Use of Assisted Migration and Community Zonation Patterns to Build a Climate-Resilient Coastal Landscape

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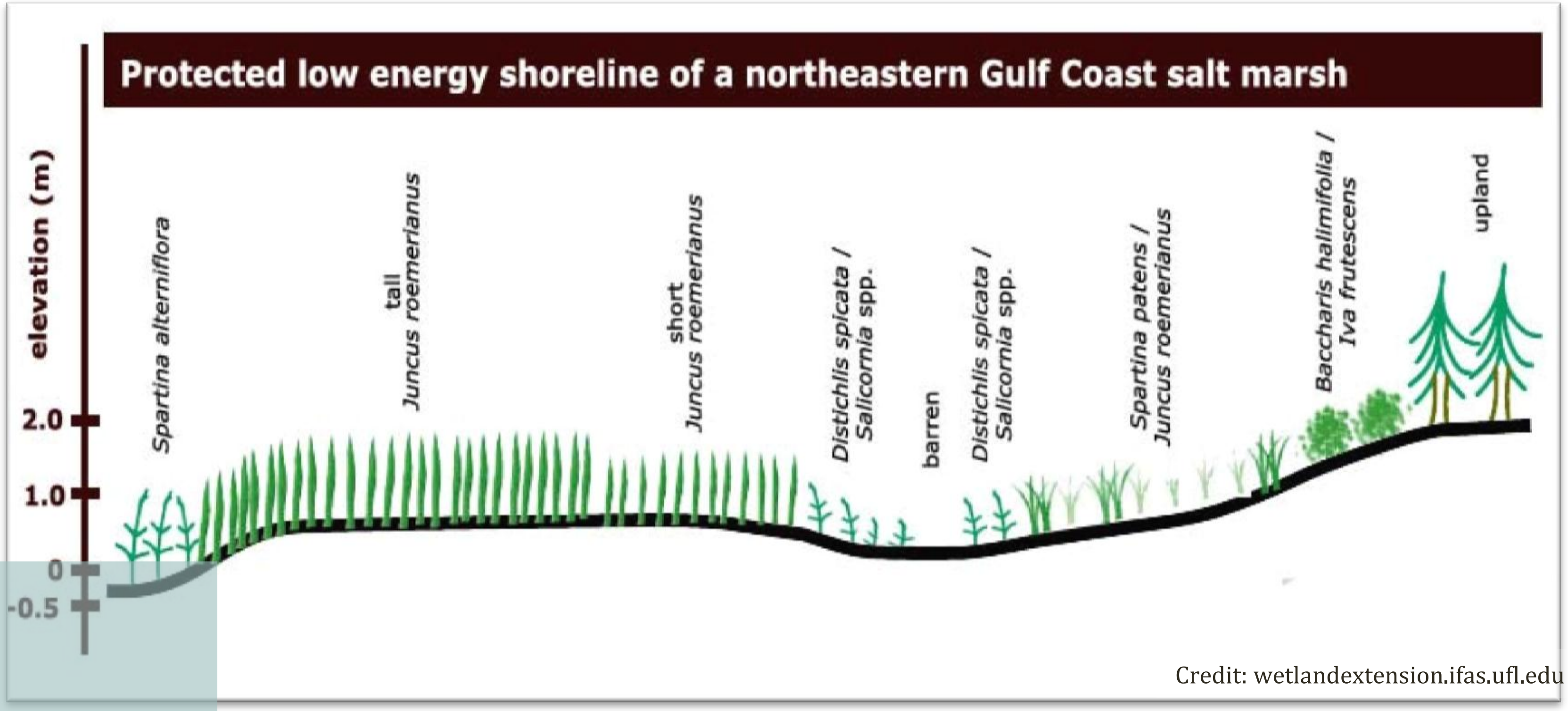
Coastal plant communities and altered inundation regimes

Adapt, go extinct, or migrate inland

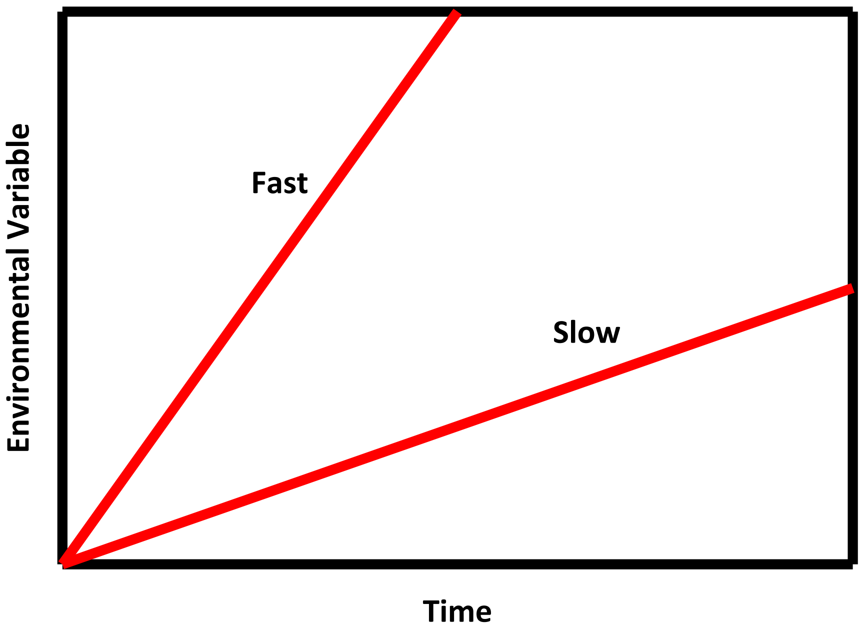


Credit: wetlandextension.ifas.ufl.edu

With only 1 m rise in sea-level, 26-66% of coastal wetlands will be lost
(Mitsch and Gosselink, 2007)

Climate Change and Restoration

- "Moving targets"
  - Rate of change
  - Direction of change
- Anticipatory or futuristic restoration
- Assisted migration

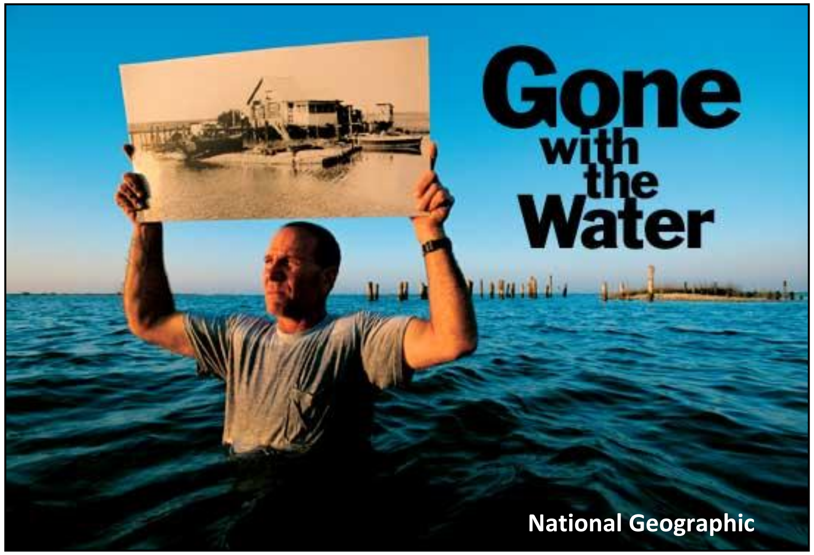


Relative Ease of Futuristic Restoration

		Rate of Change	
		Slow	Fast
Pattern of Spatial Change	Linear	High	Moderate
	Exponential	Moderate	Low
	Erratic or No-analogue	?	??

Coastal Wetlands

- Spatial zonation of communities along strong environmental gradients
- Stress-tolerant species at seaward end, stronger competitors farther inland (Bertness and Ellison 1987, Pennings et al. 1995)
- Rate of change varies depending on relative SLR, *etc*.
- N. Atlantic, Gulf of Mexico, especially at risk (Hammer-Klose and Thieler 2001, Meehl et al. 2005, Ramstorf 2007)



Relative Ease of Futuristic Restoration

		Rate of Change	
		Slow	Fast
Direction of Spatial Change	Linear	High	Moderate
	Non-linear	Moderate	Low
	Erratic or No-analogue	?	??

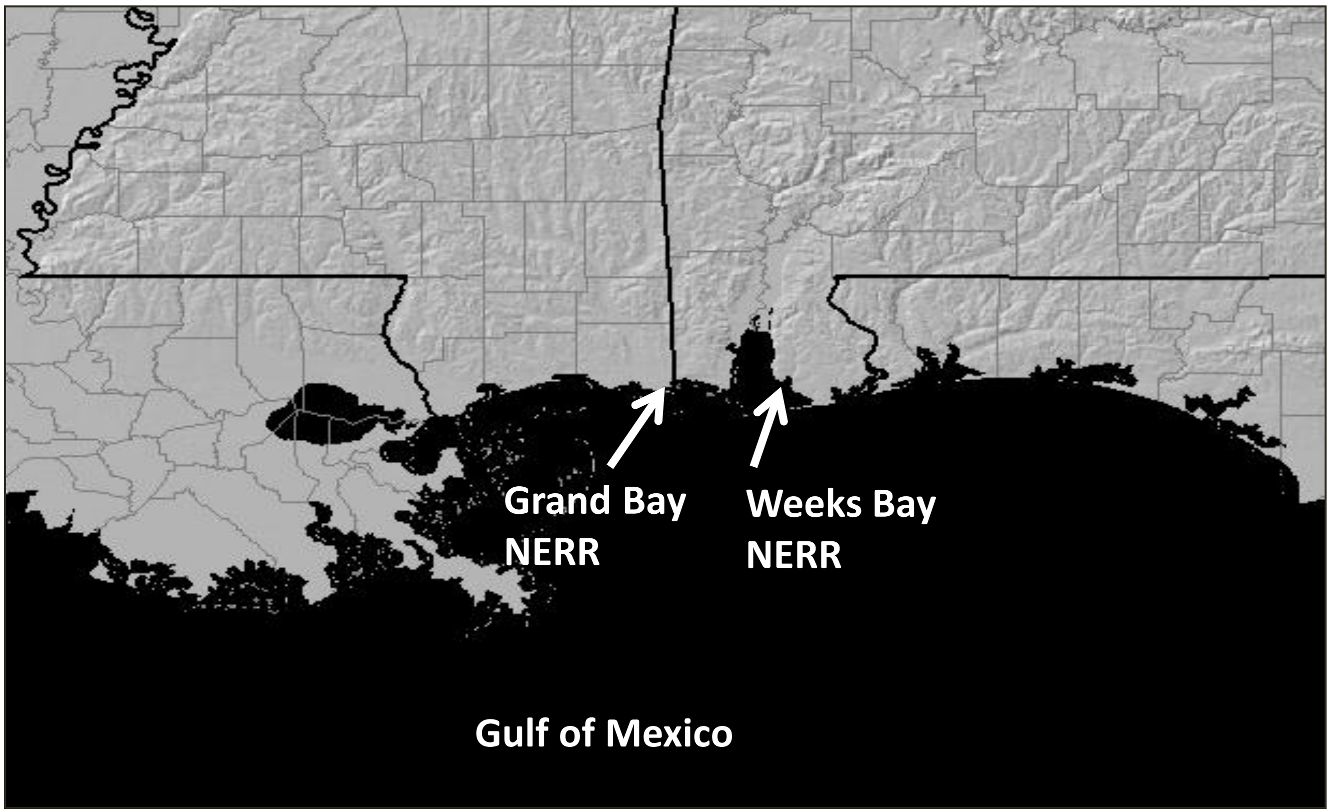
Study Questions

- With removal of biotic filters, can dominant species from seaward communities establish and survive when introduced into landward locations?
  (Reciprocal planting study – Weeks Bay, AL)

- Can assisted colonization enable successful futuristic restoration and if so, how futuristic?
  (FEMA Restoration Sites – Grand Bay, AL)

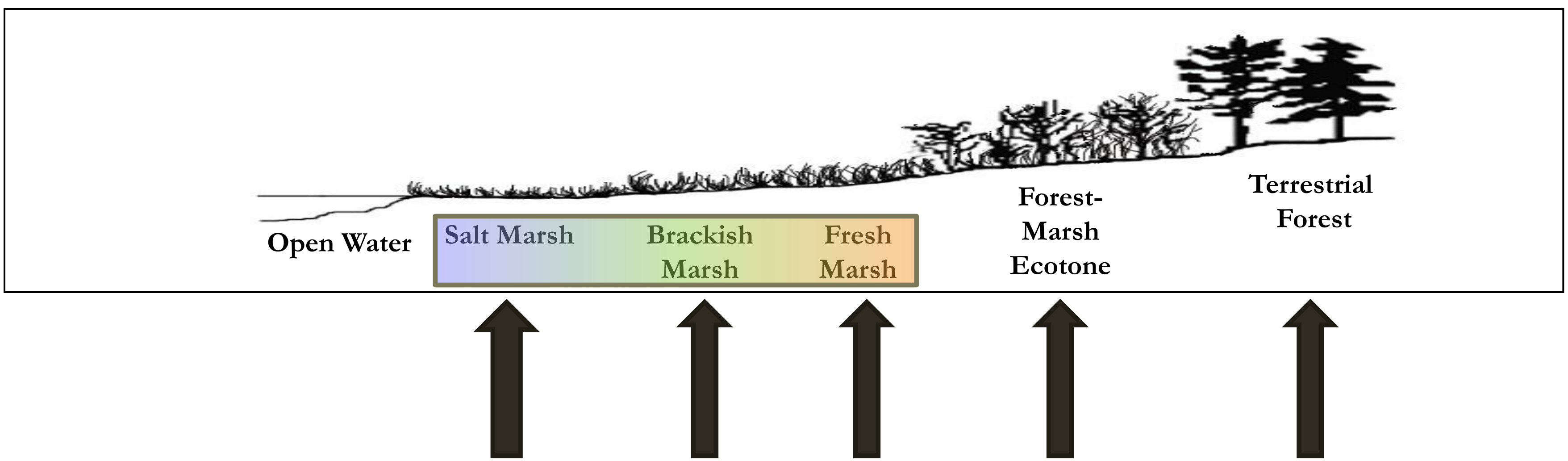
Northern Gulf of Mexico

- Relatively slow relative SLR



Dominants of Seaward Vegetation Zones

- Salt marsh: *Spartina alterniflora*
- Brackish marsh: *Juncus roemerianus*
- Fresh marsh: *Cladium jamaicense*



Methods

- Late Summer 2008 vegetation removed in 1m^2 plots
- Five culms of 3 dominant species from 3 most seaward vegetation zones planted in monoculture
- Transplant zones (3 sp x 5 reps; total plots = 75)
  - Salt marsh (SM)
  - Brackish marsh (BM)
  - Fresh marsh (FM)
  - Fresh marsh – Forest ecotone (EC)
  - Wetland seep forest (FO)

seaward

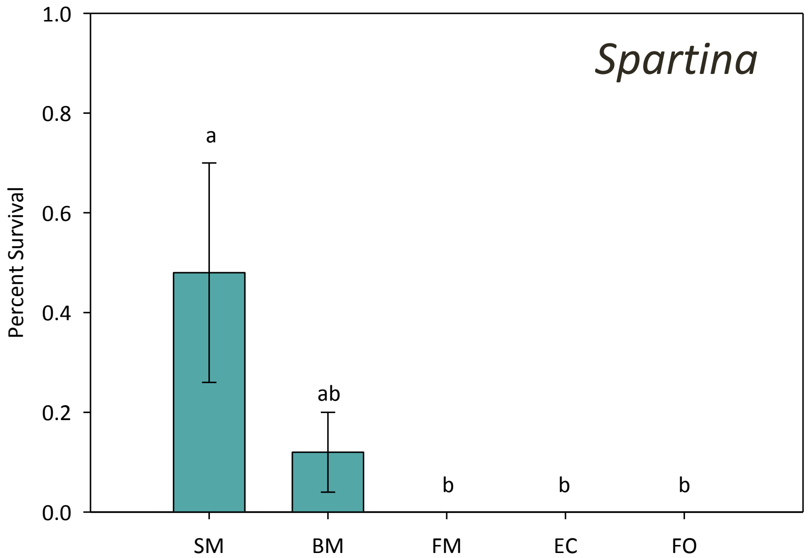
landward

- Survival (and growth) monitored seasonally for 2 years

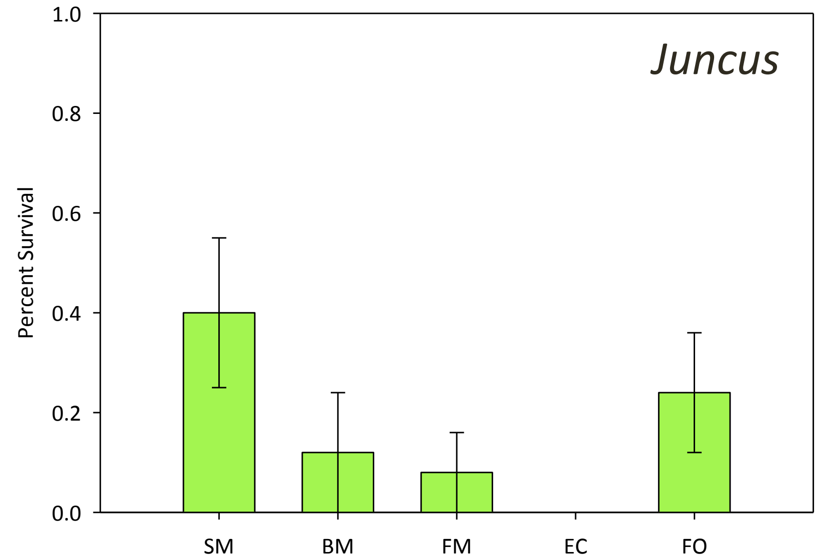
Removal of Standing Vegetation

Planting of Culms

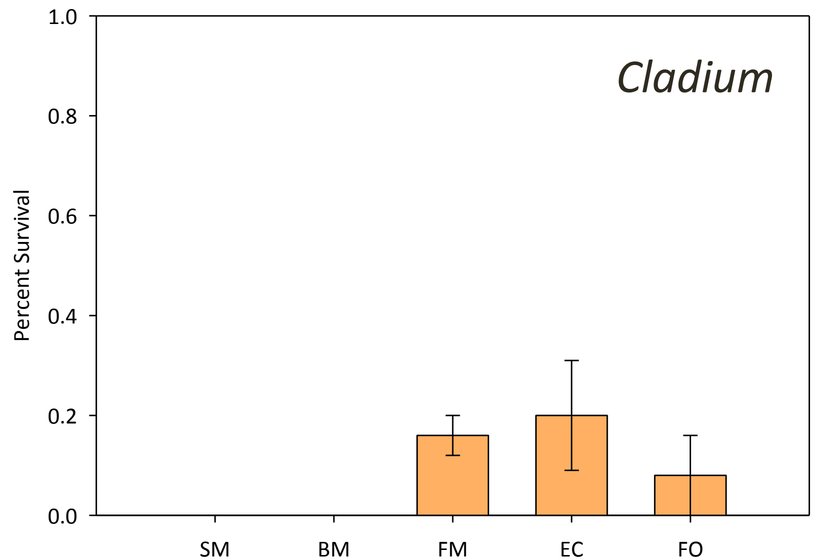
Results



Spartina
Percent Survival
1.0
0.8
0.6
0.4
0.2
0.0
a
ab
b
b
b
SM
BM
FM
EC
FO



Juncus
Percent Survival
1.0
0.8
0.6
0.4
0.2
0.0
SM
BM
FM
EC
FO



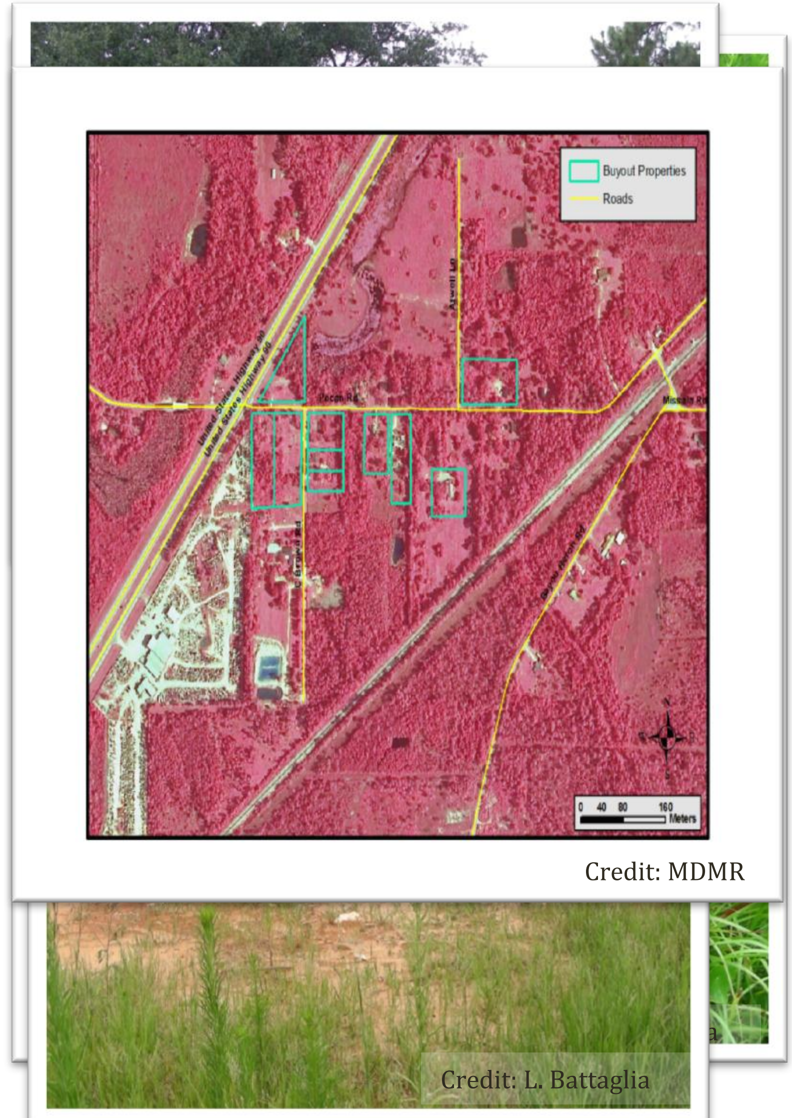
Cladium
Percent Survival
1.0
0.8
0.6
0.4
0.2
0.0
SM
BM
FM
EC
FO

Summary of Results

- All species established and survived in at least one of the zones landward of their original zone
- *Juncus* exhibited the broadest “new” distribution
  - Established seaward of original position
  - Thriving in forest (canopy openings from Hurricane Katrina in 2005)
- *Cladium* was able to establish landward as well, but not in more seaward zones

FEMA Buyout Homestead Sites

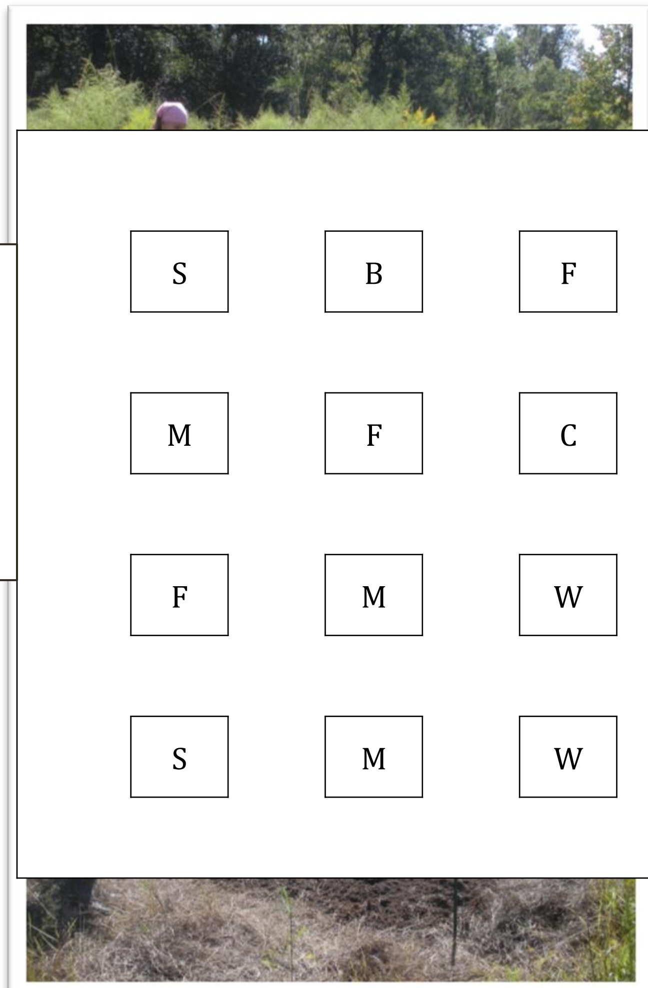
- 15 former pine forests adjacent to GBNERR
- Purchases began following inundation by Hurricanes Georges in 1998
- Highly disturbed
- Heavily infested with noxious exotics: *Imperata cylindrica* , *Panicum repens* and *Triadica sebifera*
- Vacant and awaiting management

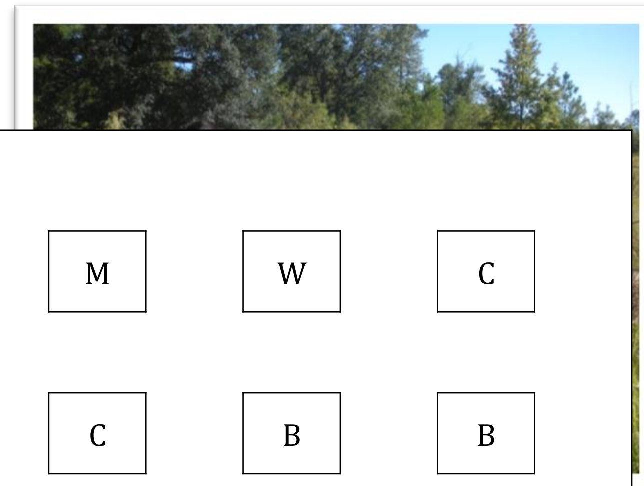


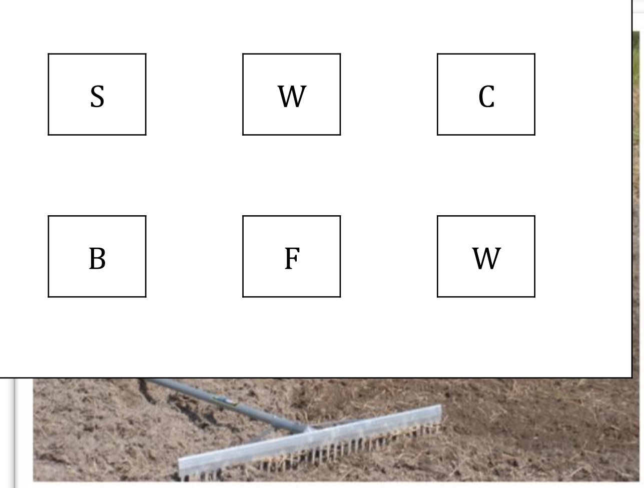
Design of Propagule Bank Experiment

Randomly Selected: 5 sites, 9m X 13m plots, 24- 1m X 1m subplots

Site Preparation: herbicide, mowing, tilling, raking







S	B	F	M	W	C
M	F	C	C	B	B
F	M	W	S	W	C
S	M	W	B	F	W

Legend

S: Salt marsh
B: Brackish marsh
F: Freshwater marsh
M: Maritime pine island
W: Wet pine flatwood
C: Control

Donor Bank Collection and Application

0.50m x 0.25 m sods

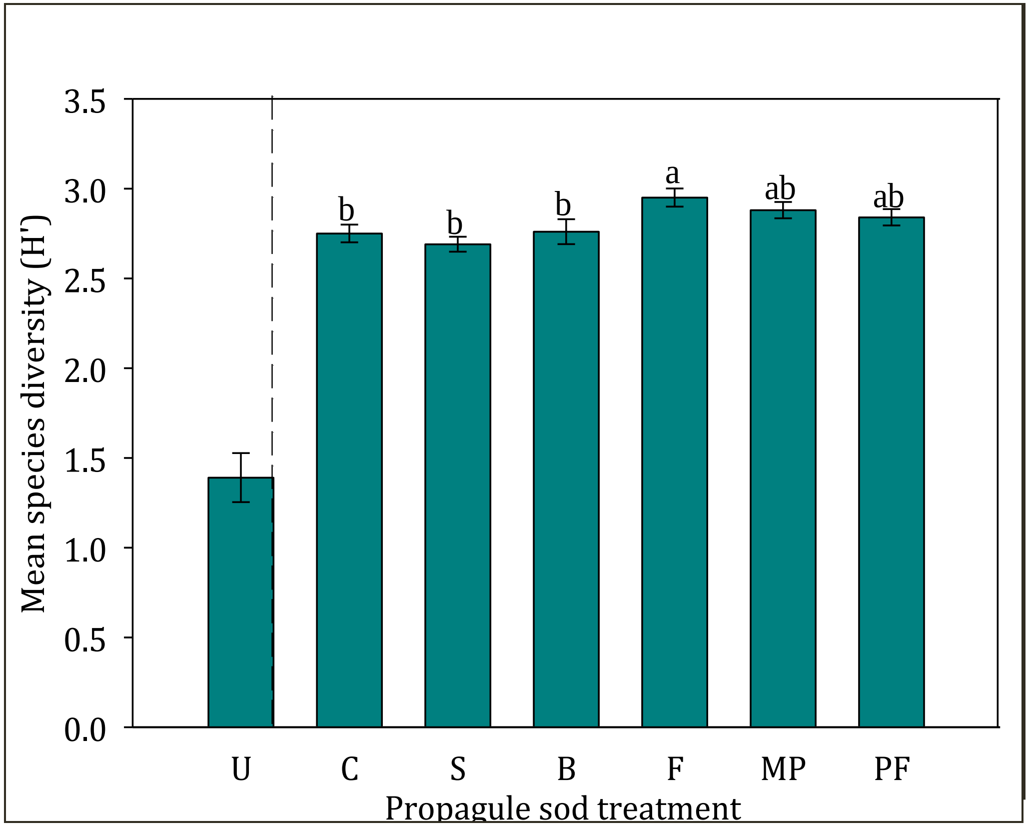
Data Collection and Site Maintenance

- Presence/Absence data

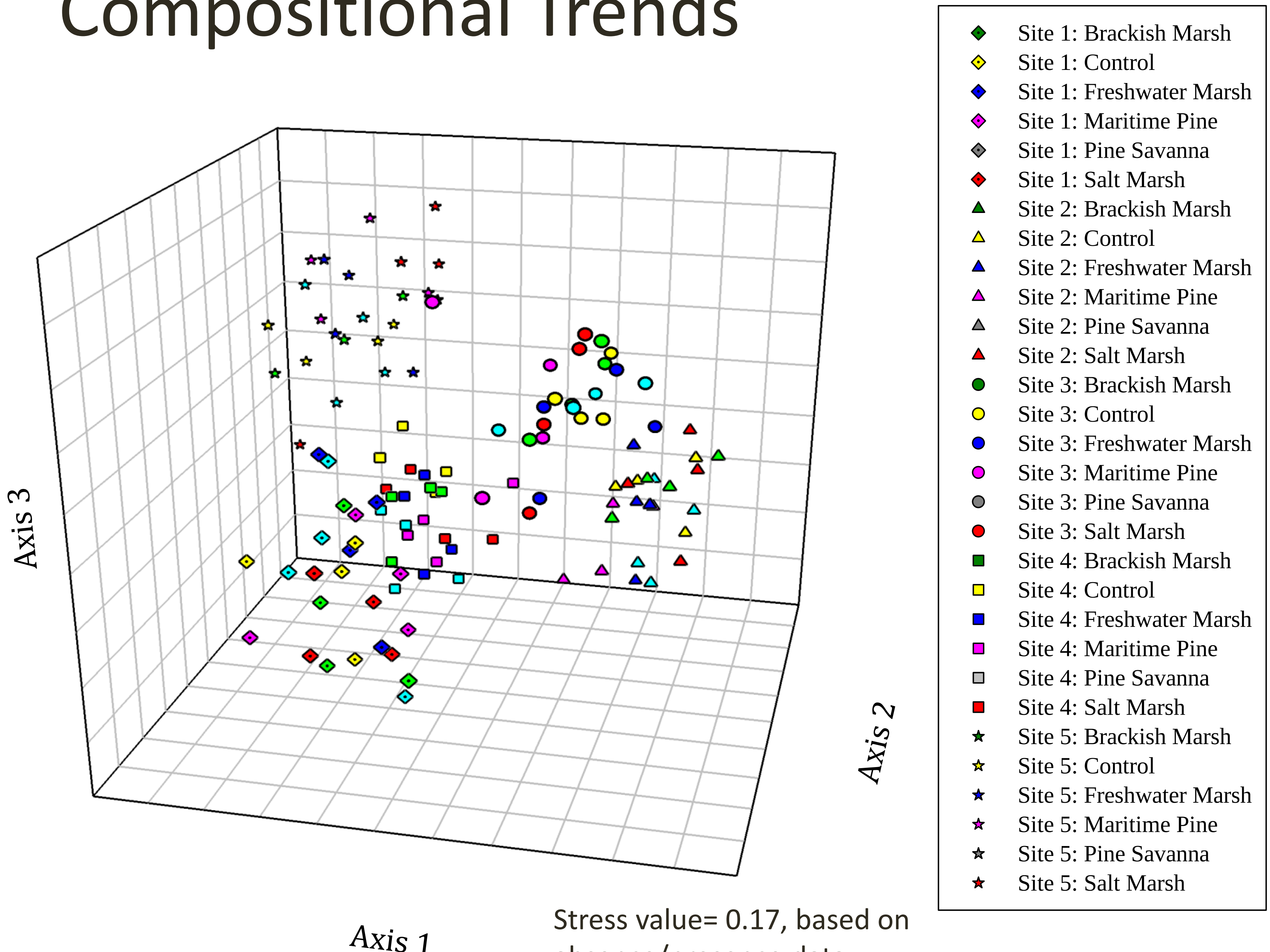
- Species removed:
Eupatorium capillifolium,
Centrosema virginiana,
Ipomoea quamoclit and
Cuphea glutinosa

Richness and Diversity

- Site preparation greatly increased species richness and diversity
- Highest in plots with freshwater sods, relative to plots with control and saline marsh sods



Compositional Trends



Stress value= 0.17, based on absence/presence data

Effects of Site on Composition

- PERMANOVA: Pseudo-F = 31.05, $p < 0.0010$

	% Sand	% Silt	% Clay	Mean % Soil Moisture	Salinity (ppt)	Conductivity(µs/cm)
Site 1	69.8	19.6	10.6	28.3	0.3	568.0
Site 2	63.8	23.6	12.6	40.0	0.1	199.2
Site 3	62.4	29.6	8.0	29.2	0.2	388.5
Site 4	66.4	25.0	8.6	33.5	0.1	221.1
Site 5	56.5	30.9	12.6	24.3	0.2	442.9

Effects of Propagule Sod on Composition

- PERMANOVA: Pseudo-F = 3.06, $p < 0.0010$

	Control	Salt marsh	Brackish marsh	Fresh marsh	Maritime pine island
Salt marsh	0.001				
Brackish marsh	0.104	0.081			
Fresh marsh	0.001	0.001	0.001		
Maritime pine island	0.001	0.001	0.001	0.105	
Pine savanna	0.008	0.008	0.007	0.001	0.001

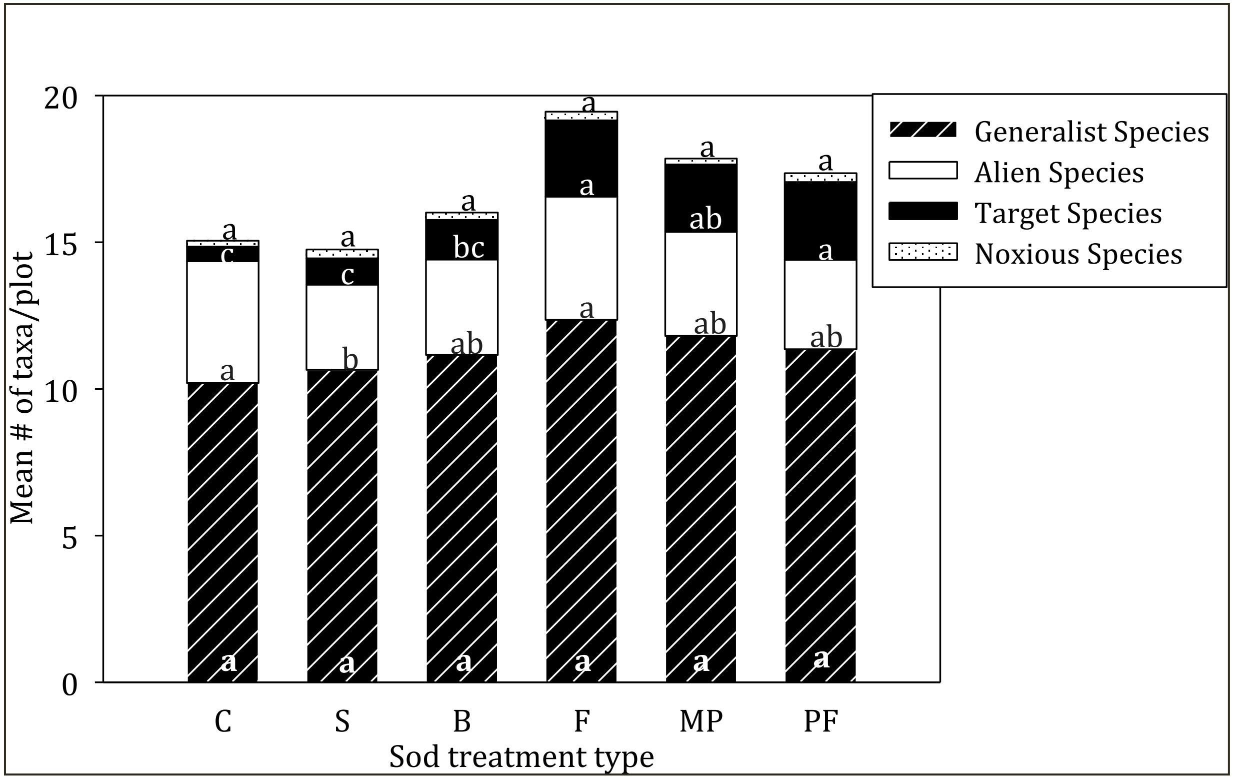
Recruitment of Target Species

- Targets emerge both from seed and resprout, most are indicator species from seed bank assessment

Vegetation Zone	Total # of Target Species	Most Abundant Species	% of Subplots (Across all 5 sites)
Salt Marsh	2	*Spartina alterniflora*	15
		Distichlis spicata	5
Brackish Marsh	1	*Juncus roemerianus*	40
Freshwater Marsh	5	*Sabatia stellaris*	45
		Panicum virgatum	15
Maritime Pine Island	6	*Spartina patens*	85
		Pinus elliottii	20
		Scirpus lineatus	15
Wet Pine Flatwood	17	*Aristida beyrichiana*	45
		Andropogon glomeratus	35
		Lachnanthes caroliniana	30
		Aletris lutea	20
		Lycopodiella prostrata	15
		Sarracenia alata	5

Distribution of Desirable Taxa

- Mean number of taxa in each functional category varies significantly across sod treatment types and sites
- More target species in freshwater and wet pine flatwood plots than in control and salt marsh plots



Summary of Results

- Species diversity and richness increased, and noxious species greatly reduced on all treated areas
- Propagule sods resulted in “hybrid” communities (Hobbs et al. 2009), containing generalist and alien species, as well as indicator species from historic communities
- A viable propagule source for restorations, containing taxa with diverse life histories and environmental tolerances (Pywell et al. 1995, Brown and Bedford 1997, Anderson and Cowell 2004)
- Freshwater marsh and maritime pine island sods best suited to the restoration sites – seaward species can tolerate inland conditions
- Local environmental conditions and proximity to ruderal source populations also drive community composition/dynamics

Is anticipatory restoration feasible?

- Yes, but…
  - Differing degrees depending on species and background environmental change
  - Short-term success of propagule bank application in instilling diverse species into degraded ecosystems, long-term storage important

- Rate and direction of underlying abiotic change are key drivers
  - Communities that are sequentially arranged along strong environmental gradients may be easiest
  - Lack of spatial contiguity may require assisted colonization
  - Exotic species

- Use of common futuristic garden experiments at natural ecotones in the landscape to ease transition for vulnerable communities and enhance landscape fluidity (Manning et al. 2009) as climate change and sea-level rise alter site conditions

Acknowledgements

- Brooks Davey
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- Scott Phipps
- Scott Schuette
- Joey Weber

Questions?

Vegetation-Seedbank Comparison

- Procrustes RMS Residual (mean distance between parent vegetation and SB, goodness of fit)