Created Marshes Could Support More Fish and Crustaceans, and be less expensive, If They Were Designed with Lower Elevation and More Edges

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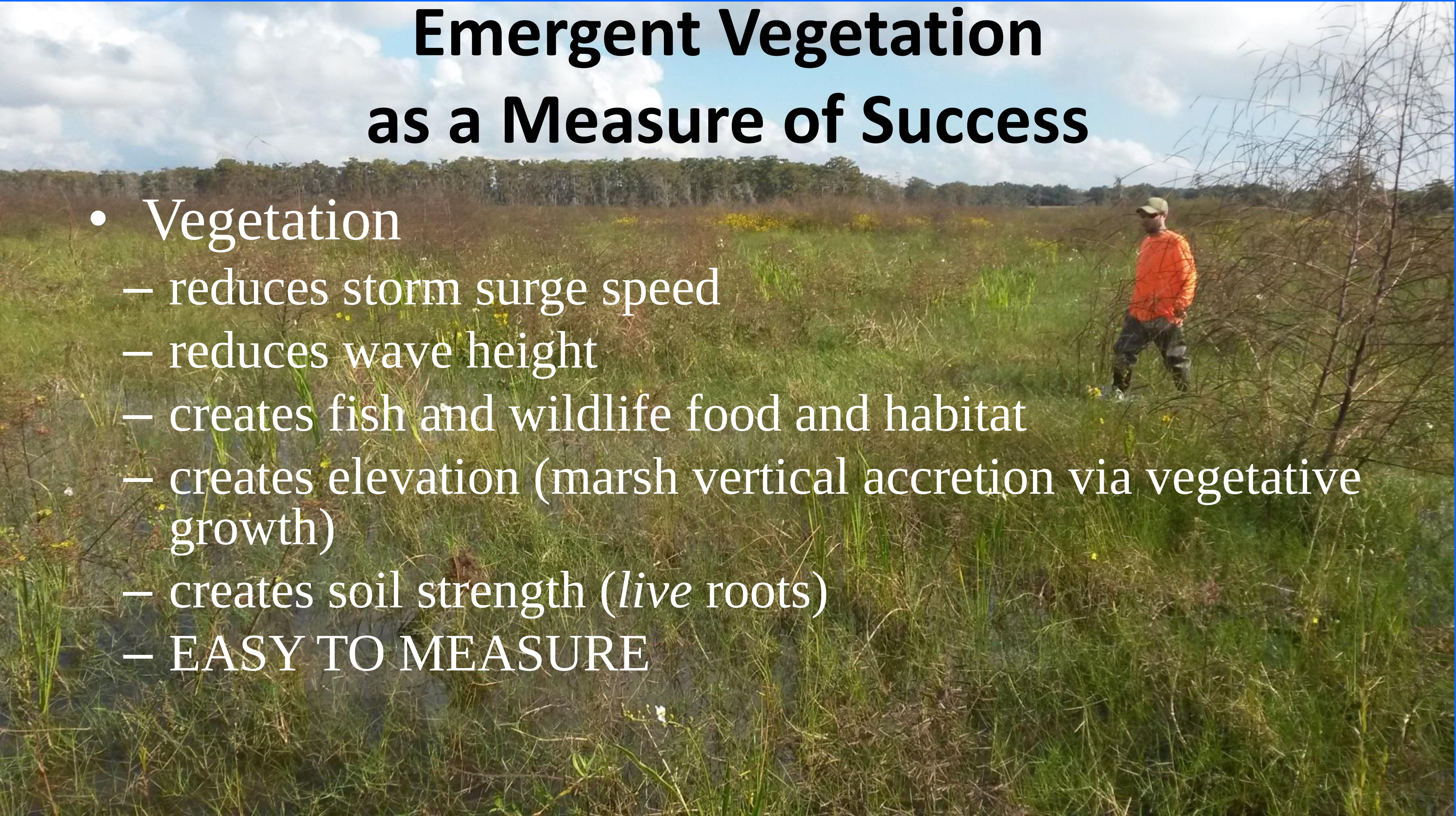
Some Restoration Techniques

2017 MP

Technique	#	$	Acres Created	$/acre
Freshwater Diversion	8	$5.18 billion	.	.
Sediment Diversion	3	$1.86 billion	79,967	$23,273 $/ac
Marsh Creation	40	$17.1 billion	321,400	$53,286 $/ac



Emergent Vegetation as a Measure of Success

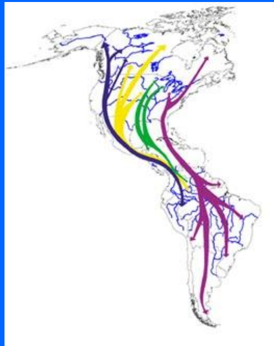
- Vegetation
  - reduces storm surge speed
  - reduces wave height
  - creates fish and wildlife food and habitat
  - creates elevation (marsh vertical accretion via vegetative growth)
  - creates soil strength (*live* roots)
  - EASY TO MEASURE

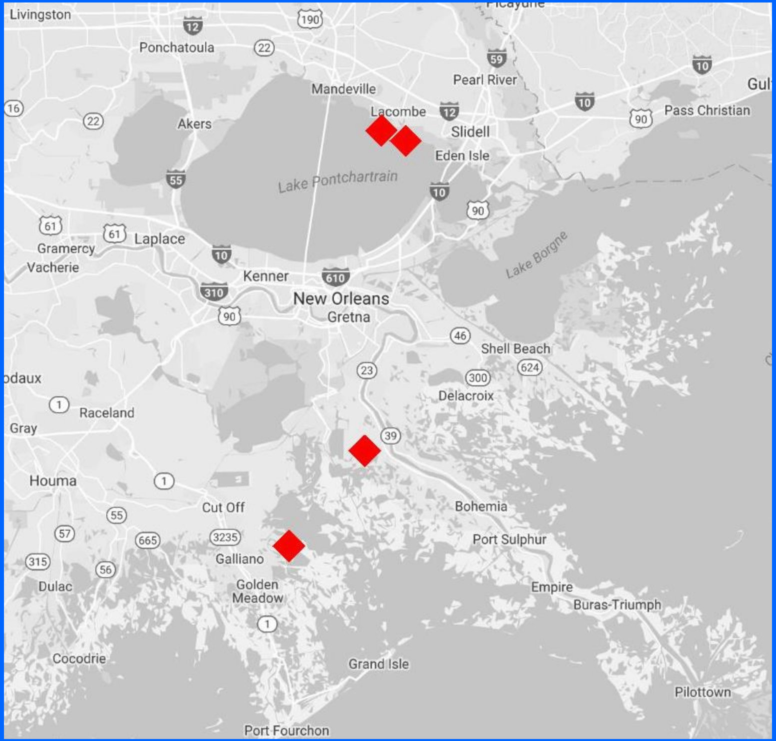
Fish and Wildlife as Measures of Success

- For over 50 years, almost every presentation and document addressing Louisiana's wetland loss problem mentions fish and wildlife.
- Public Law creating the Coastal Wetland Planning, Protection and Restoration Act (101st Congress, 1989-1990) has 5 references to wetlands and "the fish wildlife dependent thereon" or similar wording.
- Almost all restoration controversy involves fish and/or wildlife.
- Louisiana's 2017 Master Plan mentions fish twice as often as it mentions vegetation.

Fish and Wildlife as Measures of Success

- Challenges
  - Migratory wildlife cause seasonal changes in wildlife abundance that are greater than many effects of restoration.
  - Transient fish cause seasonal changes in fish abundance that are greater than many effects of restoration.
  - Even resident fish and wildlife are more expensive to sample than vegetation.





- Four study areas
  - Goose Point/Point Platte PO-33 (east)
  - Goose Point/Point Platte PO-33 (west
  - Bayou Dupont BA-39.
  - Little Lake BA-37
- Three treatments
  - open water
  - natural marshes
  - created marshes.
- Three replicates at each site/treatment combination (36 sites)
- Four seasons (144 samples)

Table 1. Characteristics of created marshes where nekton were studied.

Project name	Little Lake Shoreline Protection/ Dedicated Dredging Near Round Lake (BA-37	Goose Point/Point Platte Marsh Creation (PO-33) Dredge site A	Goose Point/Point Platte Marsh Creation (PO-33) Dredge site C	Bayou Dupont Sediment Delivery System (BA-39)
Year Constructed	2006	2009	2009	2009
Project Size (acres)	417	64	120	471
Target elevation at construction (m)	0.719	0.762	0.878	0.610
Target elevation after 3 years (m)	0.305	0.329	0.329	0.408
Measured elevations (m)	Aug-06, +0.720 Jun-07, +0.500 May-08, +0.460 Aug-09, +0.390 Aug-10, +0.420 Oct-11, +0.400	0.789	0.878	n.d.

- Habitat Quantity:
  - distance from a random point to the first available nekton habitat

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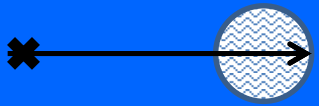
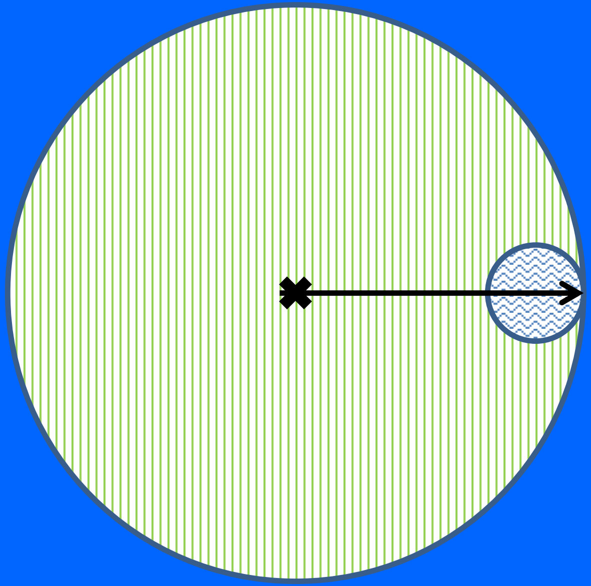


- Habitat Quantity:
  - distance from a random point to the first available nekton habitat



- Habitat Quantity:
  - distance from a random point to the first available nekton habitat

- Habitat Quality:
  - nekton biomass, numbers, species composition, etc. collected with throw-traps

Pre-existing marsh

Marsh created with
dredged material

Pre-existing marsh

Marsh created with dredged material

nekton habitat quantity

Table 3. Indicators of the quantity of nekton habitat within treatments.

Treatment	mean distance (m)	median distance (m)	maximum distance (m)	nekton habitat per treatment (m^2 ha^{-1})
natural marsh	6	1	22	6,473
created marsh	114	12	998	4,143
open water	1	1	1	10,000

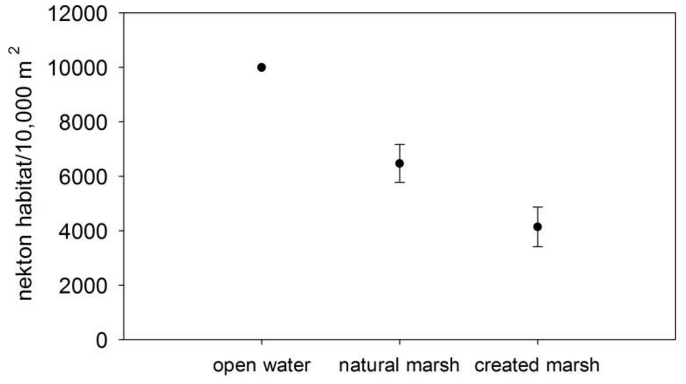


Table 4. Classification of nekton species as resident or transient and the proportion of biomass that they contributed to classes.

Species	percent of biomass within classes
	- - - - - resident decapod crustaceans - - - - -
Palaemonetes spp.	0.58
Procambarus clarkii	0.32
Xanthidea	0.05
Cambarellus shufeldtii	0.04
Cambaridea spp.	0.01
	- - - - - transient decapod crustaceans - - - - -
Callinectus sapidus	0.63
Litopenaeus setiferus	0.37
Penaeus spp.	<0.01

10 most abundant (biomass) resident fish (22 species in all)

	- - - - - resident fish - - - - -
Poecilia latipinna	0.38
Lucania parva	0.19
Cyprinodon variegatus	0.11
Lepomis microlophus	0.10
Gambusia affinis	0.07
Microgobius gulosus	0.05
Dormitator maculatus	0.02
Heterandria formosa	0.02
Fundulus pulvereus	0.02
Micropteru salmoides	0.01

	- - - - - transient fish - - - - -
Brevoorita patronus	0.78
Anchoa mitchilli	0.11
Mugil cephalus	0.08
Sciaenops ocellatus	0.02
Strongylura marina	0.01
Anguilla rostrata	0.01

nekton habitat quality

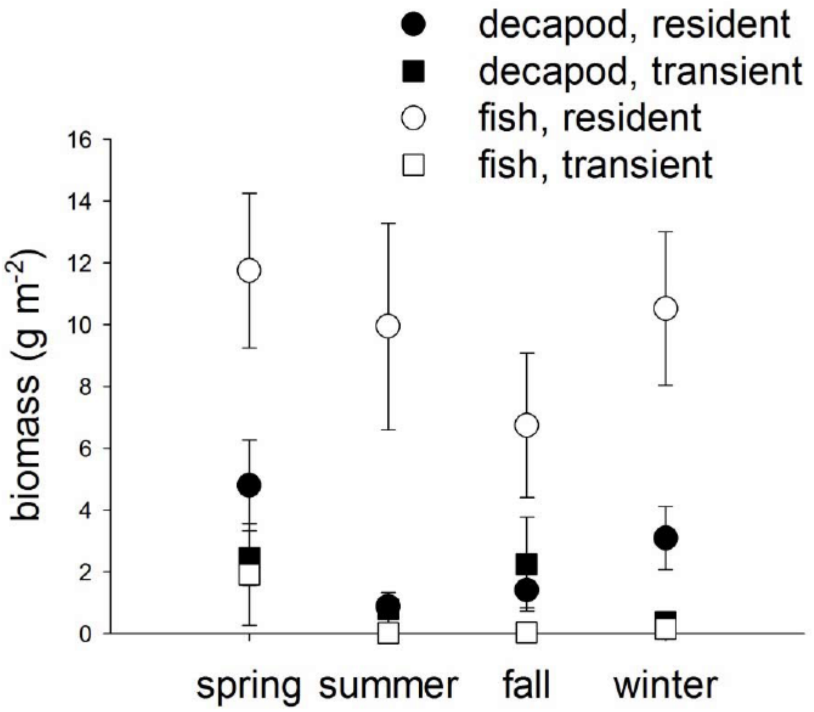


Figure 2. Seasonal patterns in biomass of fish and decapod crustaceans in coastal Louisiana, 2015 through 2016.

nekton habitat quality

Table 5. Indicators of the quality of fish habitat within treatments: average numbers and biomass of fish and decapod crustaceans in potential fish habitat. Values are least-square means and least-square standard errors generated by Proc Mixed of SAS.

Treatment	fish		decapod crustaceans	
	resident	transient	resident	transient
		- - - - - - biomass (g m^{-2}) - - - - - -		
natural	13.2 (2.3)	0.1 (0.7)	1.4 (1.2)	1.0 (0.9)
created	11.3 (2.3)	0.04 (0.7)	3.1 (1.2)	0.9 (0.9)
open water	4.8 (2.3)	1.4 (0.7)	3.1 (1.2)	2.5 (0.9)
		- - - - - - number of individuals (m^{-2}) - - - - - -		
natural	49.0 (9.9)	0.6 (2.2)	9.4 (4.4)	1.6 (0.9)
created	50.1 (9.9)	0.3 (2.2)	13.8 (4.4)	0.3 (0.9)
open water	29.1 (9.9)	6.3 (2.2)	20.6 (4.4)	3.0 (0.9)

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Conclusions

- Emergent vegetation is an excellent but incomplete measure of success for restored Louisiana wetlands.
- Nekton species composition was similar in natural marshes and created marshes (but there were differences, which agreed with research).
- Created marshes provided 2/3 the habitat that natural marshes provided and thus probably provide fewer nekton than natural marshes to estuarine ecosystems.

Recommendation

- Wetlands constructed from dredged material should be designed explicitly to create nekton habitat as well as emergent vegetation.
  - increased interspersion of ponds and channels throughout the created marshes
  - lower surface elevation

Justifications to construct wetlands higher than natural wetlands

i. dredged sediments will consolidate under their own weight for several years
ii. dredged sediments will induce consolidation of underlying sediments for several years
iii. new plants lack large root systems that allow mature plants to tolerate flood durations associated with lower elevations in natural marshes
iv. higher elevation reduces storm surge more
v. higher elevation is required for the created wetlands to survive 20 years of local subsidence and global sea-level rise (assume no marsh vertical accretion)

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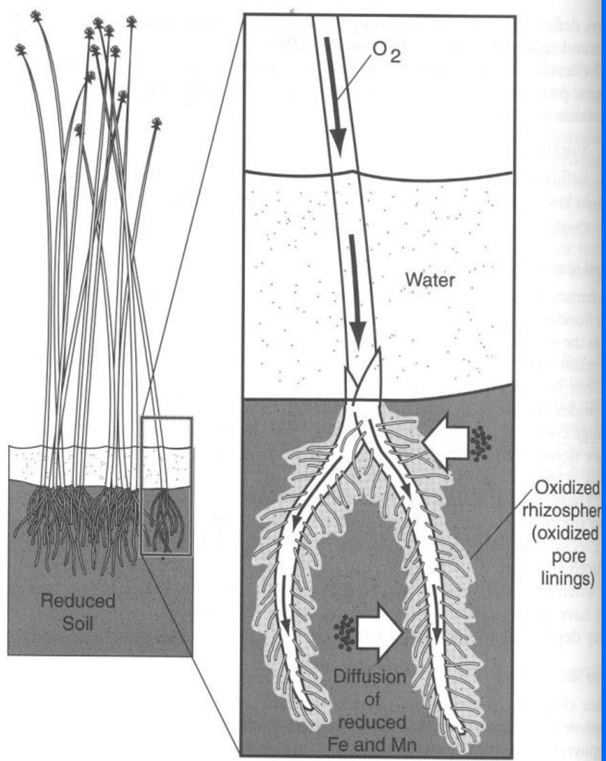

Figure 6-3 Formation of oxidized rhizospheres, or pore linings, around the roots of a wetlan plant due to the transport of excess oxygen by wetland plants to their roots. When the plant pore linings of iron and manganese oxides remain. (*After Vepraskas, 1995*)

Mitsch, W.J. and J.G. Gosselink. 2000. Wetlands. Third Edition. John Wiley and Sons, Inc.

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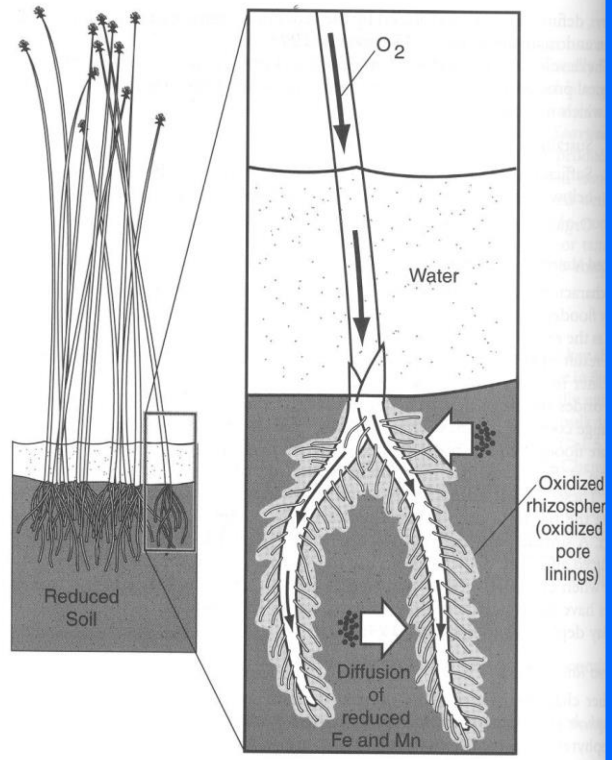
Table 7
Mean values (range in parentheses) for average annual salinity, percent time flooded, and tidal amplitude for each of the nine community types identified.

Community type	Average annual salinity	Percent time flooded	Tidal amplitude (cm)
Paus	1.5 (0.8–3.5)	68.6 (46.1–95.5)	24.3 (20.7–26.8)
Ppun	1.2 (0.2–3.6)	57.3 (1.4–100.0)	10.4 (0.3–29.9)
Humb	1.0 (0.2–3.3)	61.7 (9.6–98.5)	1.8 (0.1–6.1)
Same	4.0 (0.2–8.8)	44.9 (8.6–90.4)	11.3 (0.3–27.7)
Spat	4.3 (1.9–7.8)	55.4 (4.3–100.0)	2.2 (0.0–10.1)
Srob	7.8 (2.1–14.9)	55.2 (12.2–98.5)	7.0 (0.1–27.4)
Sten	8.2 (2.3–16.4)	44.8 (16.1–81.7)	16.4 (6.7–28.9)
Jroe	12.8 (3.5–18.5)	50.8 (29.1–72.0)	26.5 (19.8–31.7)
Salt	18.3 (13.7–20.9)	49.7 (37.1–61.5)	25.9 (15.2–32.9)

Snedden and Steyer. 2013. Estuarine, Coastal & Shelf Science 118:11-123



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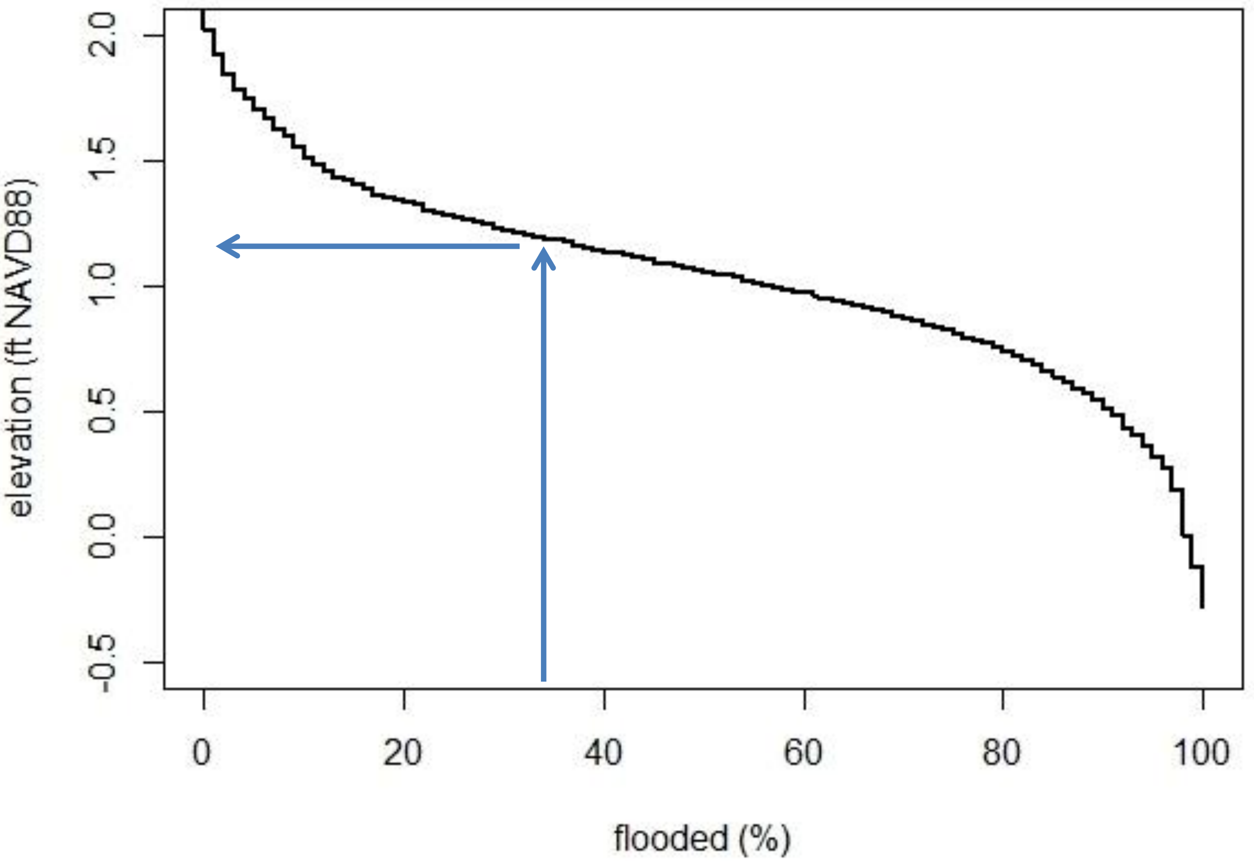

elevation (ft NAVD88)
-0.5
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
flooded (%)

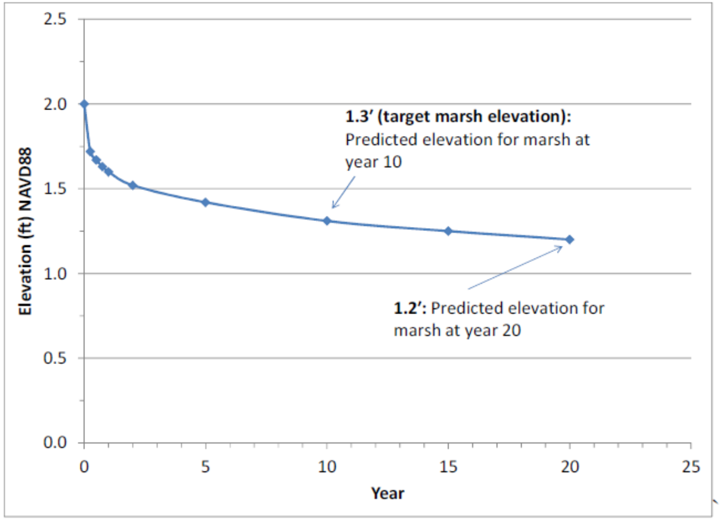
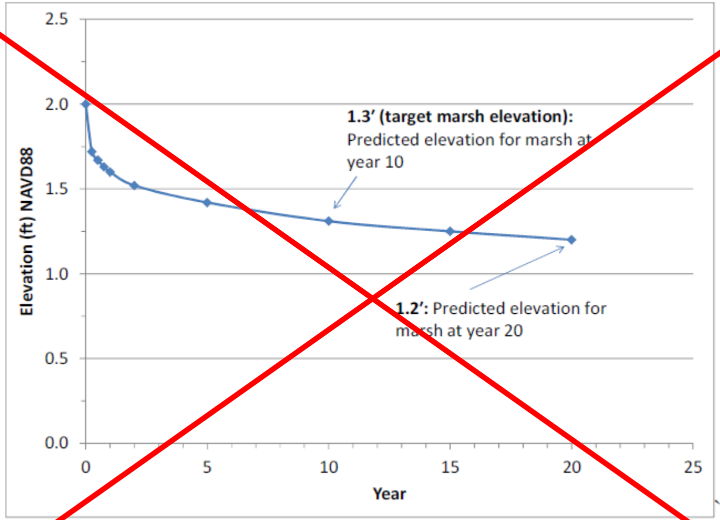


Figure 7. Predicted twenty-year settlement curve for BA-39 based on a constructed marsh fill elevation of +2.0′ NAVD88.



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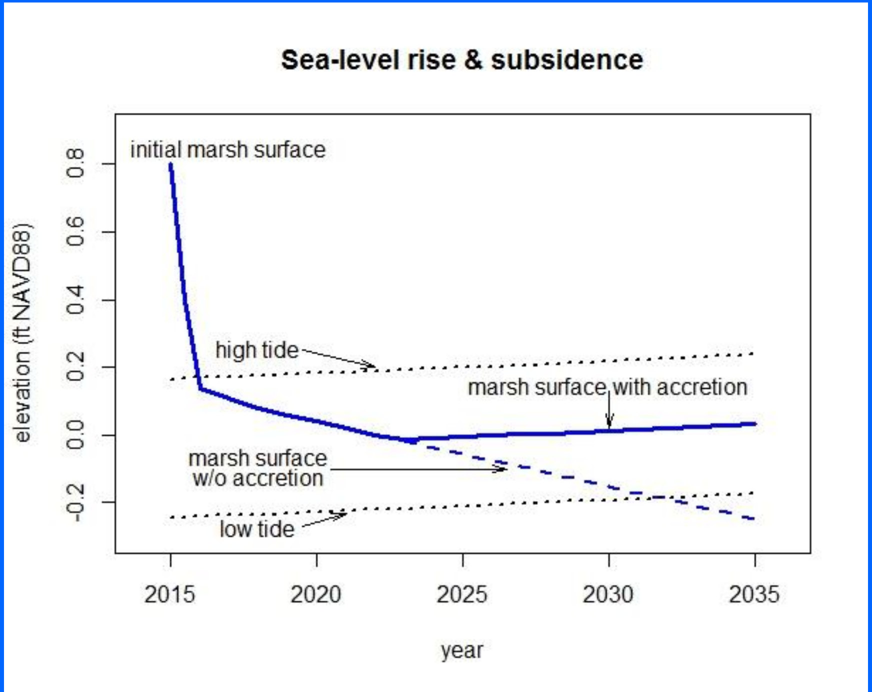


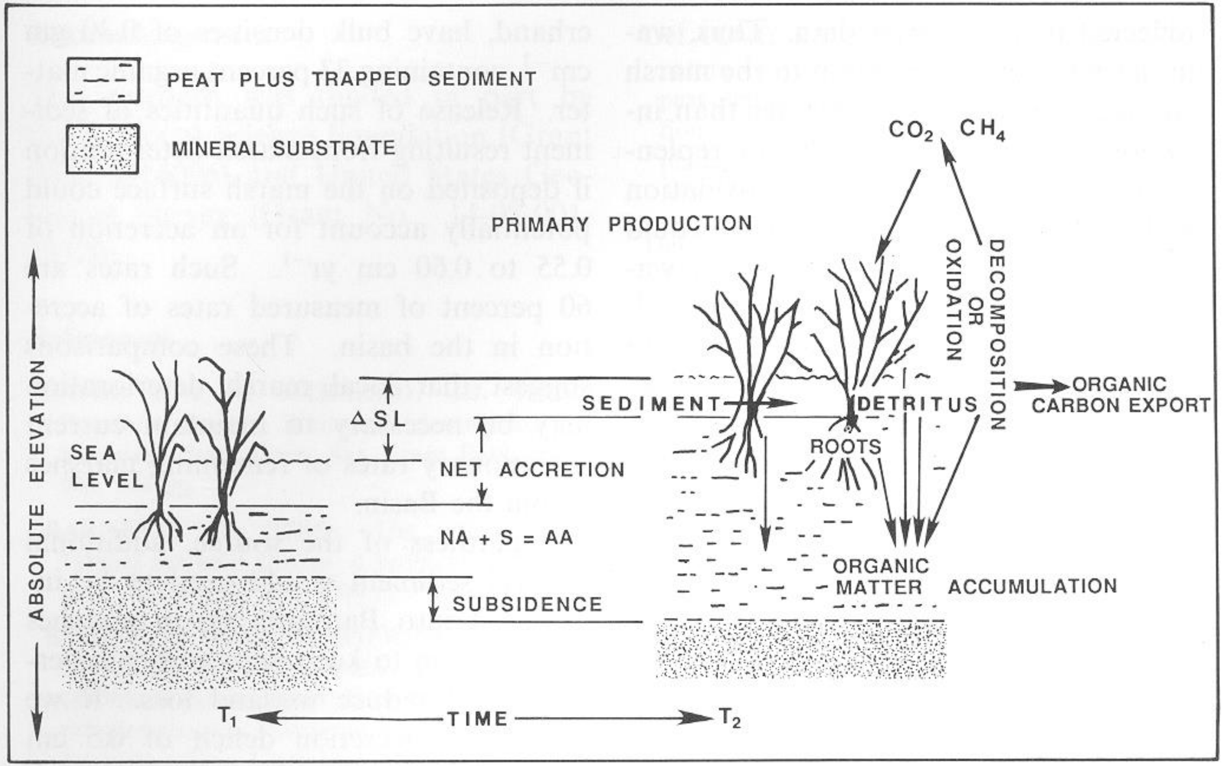
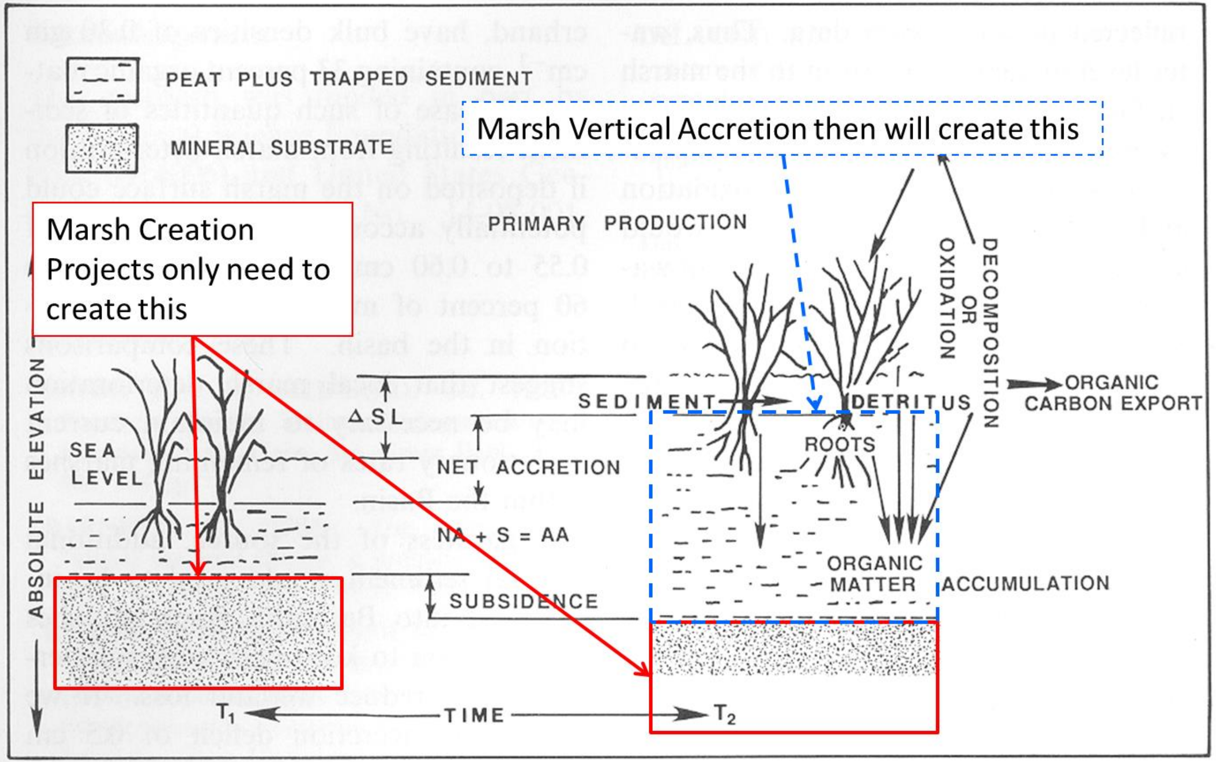


Fig. 4: *Schematic model of processes governing marsh accretion* (ΔSL = *sea level*, NA = *net accretion*, S = *subsidence*, AA = *absolute accretion*).

Delaune et al. 1990. Catena 277-288.



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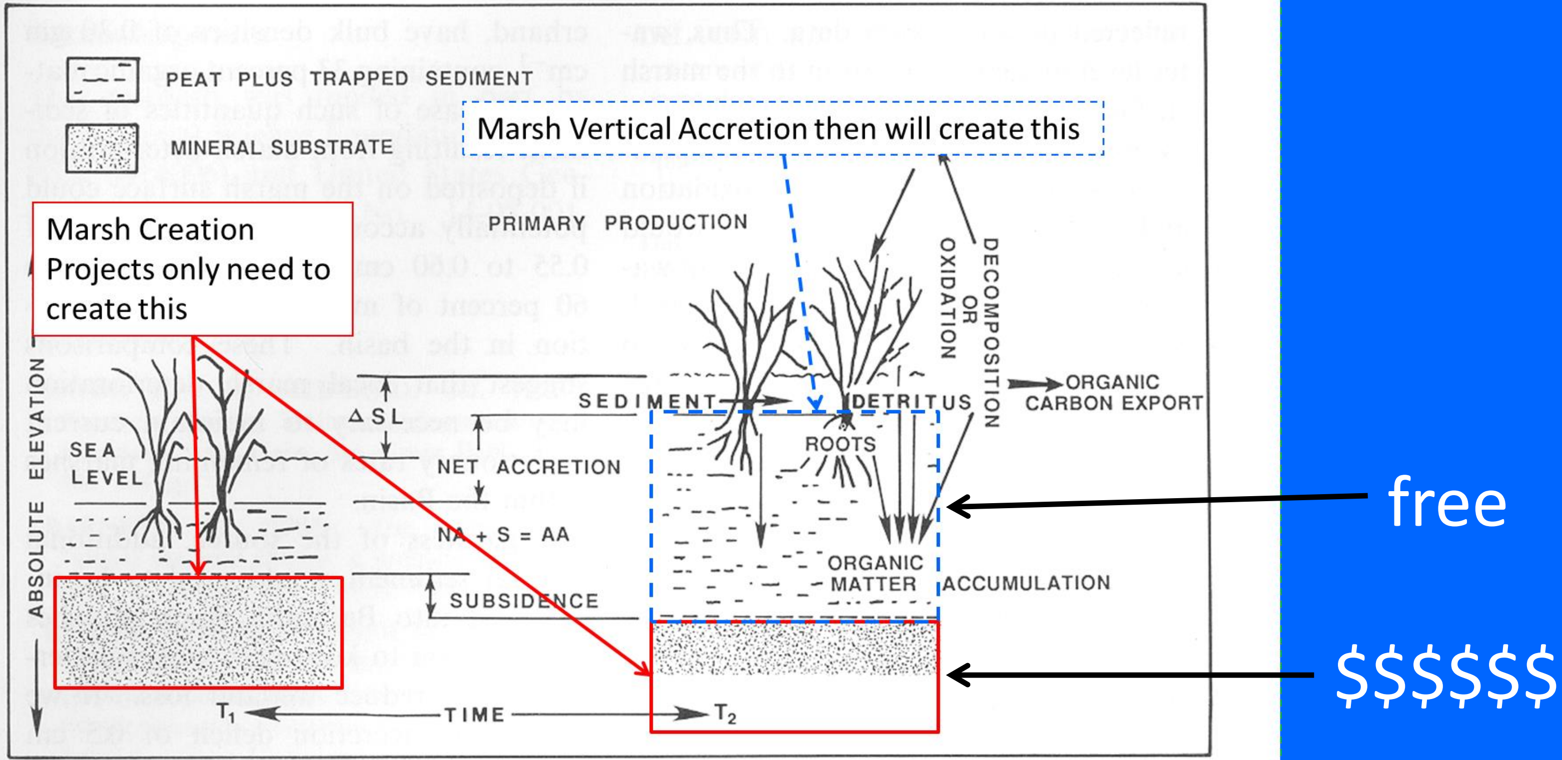

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