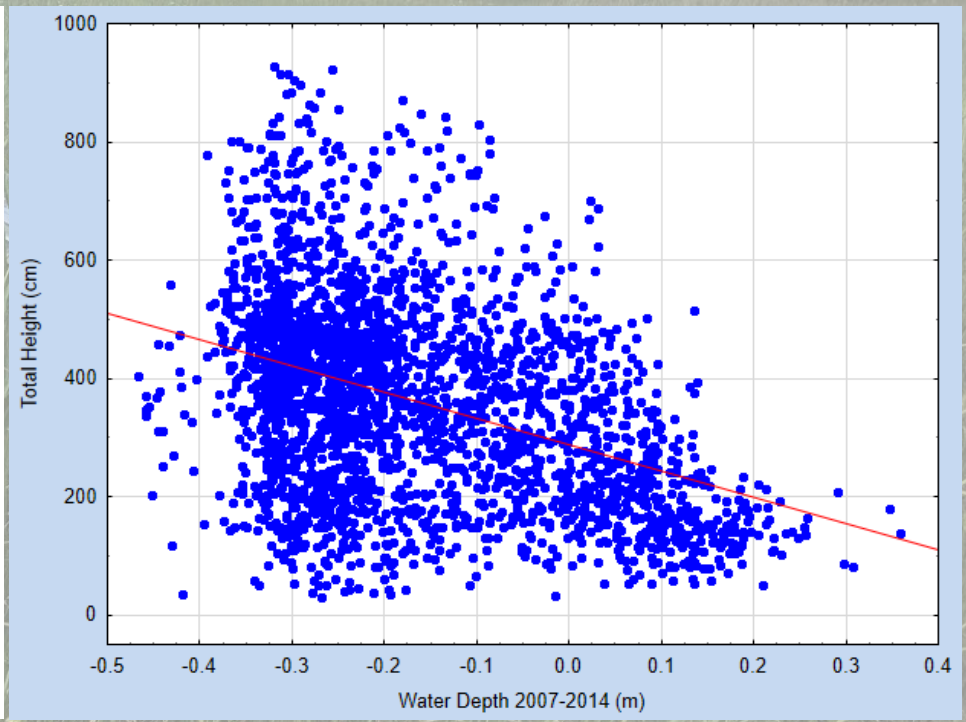
Mean water depth was estimated for each tree using elevation data from topographic surveys and water level data from nearby stage recorders



Effect of hydrology on tree survival and growth

Survival and height growth both improve as water depth decreases





As stand development proceeded, competition for light and nutrients was expected to increase, especially among neighboring trees

Relative growth rate (RGR) was calculated for each tree for a five yrs. period from 2009 to 2014

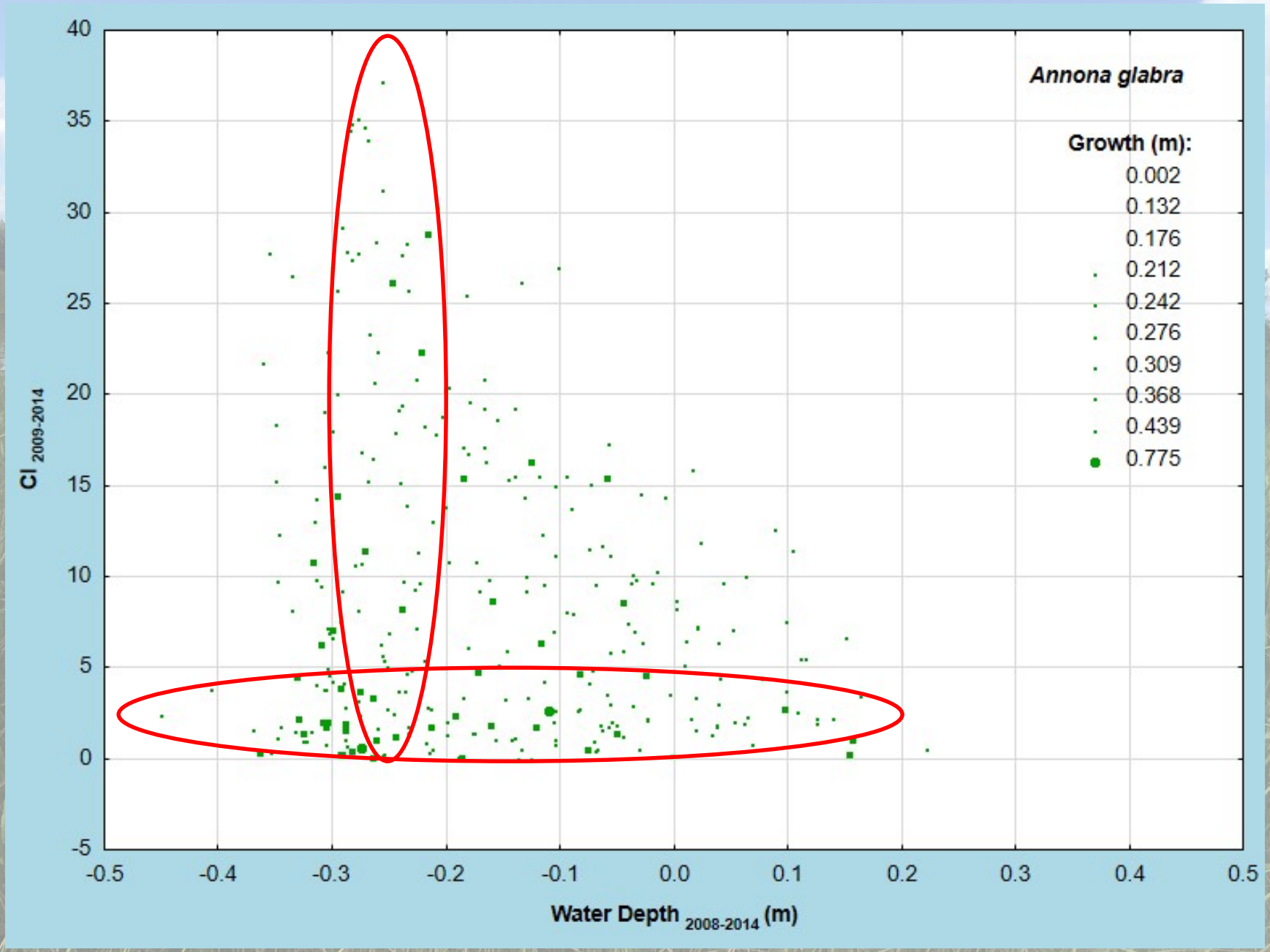
Relative Growth Rate

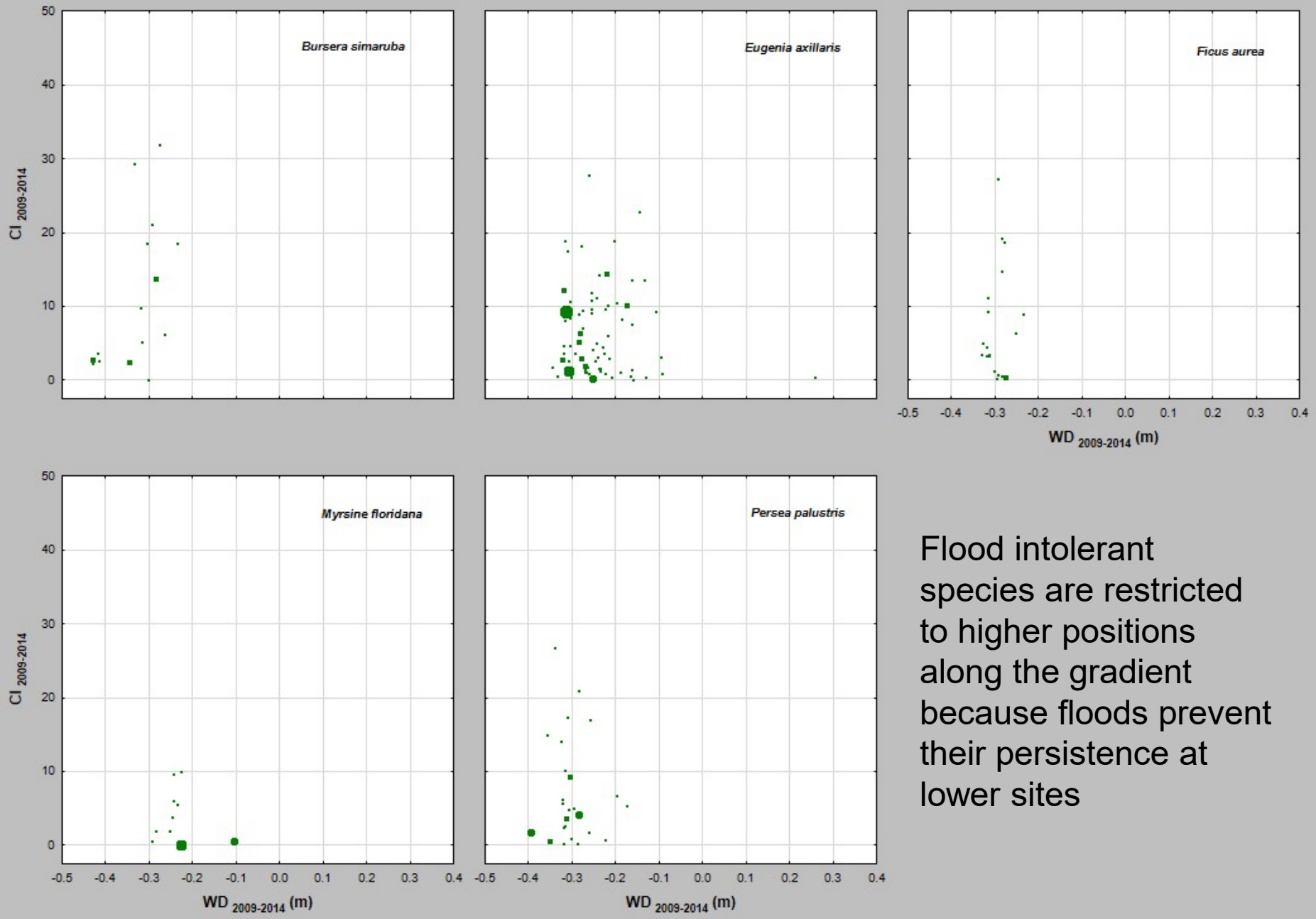
$$(RGR)_{\text{Initial-Final Period}} = \frac{\dfrac{(\text{Final Height} - \text{Initial Height})}{\text{Initial Height}}}{\text{Period of growth in years}}$$

An interference index was used to characterize the competitive neighborhood of a target individual based on the nearness and sizes of neighbors.

$$\text{Competition index (CI)} = \sum {T_m}/{R_m^2}$$

where T_m is the biomass of the m^{th} competitor at the beginning of the period, and R_m
is the linear distance (in meters) between the target tree and competitor tree “m”.


Annona glabra
Growth (m):
0.002
0.132
0.176
0.212
0.242
0.276
0.309
0.368
0.439
0.775
CI 2009-2014
Water Depth 2008-2014 (m)
40
35
30
25
20
15
10
5
0
-5
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5



Flood intolerant species are restricted to higher positions along the gradient because floods prevent their persistence at lower sites

Mean species cover in different plant communities in 3 Shark Slough tree islands sampled in 2001-2002. *Source: Sah et al 2018*.

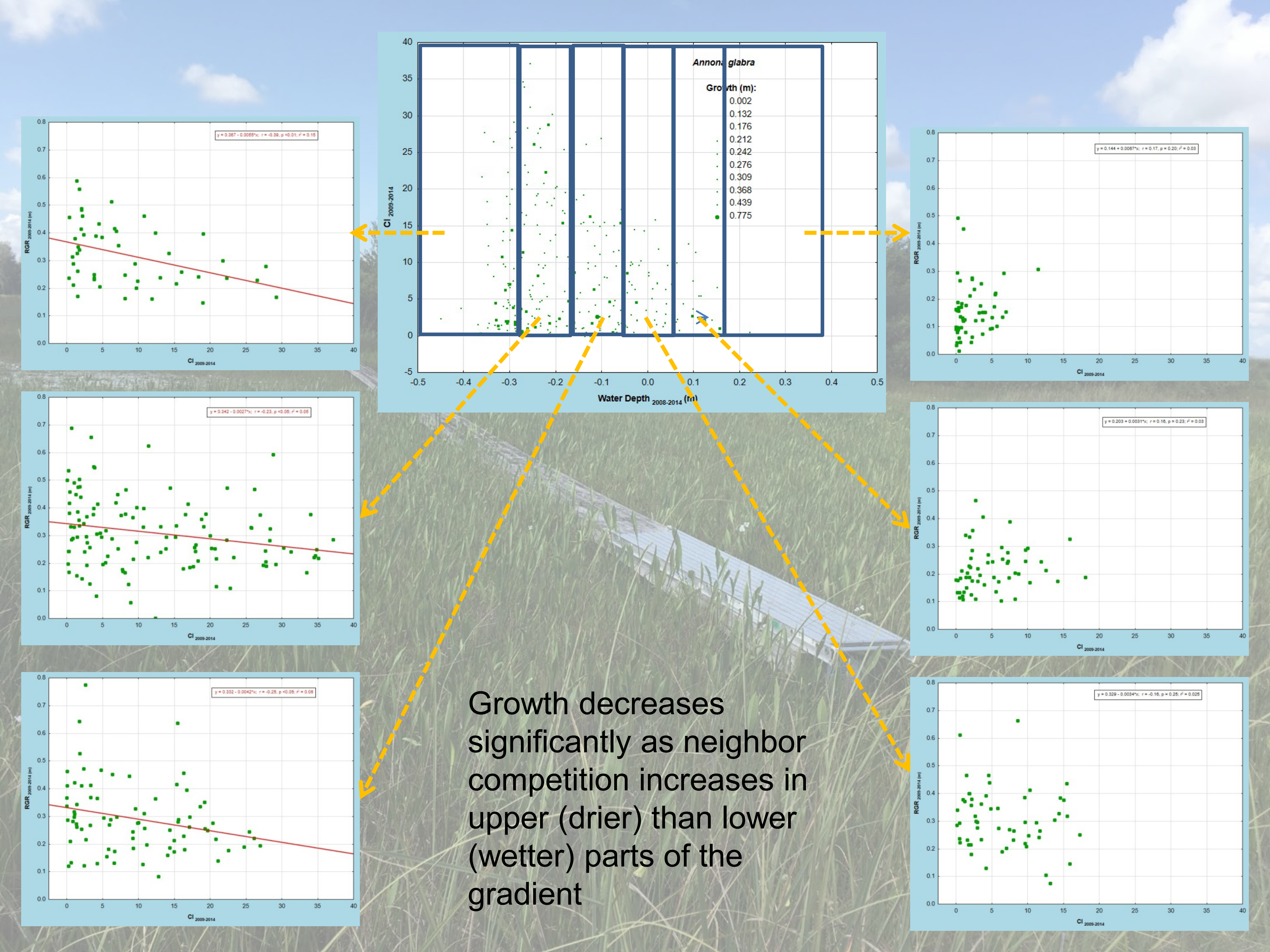
Species	Black Hammock				Gumbo Limbo				Satinleaf			
	HH	BH	BS	M	HH	BH	BS	M	HH	BH	BS	M
Annona glabra	11.4	31.3	17	0.06		11	0.15		0.19	18.5	0.92	
Chrysobalanus icaco	30.3	4.93	0.53		13	3.85			27.5	5.97		
Ilex cassine			0.13			1.75						
Morella cerifera	3.71	5.33	3.88			5.58				6.17		

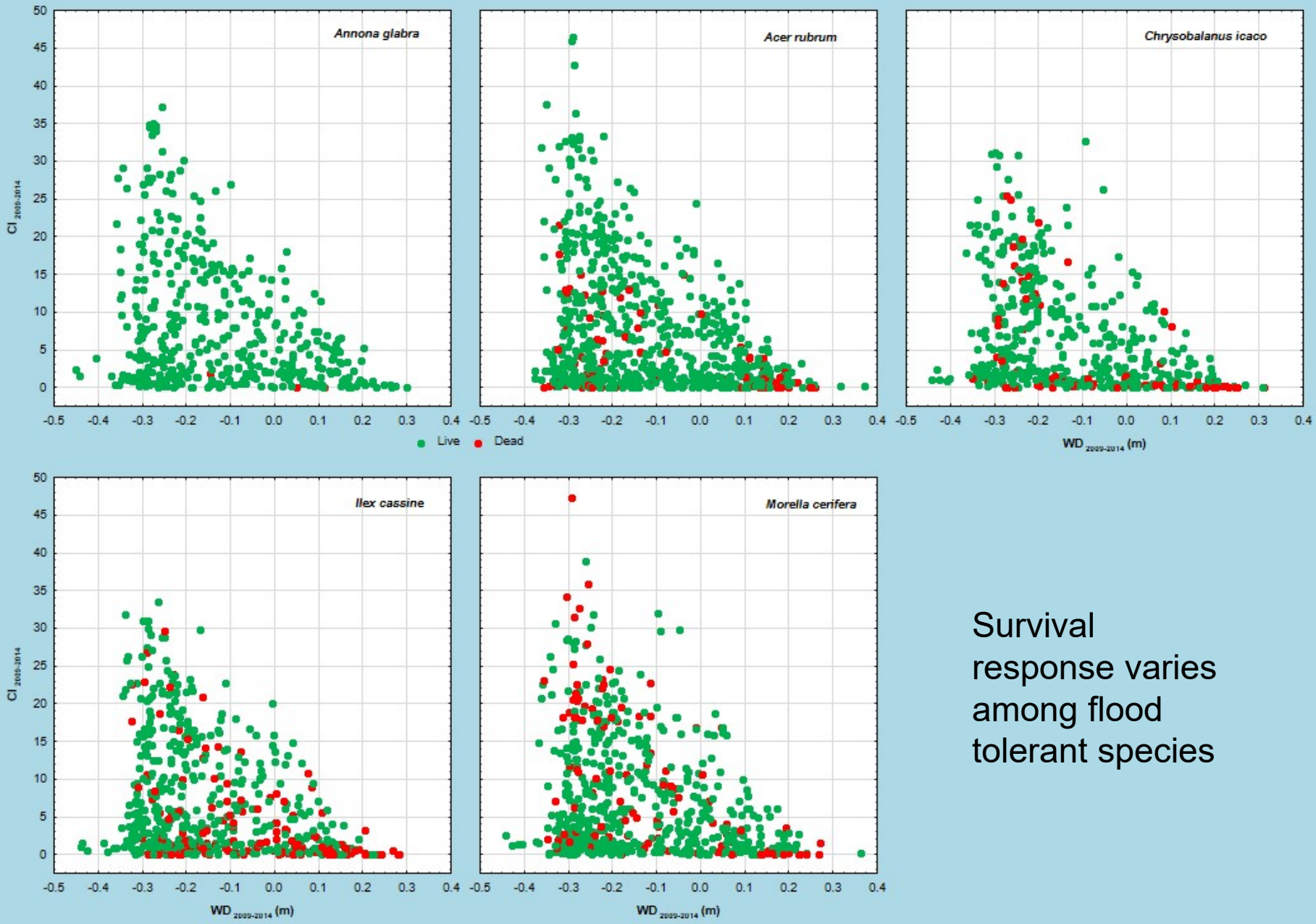
Competitive release hypothesis

The competitive release hypothesis (CRH) proposes that intense competition at the most benign parts of the gradients exclude species with low competitive ability. Weaker competitors are viewed to be more tolerant to disturbance and find refuge at the most disturbed end of the gradient.

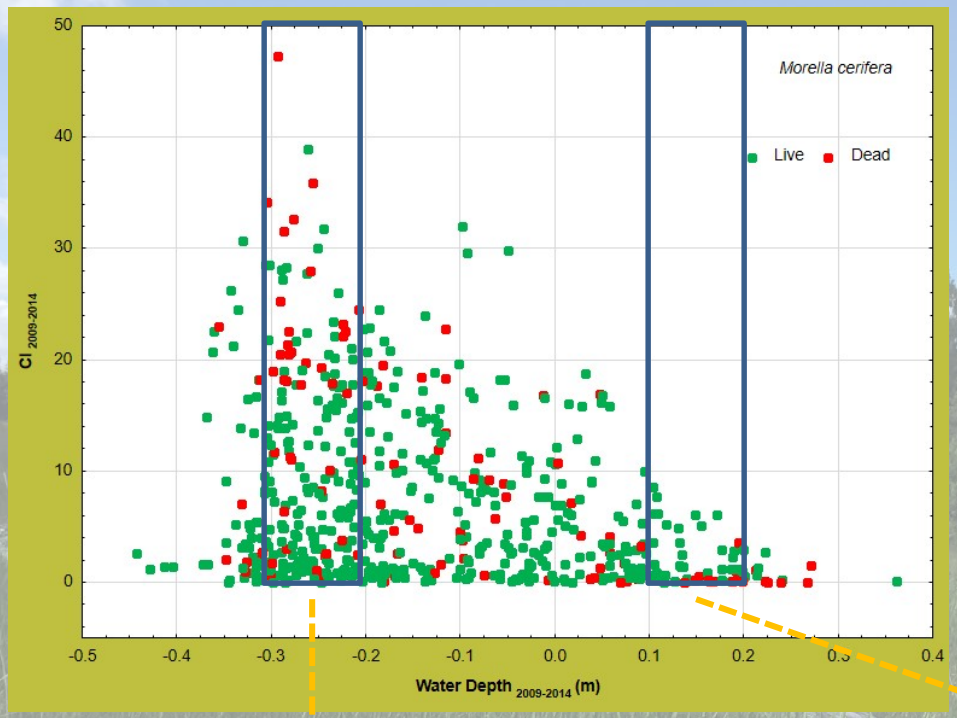
Prediction

Flood-tolerant plant species are weak competitors on well-drained sites, but benefit in the flooded part of the gradient, where competition is less important due to high mortality rates among mesic tree species.

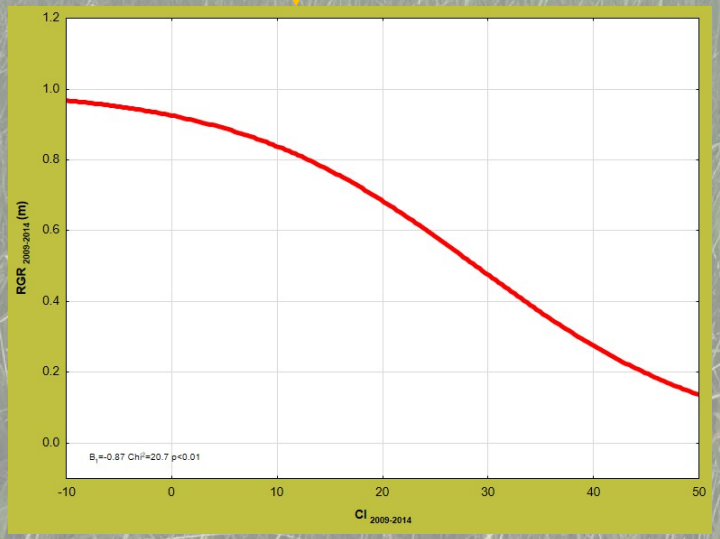

Annona glabra
Growth (m):
0.002
0.132
0.176
0.212
0.242
0.276
0.309
0.368
0.439
0.775
CI 2009-2014
Water Depth 2008-2014 (m)
y = 0.367 - 0.0055*x; r = -0.39, p <0.01; r² = 0.15
y = 0.342 - 0.0027*x; r = -0.23, p <0.05; r² = 0.05
y = 0.332 - 0.0042*x; r = -0.25, p <0.05; r² = 0.06
y = 0.144 + 0.0067*x; r = 0.17, p = 0.20; r² = 0.03
y = 0.203 + 0.0031*x; r = 0.16, p = 0.23; r² = 0.03
y = 0.329 - 0.0034*x; r = -0.16, p = 0.25; r² = 0.025
Growth decreases significantly as neighbor competition increases in upper (drier) than lower (wetter) parts of the gradient

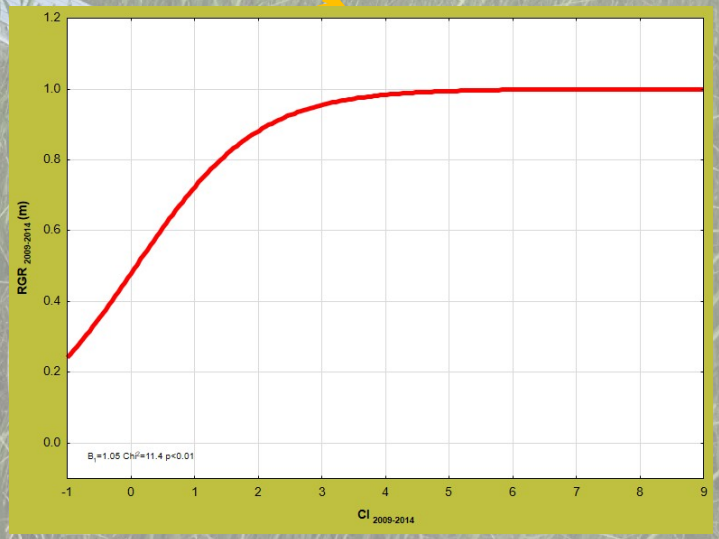


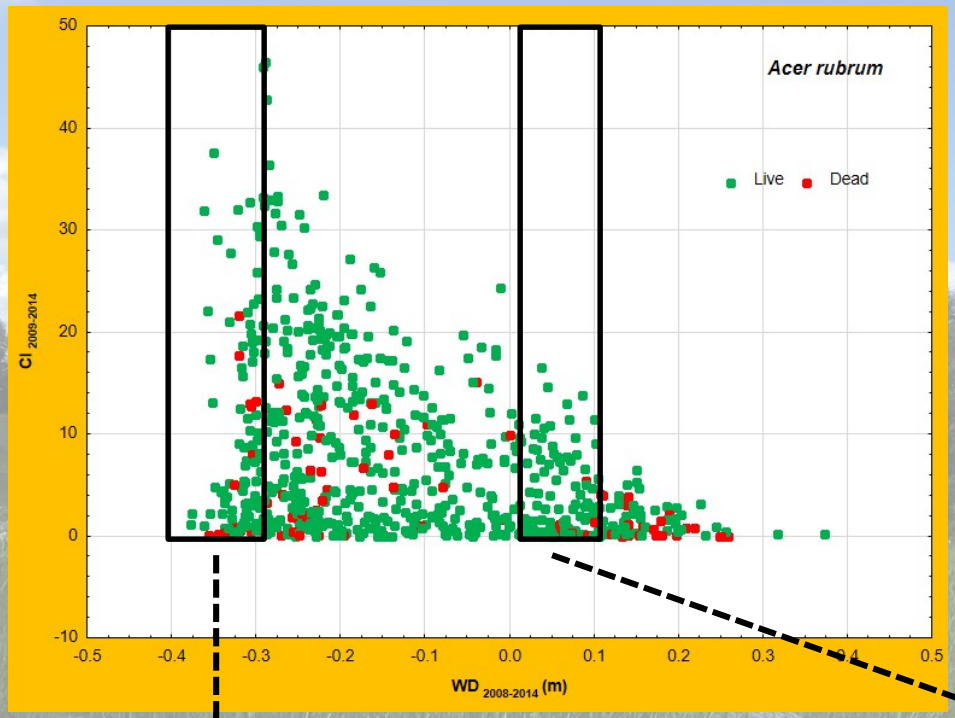
Survival response varies among flood tolerant species



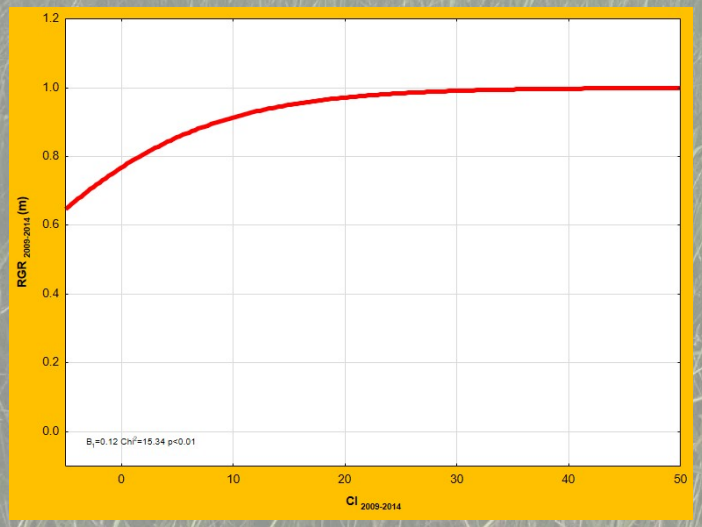
Survival decreases more in non-flooded than flooded parts of the gradient

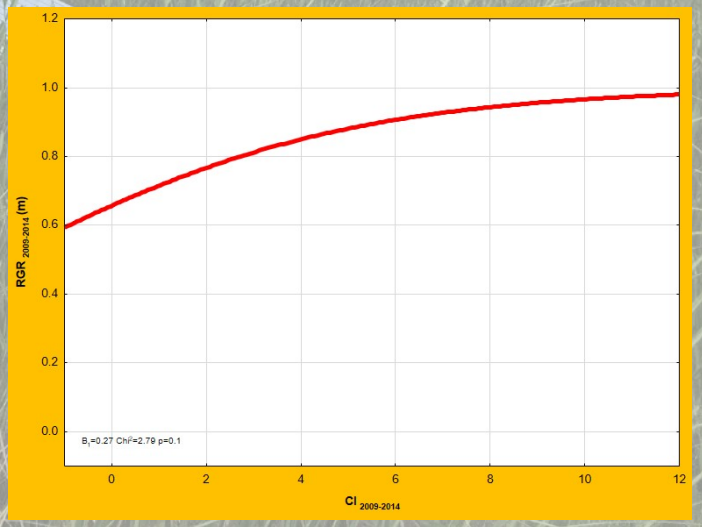






Survival increases in both non-flooded and flooded parts of the gradient





Conclusions

- Neighborhood competition experienced by all species was stronger in the dry upper end of the gradient
- Higher neighborhood competition experienced by flood-tolerant species decreased their growth relative to more waterlogged locations
- During this early stage of stand development higher neighborhood competition experienced by flood-tolerant species did not exclude them from more favorable elevated positions but it is negatively affecting their abundance and survival relative to more waterlogged locations differently depending on the species


Thank You!
Questions?
FIU
Southeast Environmental
Research Center