WETLANDS AND FLOOD RISK:
PROCESSES, CONSIDERATIONS, AND EXAMPLES




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US Army Corps of Engineers

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OVERVIEW: WETLANDS AND FLOOD RISK

- Rationale and scope
- Context
- Modes of FRM
  - Principles
  - Examples
- Designing solutions
- Monitoring and maintenance

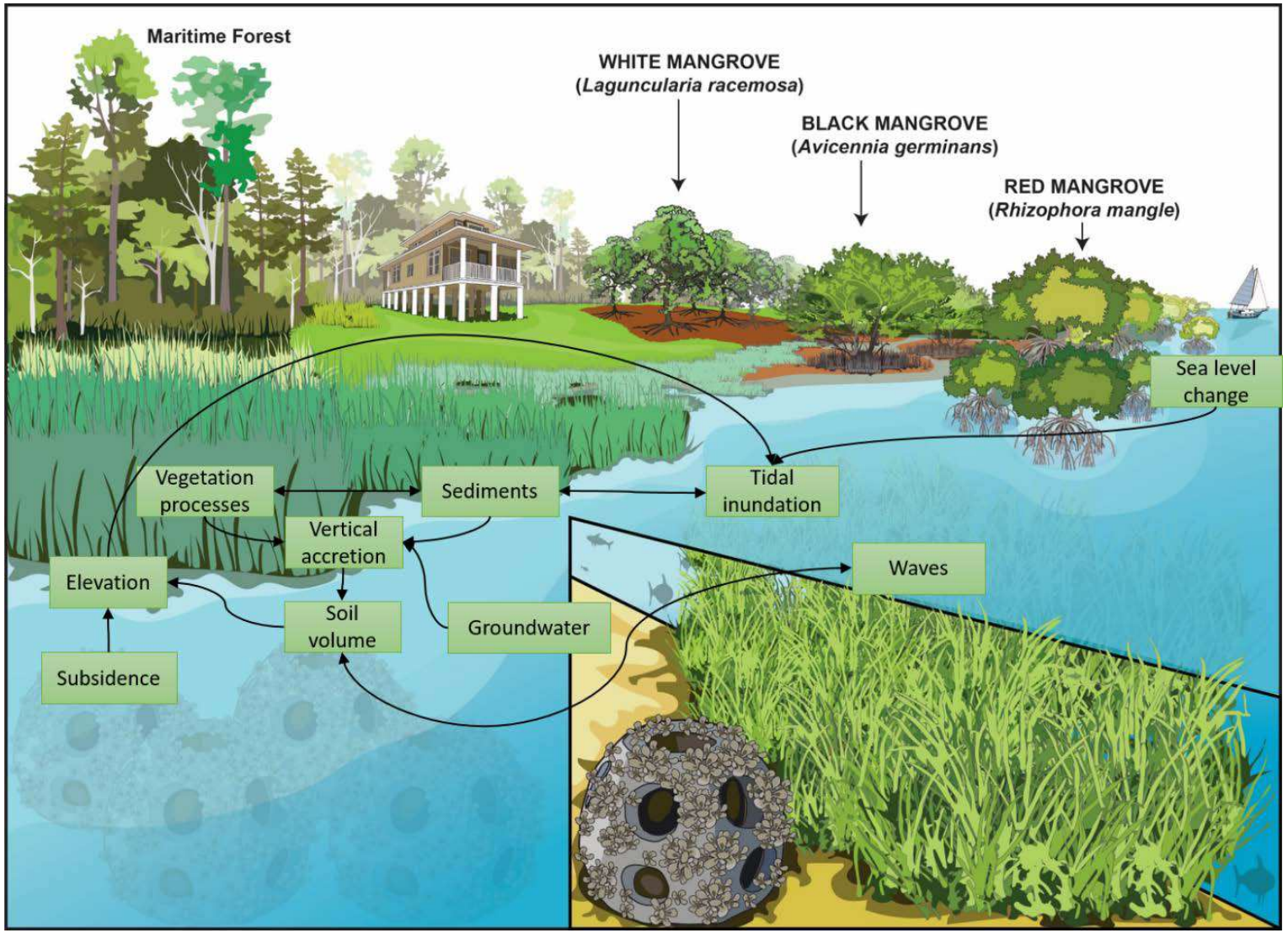
WHY WETLANDS OVER CONCRETE?

Co-benefits!!

	Supporting		
Sediments – trapping and formation	• Organic matter • Fodder		on (e.g. fishing, bird , canoeing king)
Water and Nutrients – recycling and storage	• Water		n g
Biological productivity	es)	• Species richness	• Livelihoods (fishing

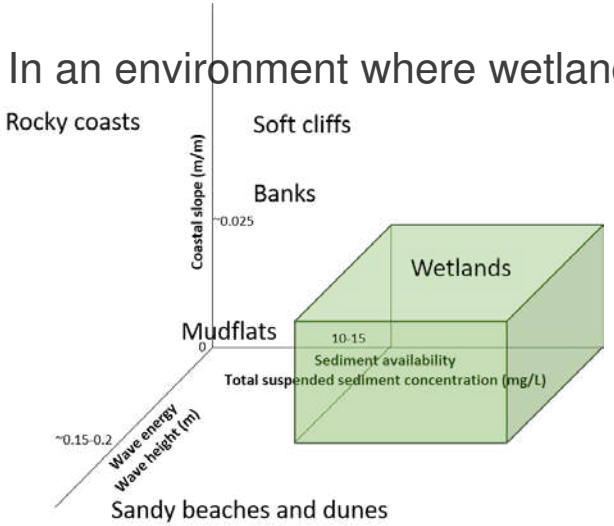
CONSIDERATION OF WETLANDS REQUIRES WE UNDERSTAND WETLAND FUNCTION

- What types of wetlands?
  - Coastal marshes (salt and brackish)
  - Mangroves
- What processes?
  - Physical processes
  - Biophysical feedbacks
  - Limiting conditions that control these processes
- Landscape
  - Relatively sheltered estuaries
  - Alone or (likely) in combination with other measures



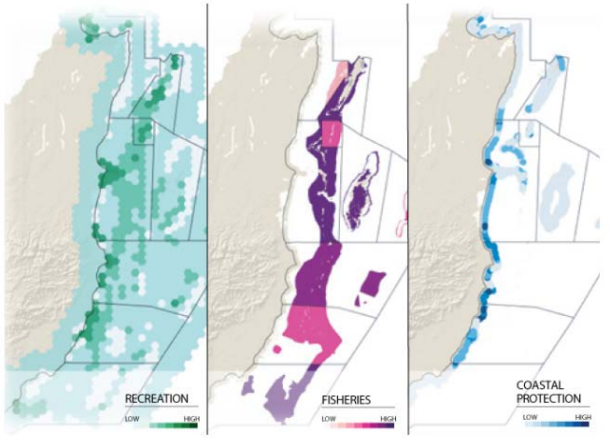
IN WHAT CONTEXT DO WETLANDS MAKE SENSE?

In an environment where wetlands can persist



These boundaries are not rigid. Engineered structures can modify wave energy and SLR can increase the required sediment.

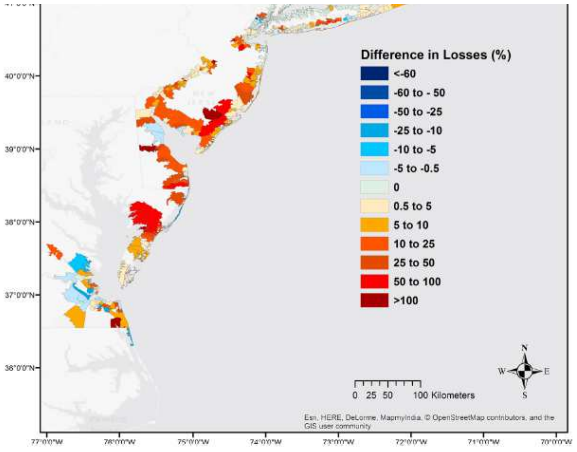
Where they can provide the desired co-benefits



Co-benefits are not uniformly produced at all locations.

InVEST documentation

Where they can provide the required engineering performance



Wetlands in some areas can reduce flood damages but may increase them in others.

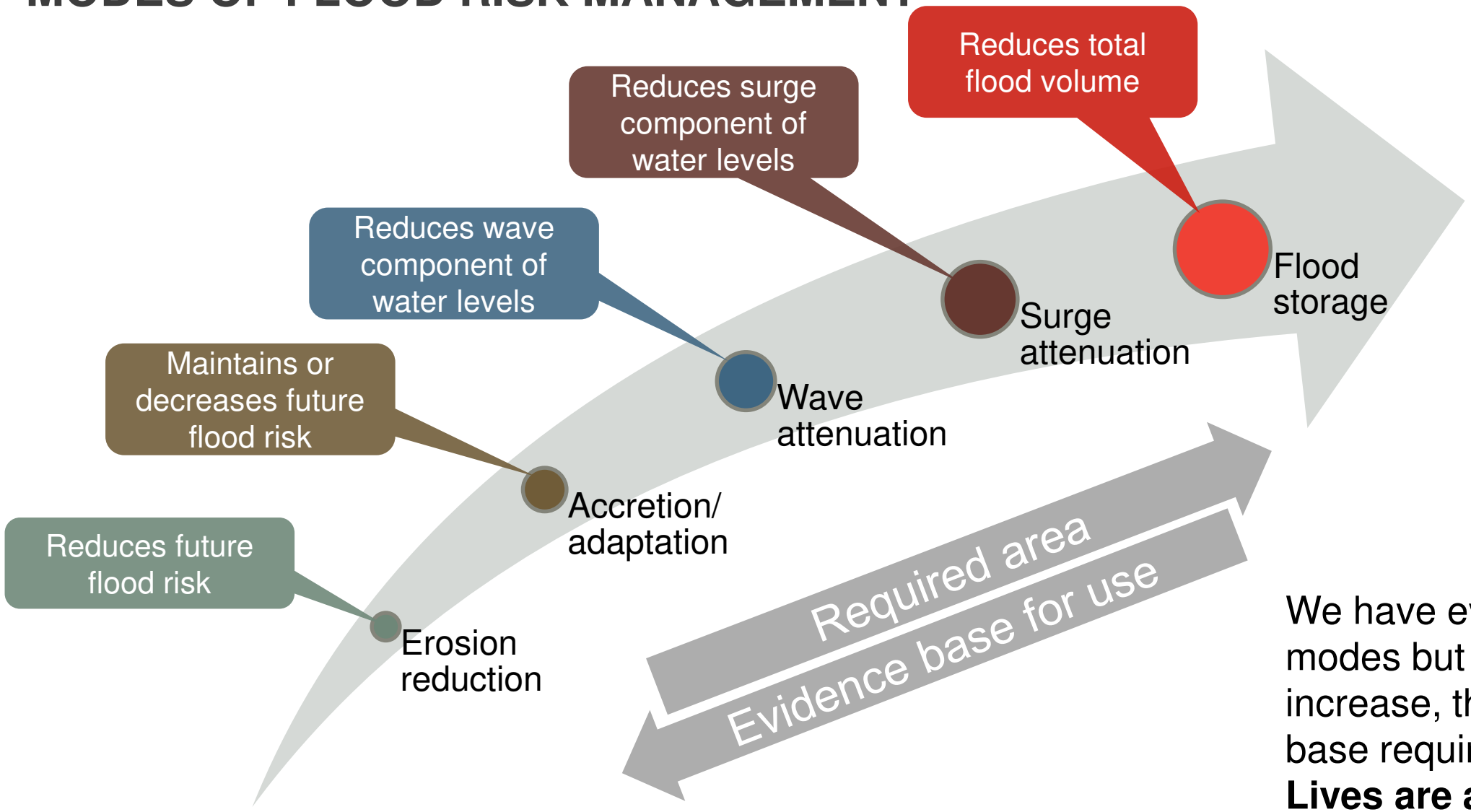
from Narayan and Beck 2017

Where they are accepted

Education, outreach, and guidance are required to ensure wetlands are accepted.

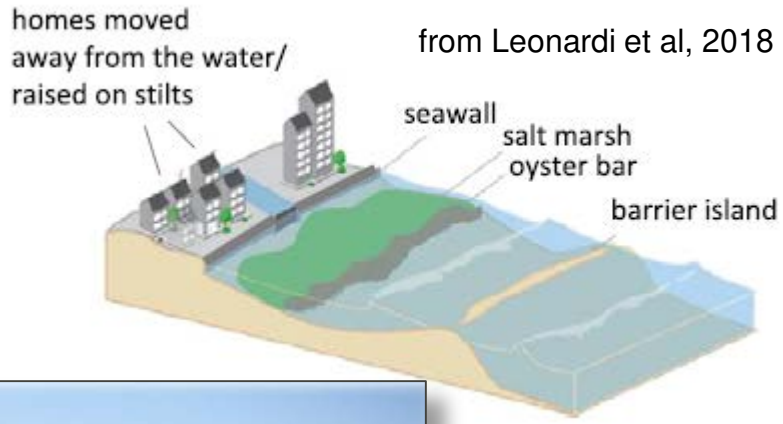
from TNC *Mangroves for Coastal Defence : Guidelines for coastal managers & policy makers*

MODES OF FLOOD RISK MANAGEMENT

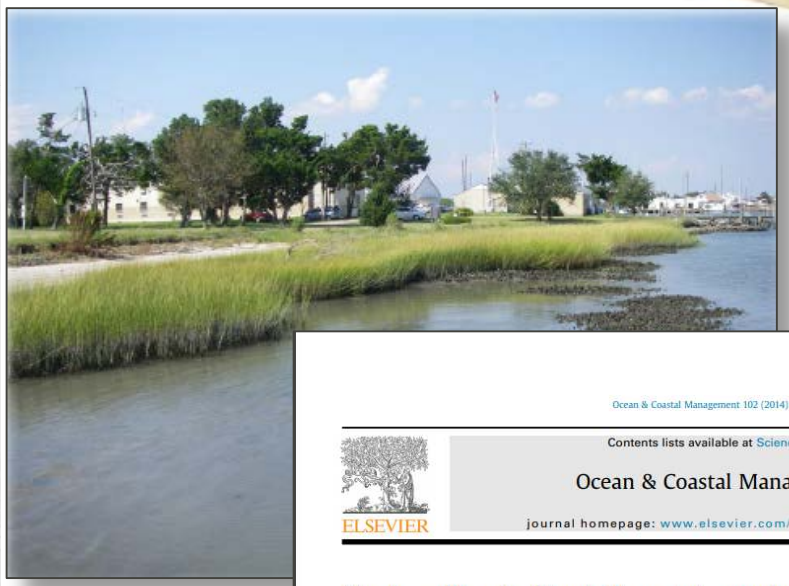


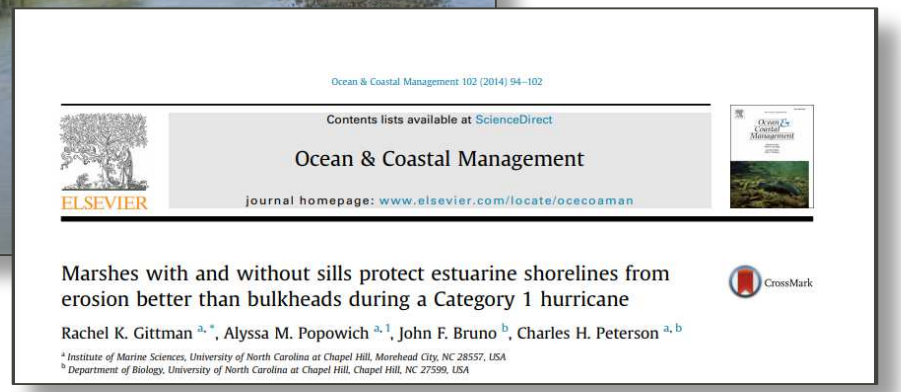
We have evidence for all modes but as risks increase, the evidence base required increases. **Lives are at stake.**

EROSION REDUCTION



from Leonardi et al, 2018





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Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane

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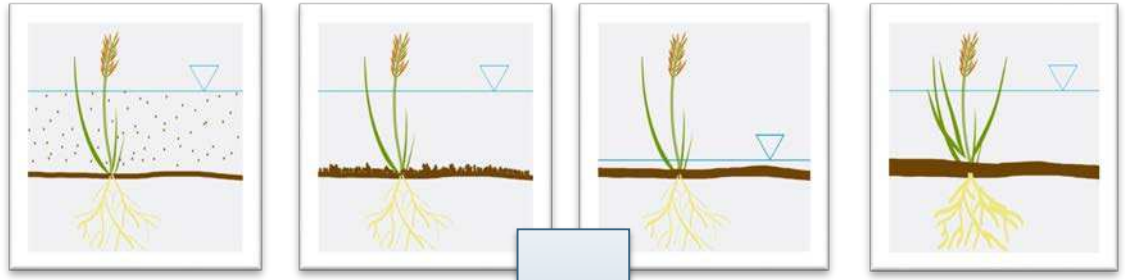
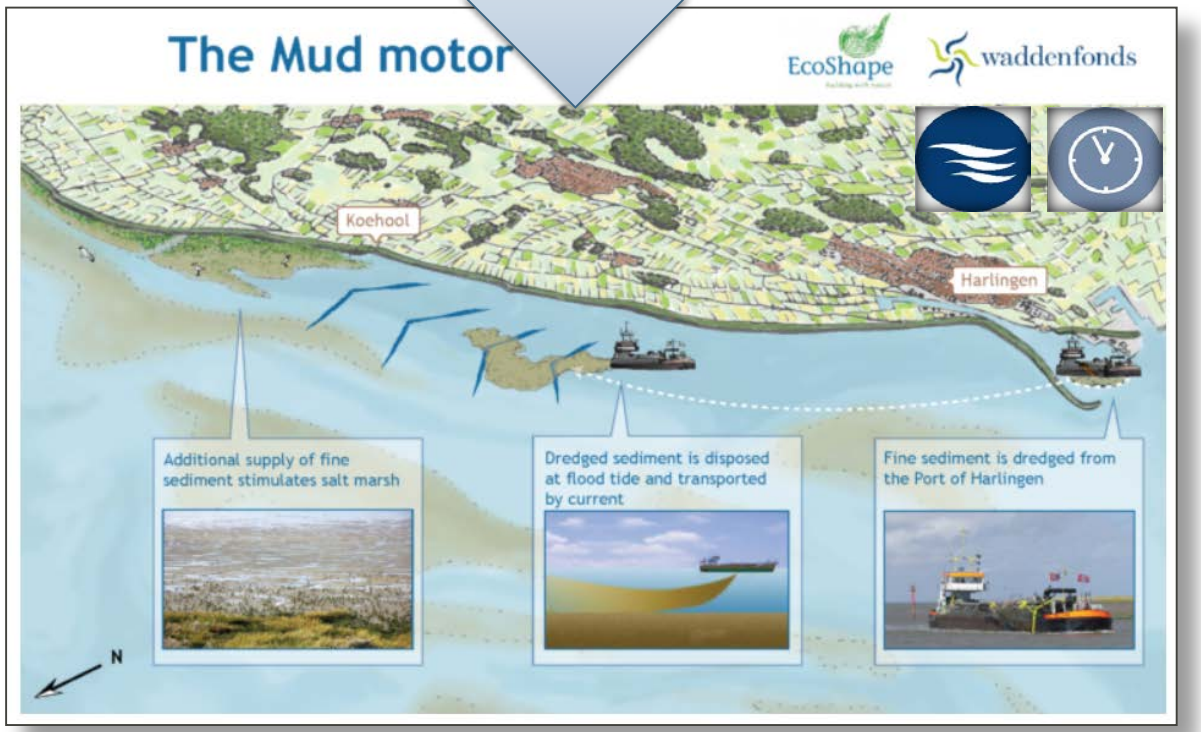
ACCRETION AND ADAPTATION



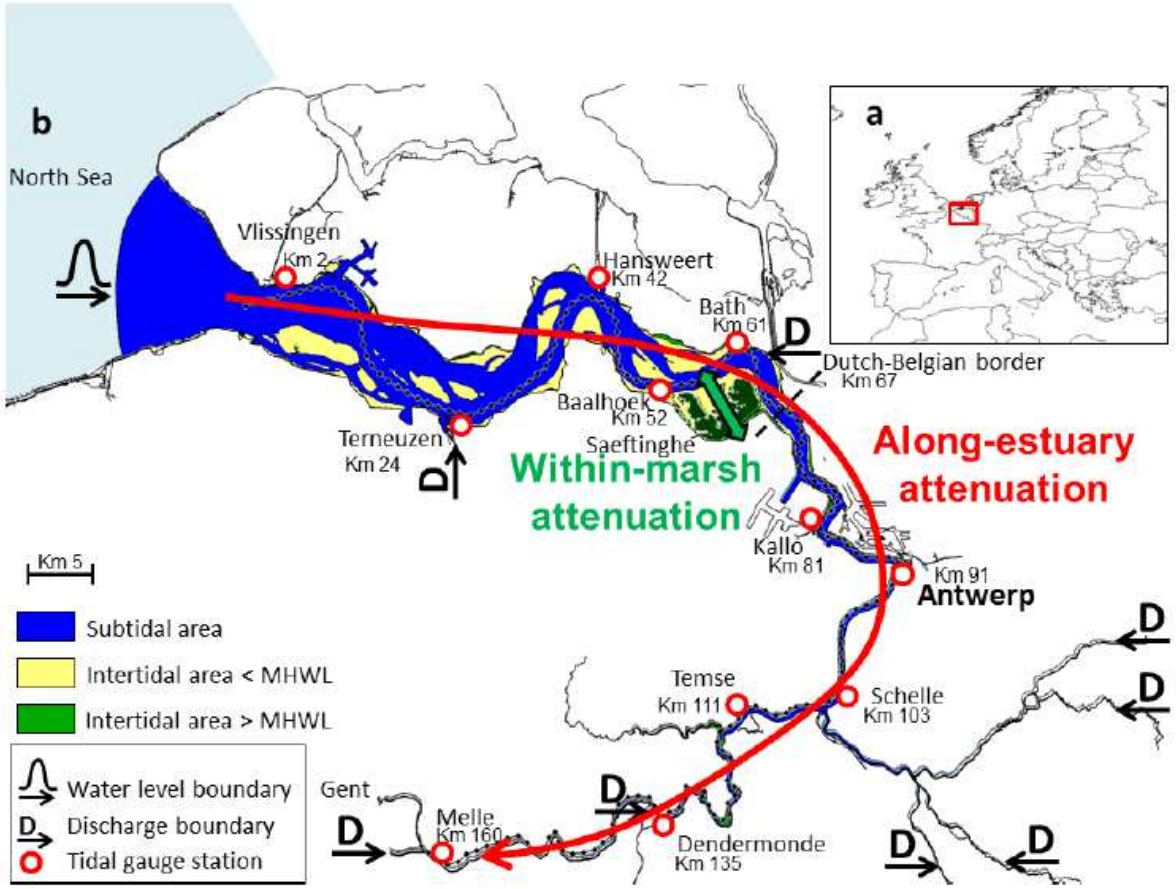


WAVE ATTENUATION

- Evidence of wave height reduction available from field measurements, laboratory studies and numerical modelling
- Main parameters known

Habitat	Wave reduction factors
Salt Marshes	• Incoming wave height & period • Depth of water above the marsh surface • Vegetation properties - number of stems, diameter, branching, height, stiffness, buoyancy
Mangroves	• Incoming wave height & period • Depth of water above the bed of forest • Underlying topography • Vegetation properties - density of vegetation, presence of aerial roots

SURGE ATTENUATION



Smolders et al., 2015

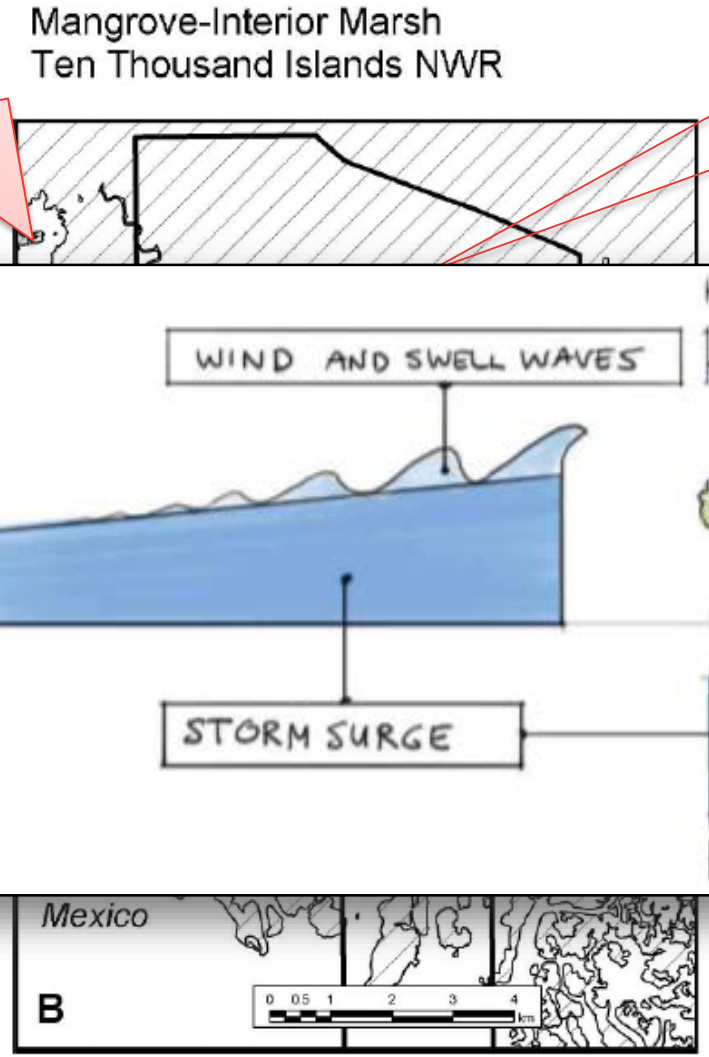
Relevant variables

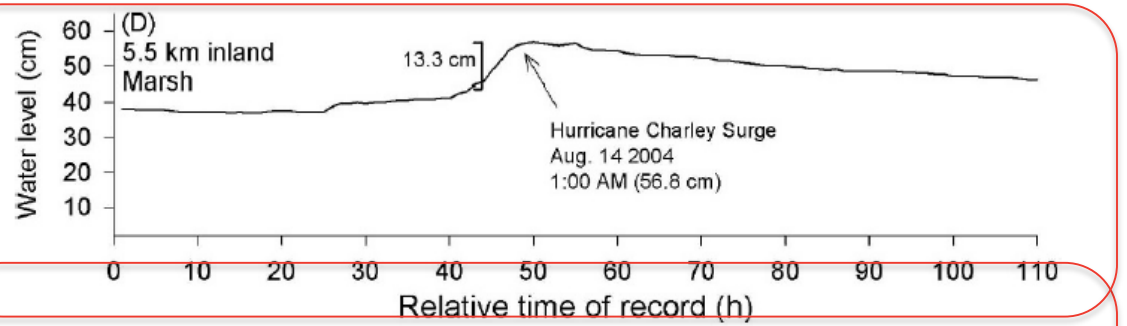
- Landscape position
- Bathymetry
- Wind direction and duration
- Storm speed and direction
- Wetland morphology
- Vegetation characteristics

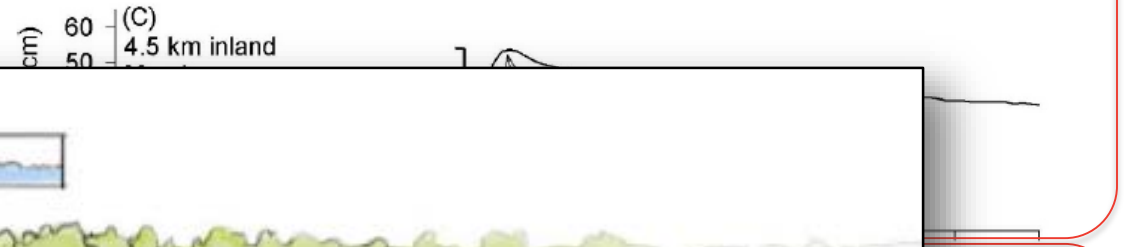
Reported attenuation

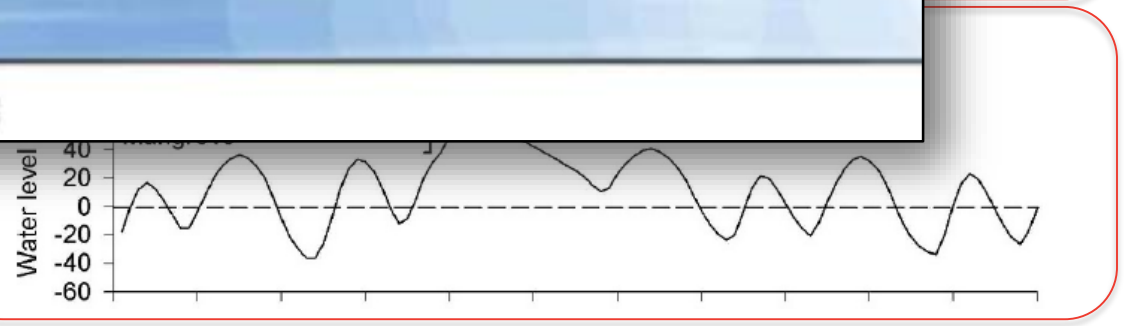
- 1 m/1.4 km to 1 m/25 km
- Most effective for fast-moving storms with smaller storm surges

SURGE ATTENUATION









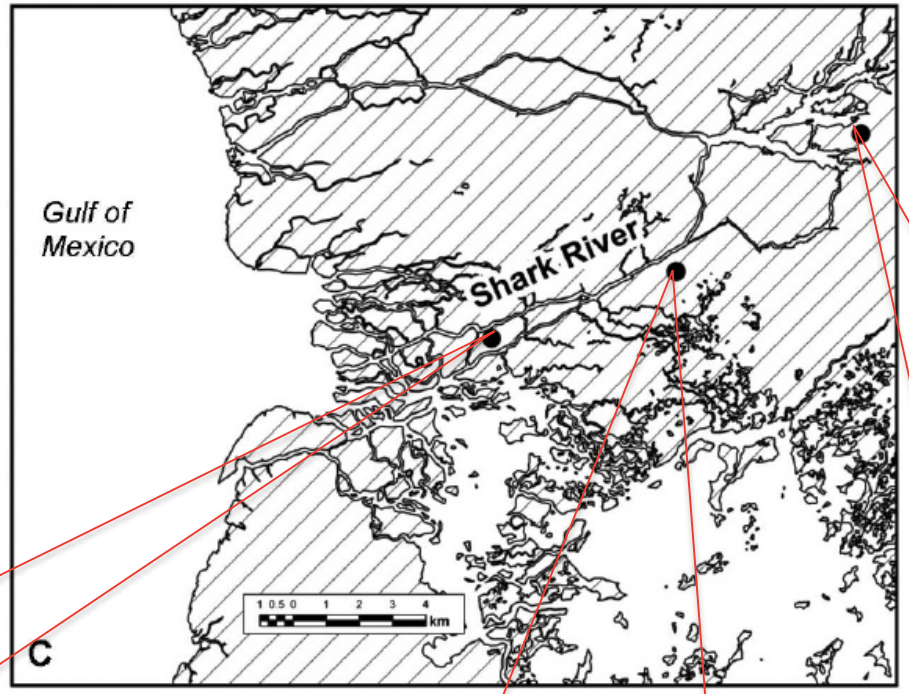
Hurr
Charley

Krauss et al., 2009

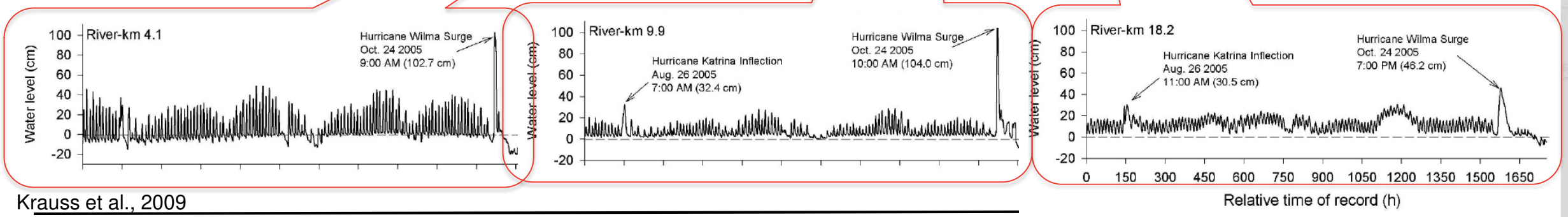
SURGE ATTENUATION

Riverine Mangrove
Shark River
Everglades NP

Hurricane
Wilma (2005)



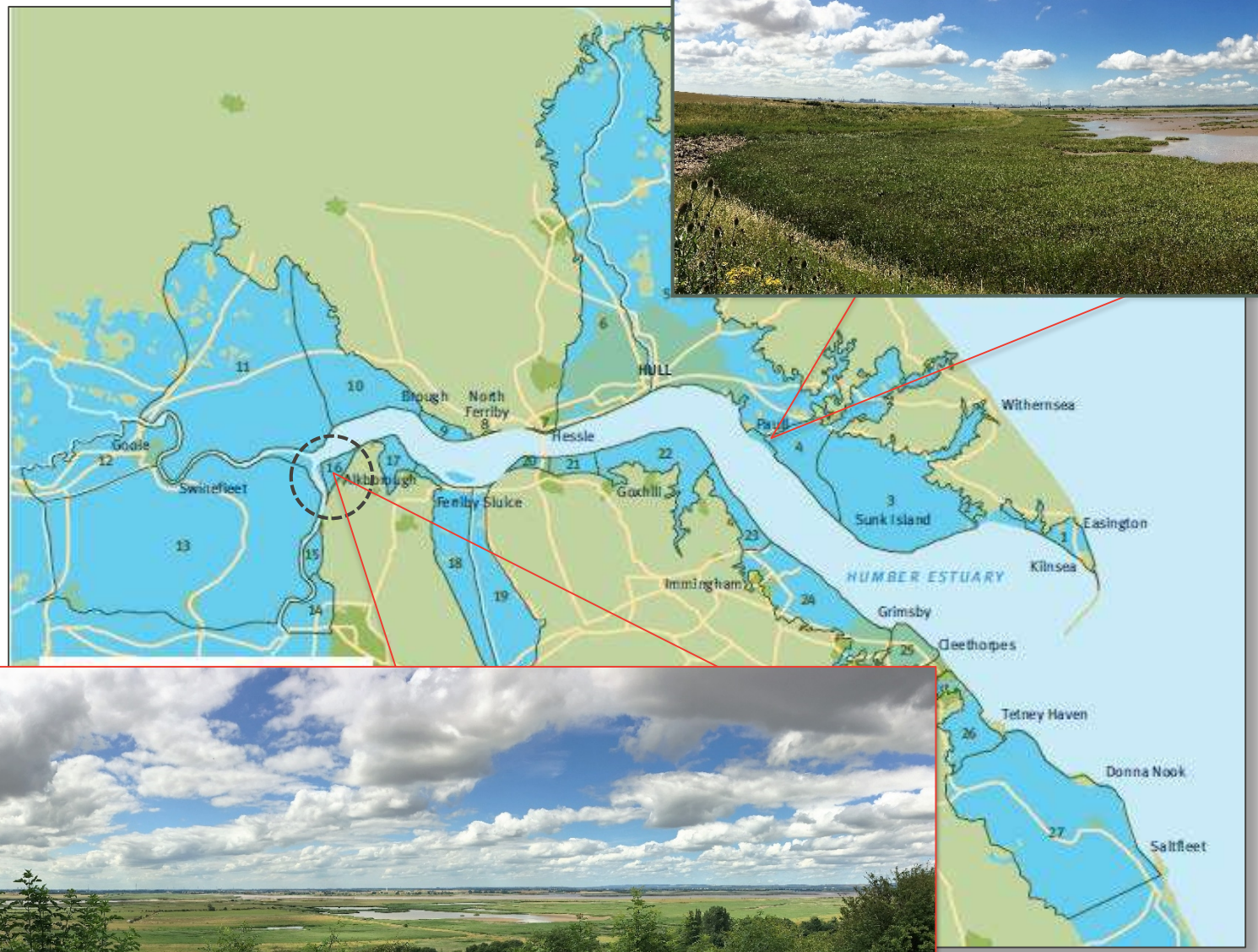
Surge attenuation in one area can lead to surge amplification in another.



Krauss et al., 2009

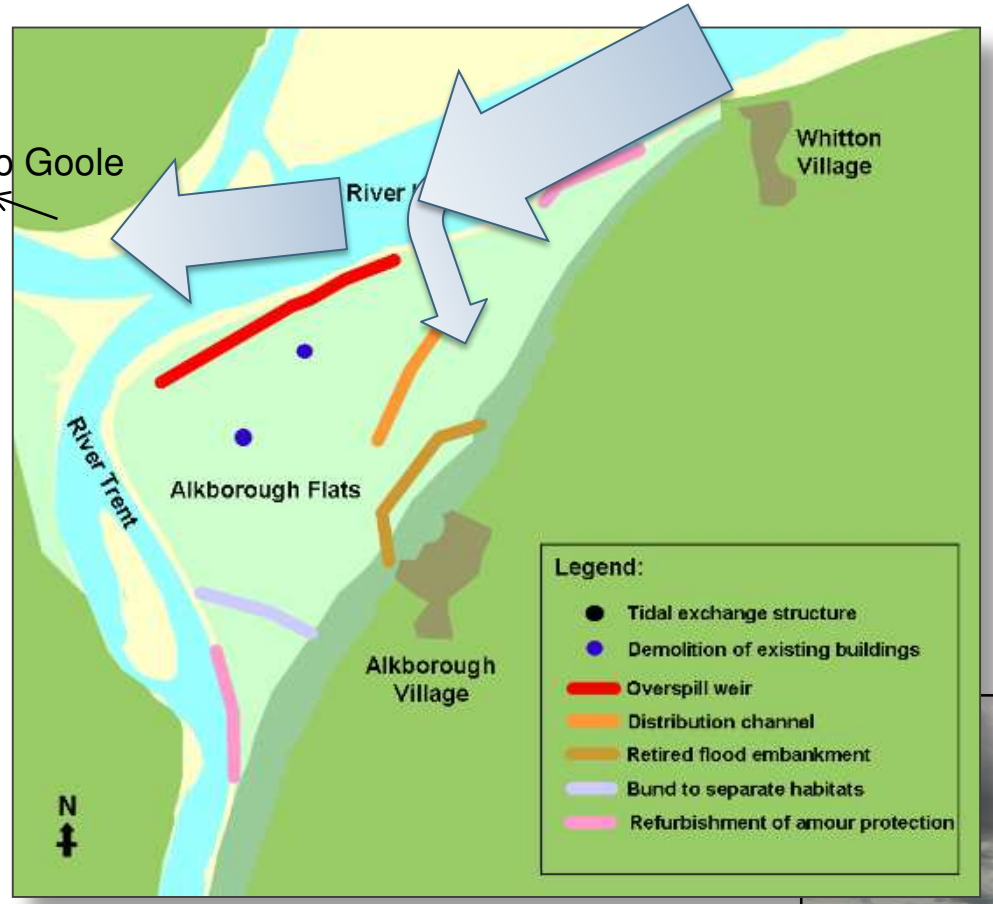
FLOOD STORAGE – HUMBER ESTUARY CASE STUDY

Paull Holme Strays
80 ha primarily for habitat



Alkborough Flats
440 ha primarily
for tidal defence

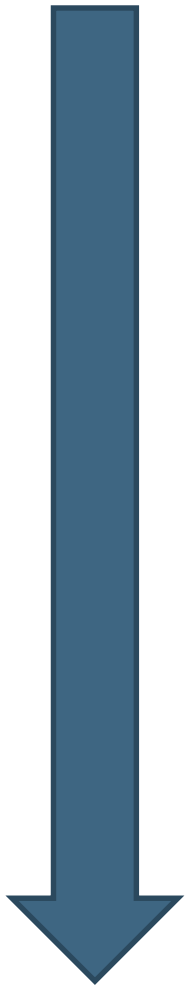
FLOOD STORAGE – ALKBOROUGH FLATS IN THE HUMBER ESTUARY



HOW DO WE IMPLEMENT WETLAND NNBF SOLUTIONS?

Level of effort

- Conserve existing wetlands
- Restore degraded wetlands
- Expand the footprint of existing wetlands
- Build new wetlands



Data requirements

Modeling requirements

Regulatory involvement

Time required to see benefits

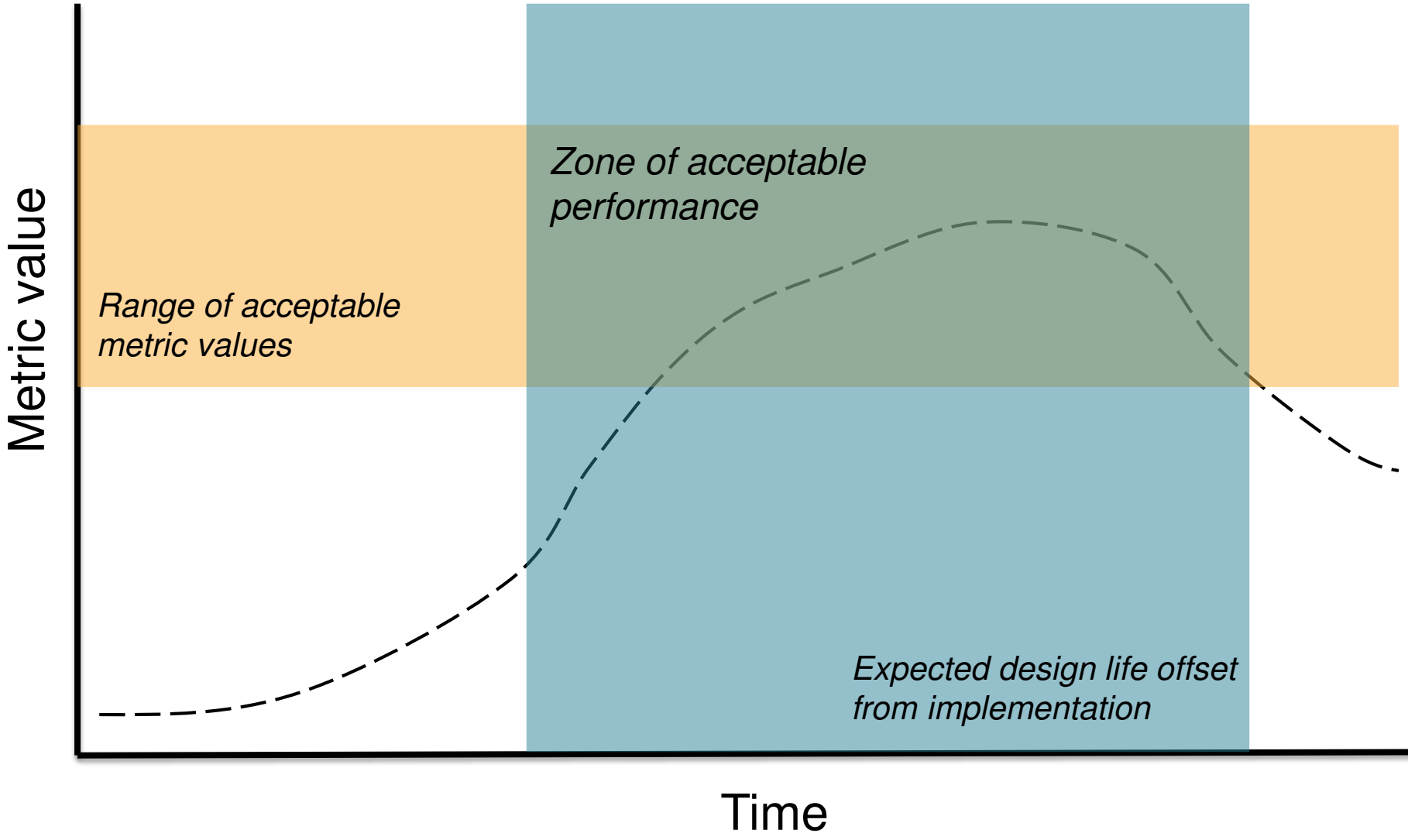
Cost

HOW DO YOU DESIGN A WETLAND NNBF SOLUTION?

Focus on the aspects of the design you can control.

Design parameter	Performance factors
Size and configuration (x,y)	Location in estuary Distance from shoreline to upland or structure Total storage volume as a function of water level
Platform elevation (z)	Elevation relative to tidal datum/tide range Topography of wetland and transitions to other habitats
Channel network	Drainage density, sinuosity, junction angles etc. Channel width and depth
Vegetation	Species, height, shape, density, flexibility, roots, distribution
Sediment properties	Grain size, organic matter, bulk density, shear strength
Nearshore bathymetry	Depth, slope, sediment properties of adjacent subtidal mud/sand flats Proximity to deep water
Proximity to traditional defenses	Distance to defense, configuration and geometry of defense

MONITORING AND ADAPTATION



If at any time in design life acceptable performance is not achieved, adaptive actions must be taken. The wetland is part of your flood defense!

MONITORING AND ADAPTATION

Type of Measure	Monitoring parameter	Metric	Performance criteria
Core Measures			
Geomorphology	Spatial area and configuration	• Total wetland width/length • Unvegetated-vegetated ratio	• Should exceed minimum acceptable design criteria • Should be stable or decreasing relative to reference sites
Vegetation	Vegetation abundance Vegetation structure	• Aboveground biomass • Average stem density, diameter, height	• Aboveground biomass should exceed design • Should meet or exceed minimum for FRM reqs
Secondary Measures			
Hydrology/ Hydrodynamics	Water levels	Inundation time	
Soils	Physical properties	Bulk density	
Chemistry	Salinity		
Vegetation	Abundance (secondary)	Belowground biomass	
Infauna	Abundance		
Co-benefit Measures			
Infauna			
Tourism			
Biodiversity			

WETLAND NNBF: GUIDING PRINCIPLES AND SUMMARY

- Wetland NNBF combines aspects of flood/erosion risk management and wetland restoration.
- FRM capacity of wetlands depends on critical biophysical and geomorphological characteristics *including the location in the landscape.*
- The temporal and spatial dynamics of wetlands need to be considered in the design.
- Wetland design solutions are diverse.
- Monitoring and maintenance are critical.


National Parks Foundation


TNC