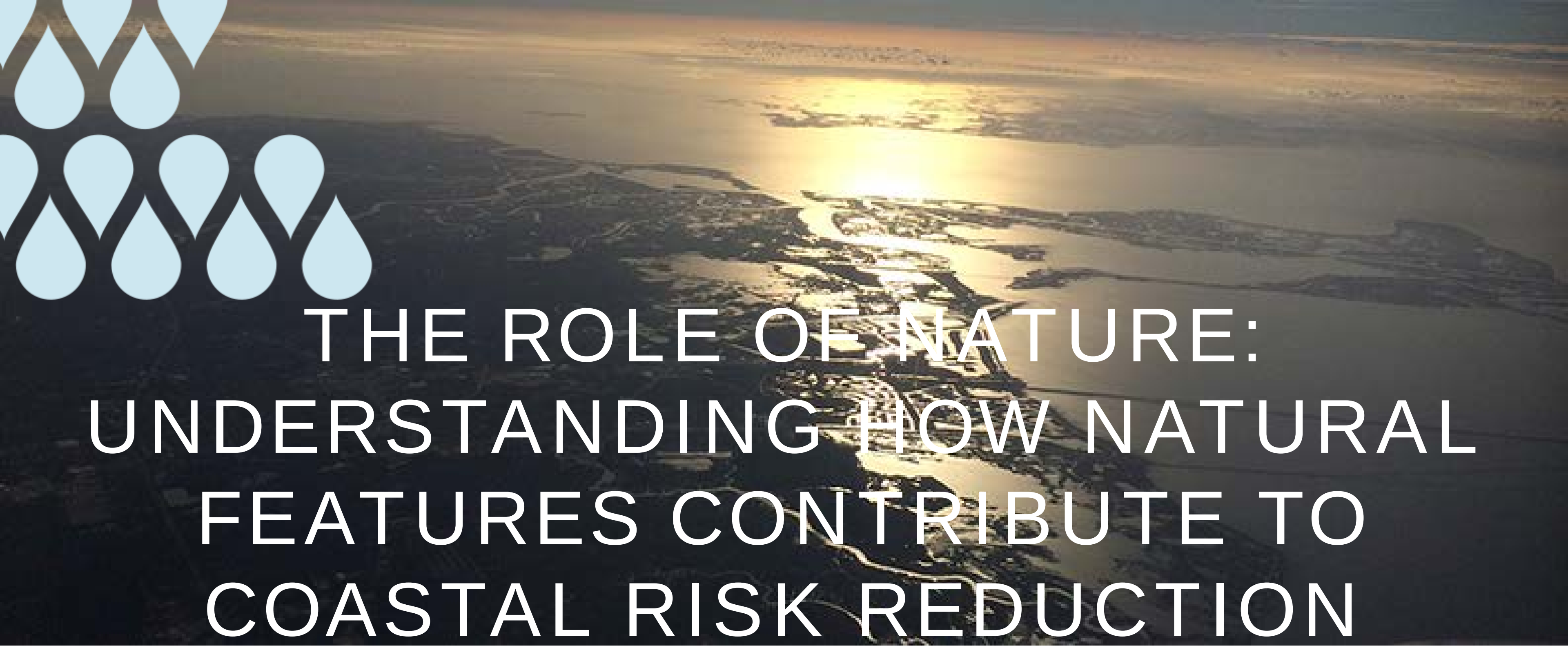


THE ROLE OF NATURE: UNDERSTANDING HOW NATURAL FEATURES CONTRIBUTE TO COASTAL RISK REDUCTION

Denise Reed, Chief Scientist

THE WATER INSTITUTE OF THE GULF™

- The Water Institute of the Gulf is a **not-for-profit, independent research institute** dedicated to providing advanced understanding and technical expertise to support management of **coastal, deltaic and water systems**, within Louisiana, the Gulf Coast and around the world.
- Our mission supports the practical, relevant and timely application of state-of-the-art science and engineering, **providing solutions that benefit society**.

ABOUT US

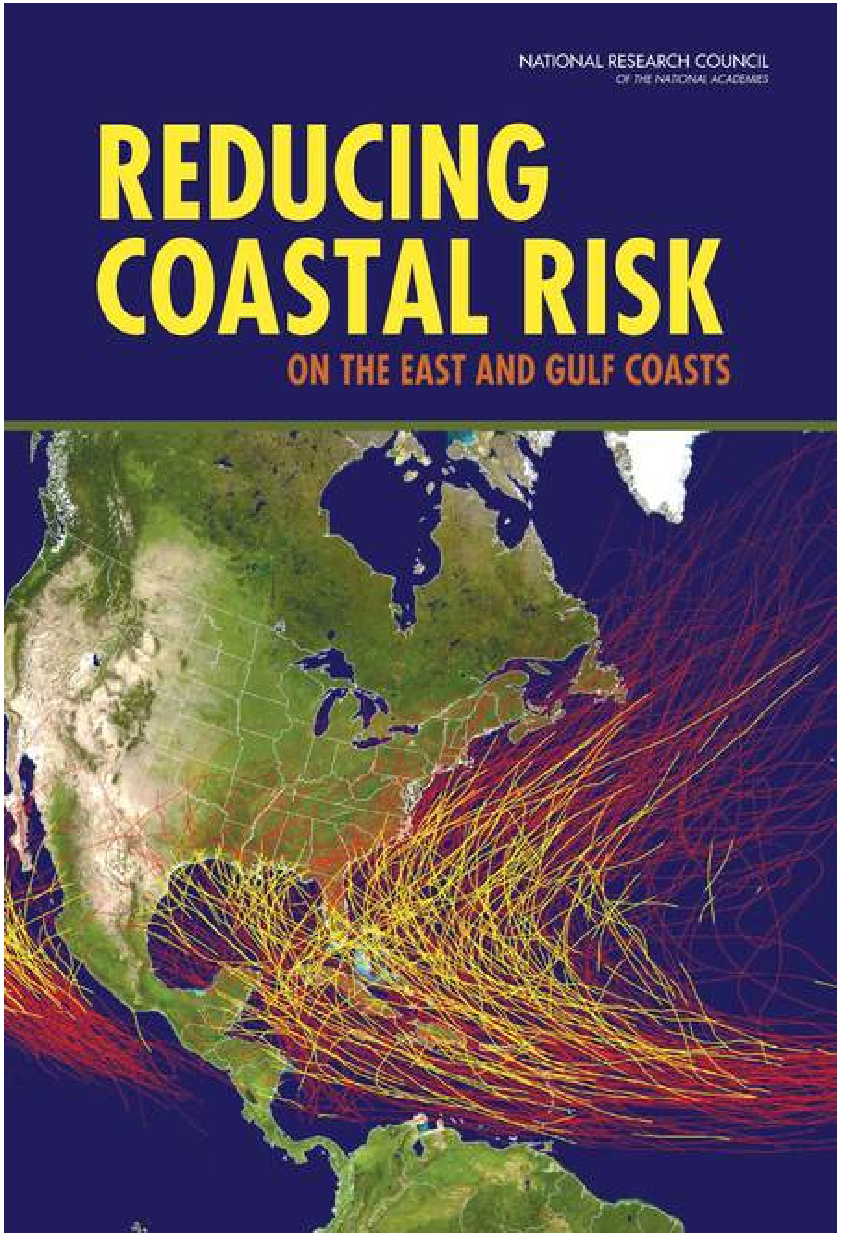
PROGRESS?

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED; SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY





Dunes and Beaches	Vegetated Features	Oyster and Coral Reefs	Barrier Islands	Maritime Forests/Shrub Communities
Benefits/Processes Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer Increased infiltration	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Wave attenuation and/or dissipation Sediment stabilization	**Benefits/Processes** Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention
Performance Factors Berm height and width Beach slope Sediment grain size and supply Dune height, crest, and width Presence of vegetation	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density

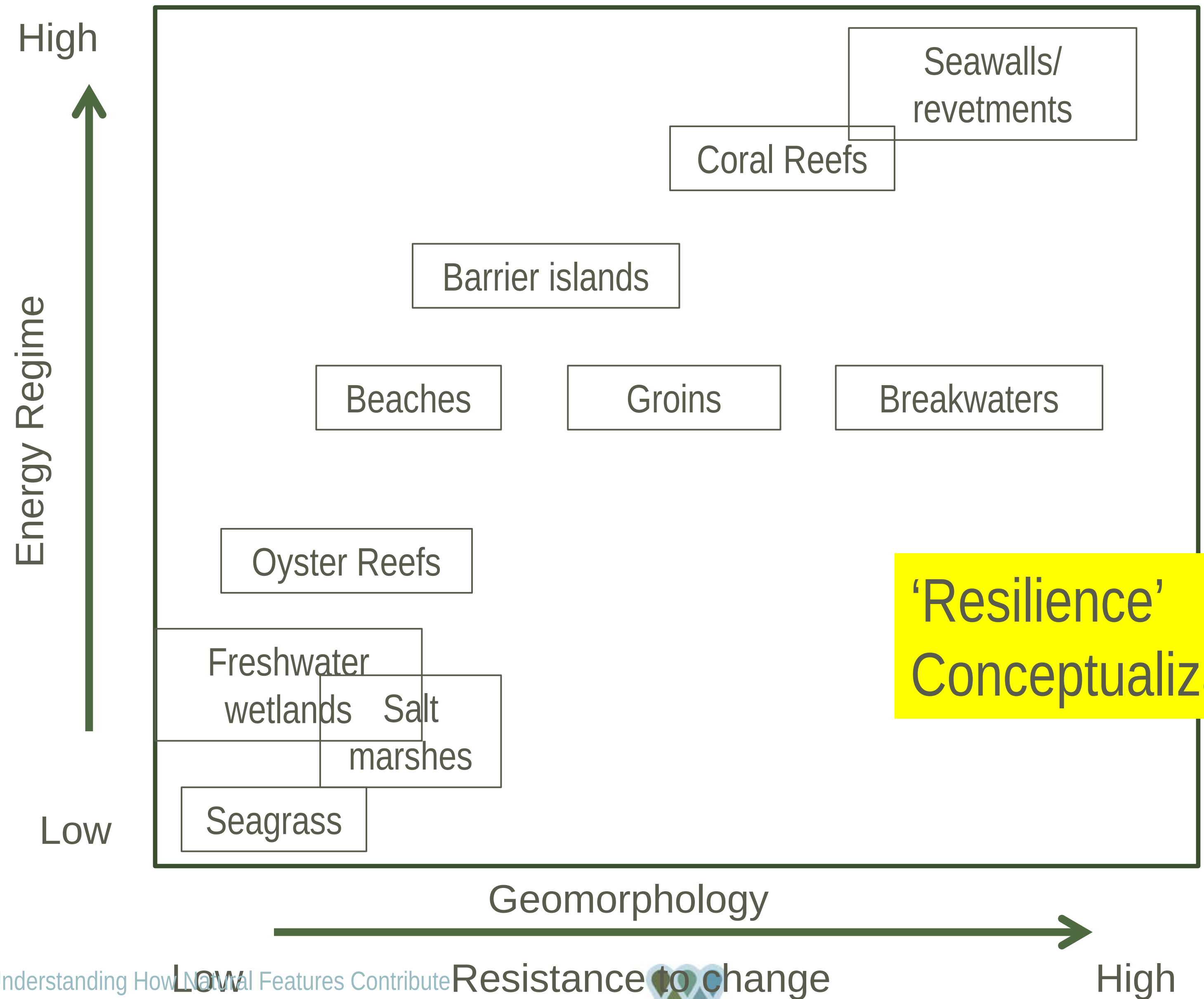

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES
REDUCING
COASTAL RISK
ON THE EAST AND GULF COASTS

NRC, 2014

Much is known about the capacity of nature-based features to reduce coastal erosion from smaller storms, but additional research is needed to better understand and quantify the effects of natural features (other than beaches and dunes) on storm surge, wave energy, and floodwater inundation. In general, the level of risk reduction provided by *oyster reefs and seagrasses* appears much lower than that provided by constructed dunes and hard structures, and most of the benefits are associated *with reductions in wave energy during low- to moderate energy events*. Research has documented reductions in peak water levels from *salt marshes and mangroves*, but certain storm conditions and *large expanses of habitat* are needed for these to be most effective.

NRC, 2014

Reducing Erosion by Waves



'Resilience' Conceptualization

WHAT DO WE KNOW?

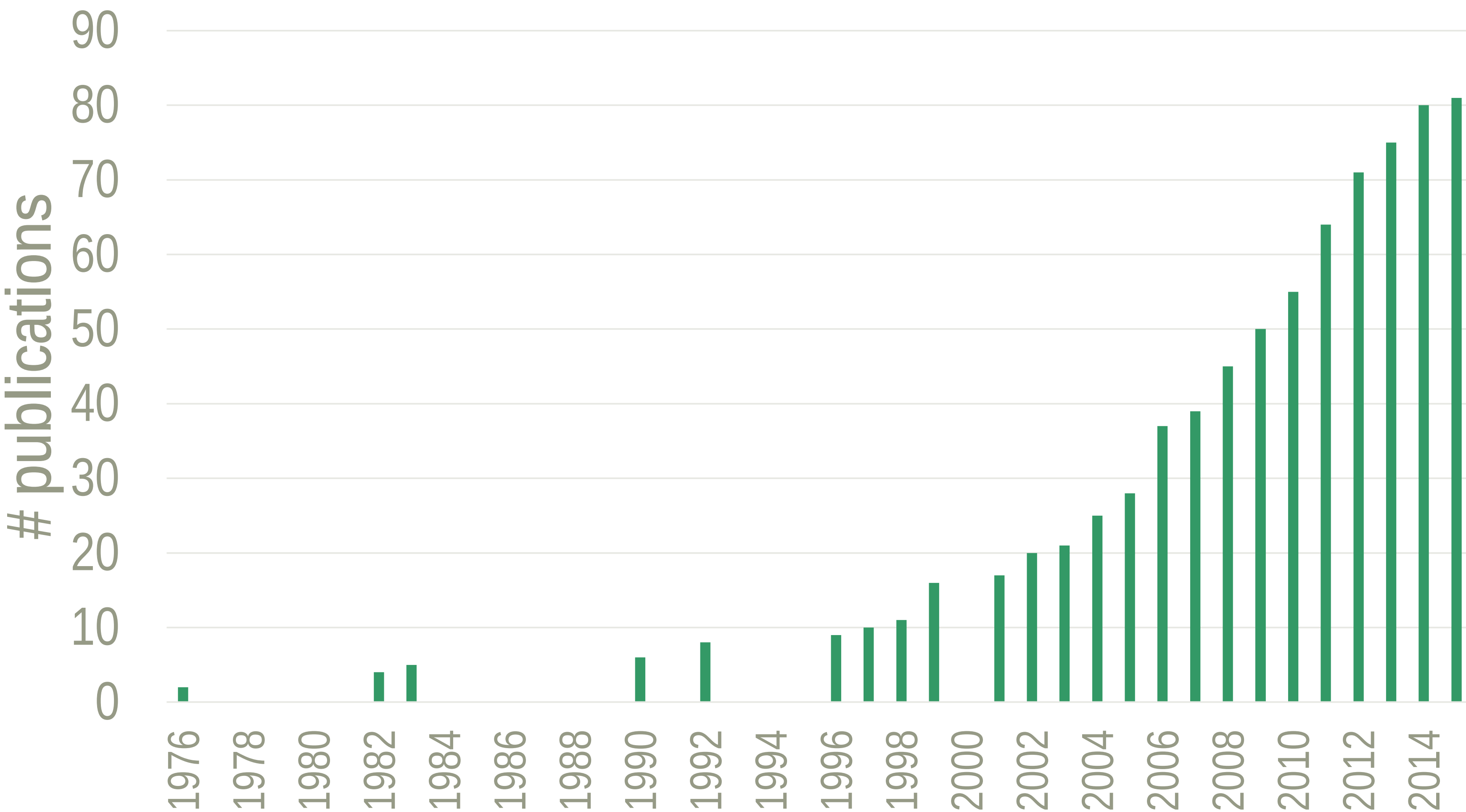
Reviewed ~80 separate studies

- Field, lab, modeling
- Waves, surge

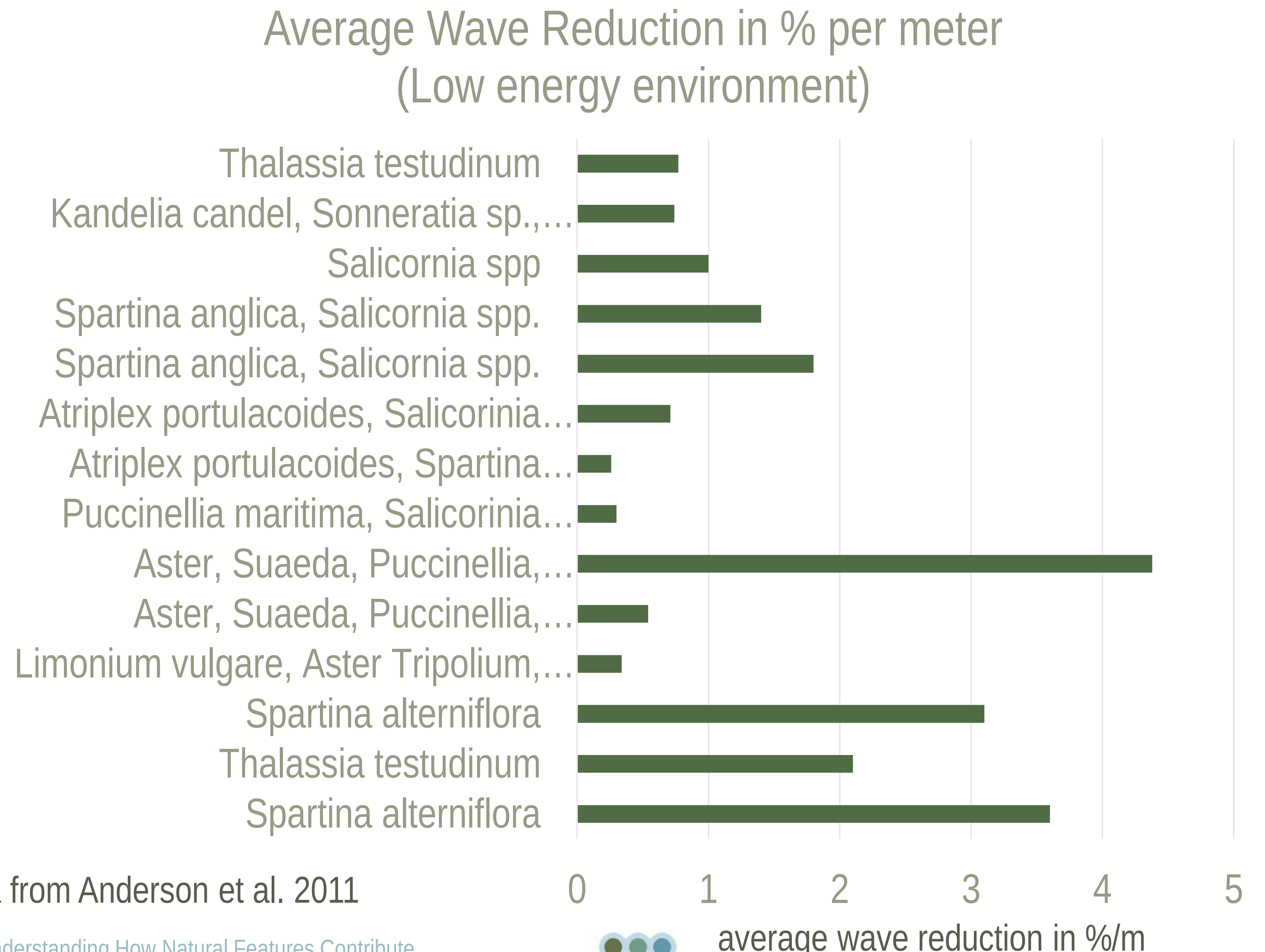
Across coastal environments:

- Barrier island
- Coastal Forests
- Coral reefs
- Marshes
- Oyster reefs
- SAV
- Sand dunes

INCREASING UNDERSTANDING?

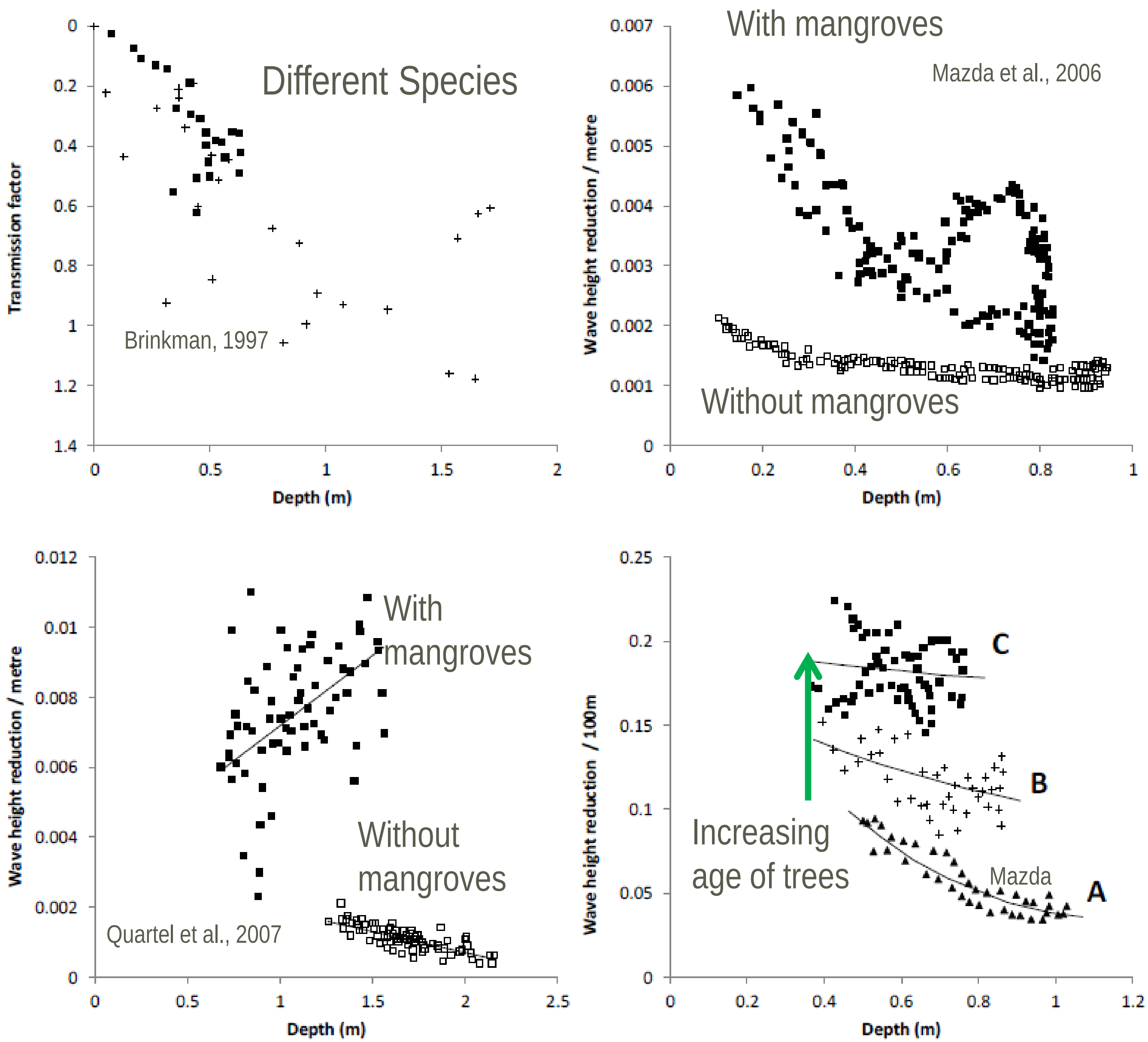


SITE/SPECIES SPECIFIC RESPONSE

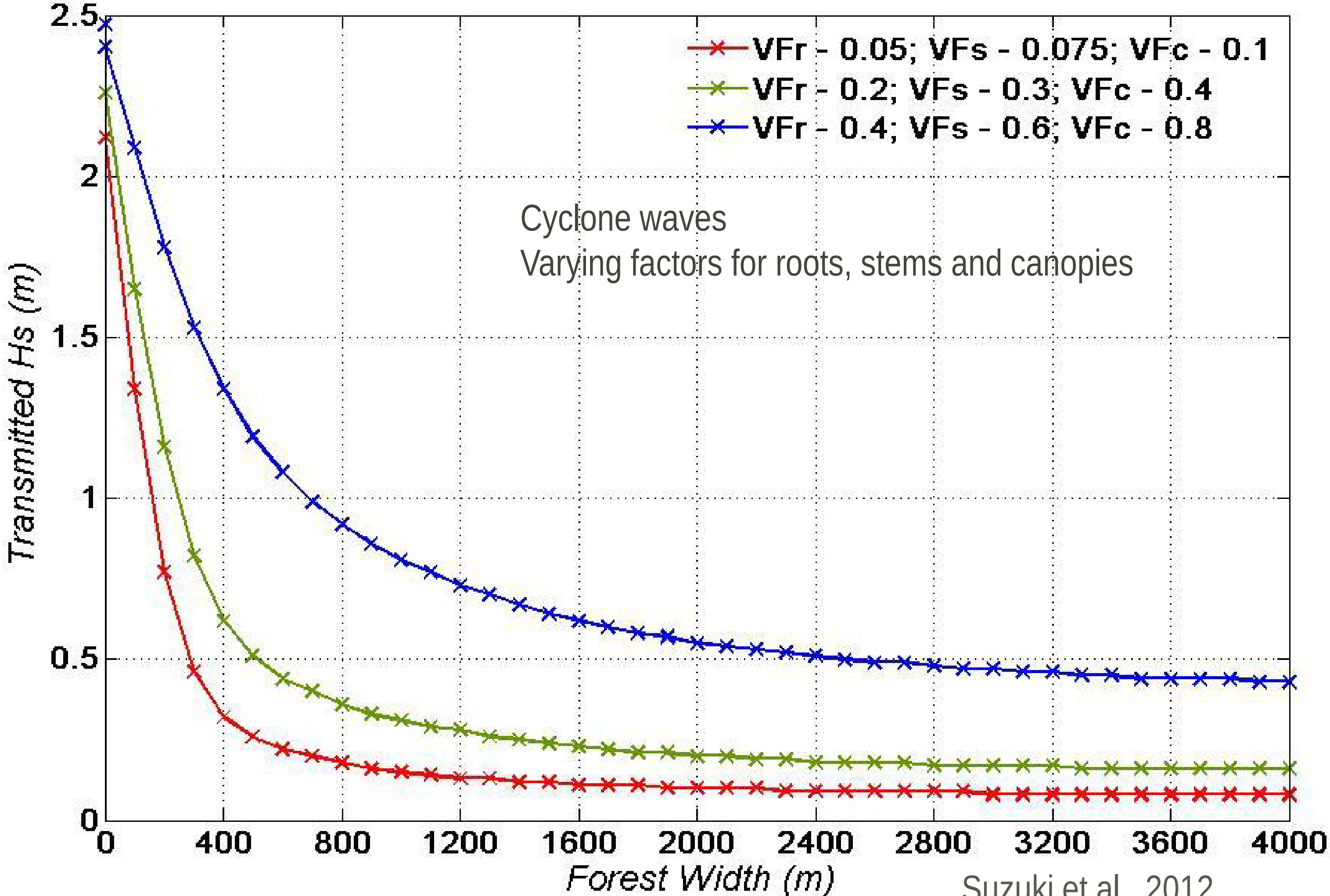


Data from Anderson et al. 2011

Mangroves


Different Species
Brinkman, 1997
Transmission factor
Depth (m)
With mangroves
Mazda et al., 2006
Without mangroves
Wave height reduction / metre
Depth (m)
With
mangroves
Without
mangroves
Quartel et al., 2007
Wave height reduction / metre
Depth (m)
C
B
A
Increasing
age of trees
Mazda
Wave height reduction / 100m
Depth (m)

Mangroves



Suzuki et al., 2012

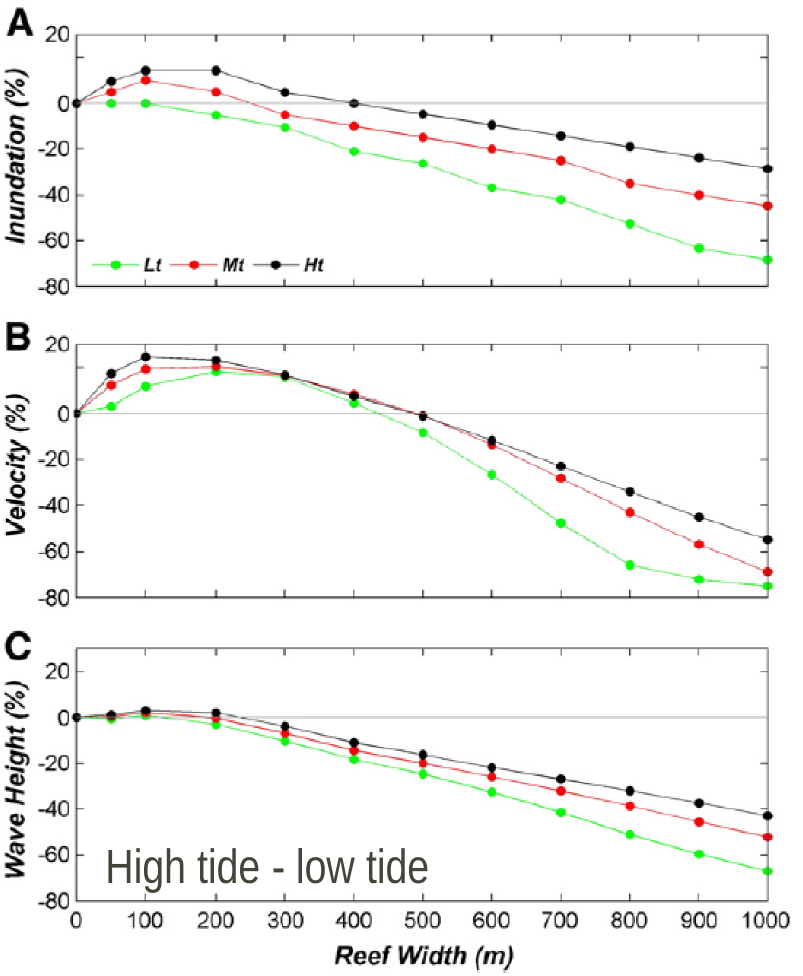


Fig. 6. Percent change in (A) inundation distance, (B) maximum velocity at the shoreline, and (C) maximum wave height at the shoreline relative to no reef as a function of reef width. The three curves are for a tsunami arriving at low tide (0.5 m below msl; green curve), mid tide (msl; red curve), and high tide (0.5 m above msl; black curve).

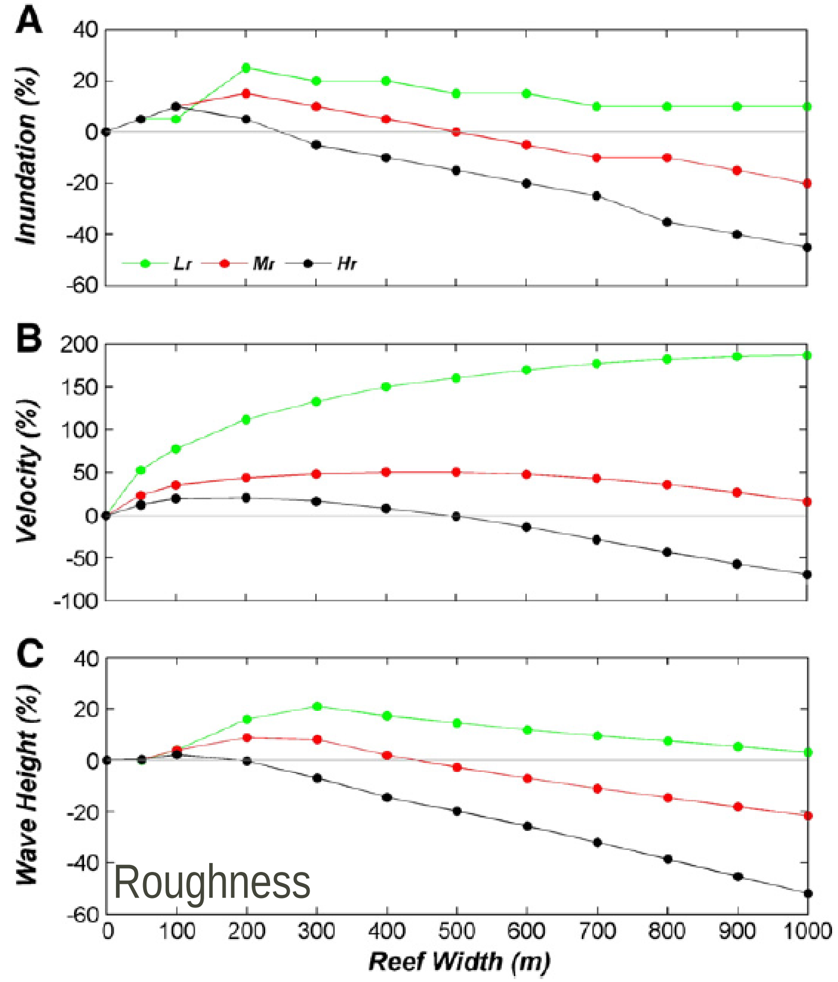
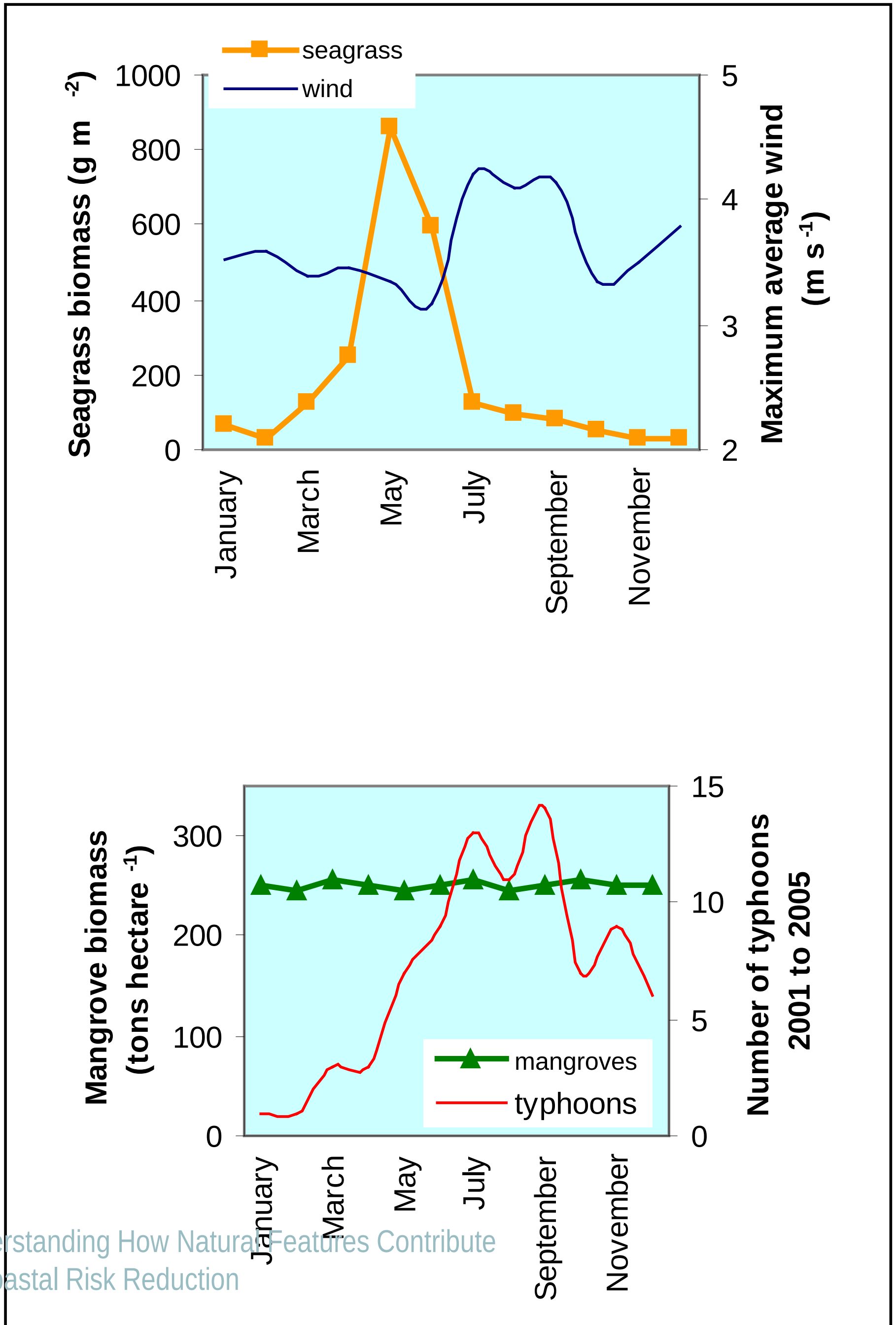


Fig. 7. Percent change in (A) inundation distance, (B) maximum velocity at the shoreline, and (C) maximum wave height at the shoreline relative to no reef as a function of reef width. The three curves are for a tsunami traveling over a reef with low roughness (n = 0.02; green curve), medium roughness (n = 0.05; red curve), and high roughness (n = 0.0962; black curve).

Gelfenbaum et al. 2011

Coral Reefs



When do the events occur?

When does the ecosystem act to reduce the effect?

Koch et al., 2009

nature geoscience

LETTERS

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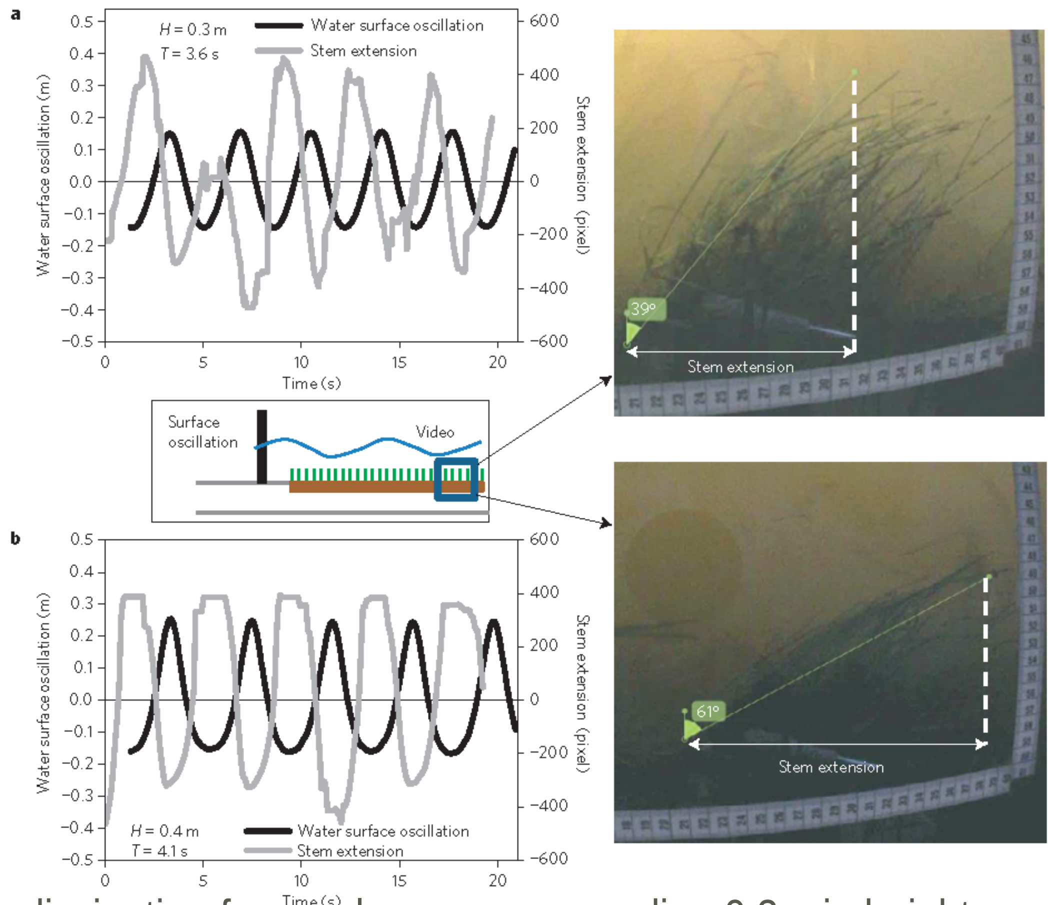
Wave attenuation over coastal salt marshes under storm surge conditions

Iris Möller[1,2]*, Matthias Kudella[3], Franziska Rupprecht[4], Tom Spencer[1], Maike Paul[3], Bregje K. van Wesenbeeck[5], Guido Wolters[5], Kai Jensen[4], Tjeerd J. Bouma[6], Martin Miranda-Lange[3] and Stefan Schimmels[3]

Figure 1 | Experimental set-up and photographs of excavation. a, General experimental set-up in the wave flume, with position of recording equipment relevant to reported results. **b**, Excavation of marsh blocks, northern German Wadden Sea (53° 42.754′ N, 7° 52.963′ E). **c**, Marsh blocks with *Elymus* vegetation cover before positioning in the flume test section. **d**, Reassembled salt marsh inside the 5-m-wide flume, looking towards the wave generator; lamps are mounted at about 3 m above the soil surface.

300m flume experiment

Real marsh sods



- Reduction in dissipation for regular waves exceeding 0.3m in height - a change in behavior of the marsh vegetation.
- Under low incident waves (H < 0.3 m; T < 3.6 s), the plants swayed and interacted with wave motion throughout the wave
- For larger waves (stronger currents stems bent over to angles >50 during the forward wave motion
- Allows the flow for part of the wave cycle to skim over, rather than travel through the vegetation, thus retaining energy and reducing dissipation

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Wave attenuation in mangroves: A quantitative approach to field observations

E.M. Horstman [a,b,*,1], C.M. Dohmen-Janssen [a,1], P.M.F. Narra [c,2], N.J.F. van den Berg [b,d,3,4], M. Siemerink [b,d,5,6], S.J.M.H. Hulscher [a,1]

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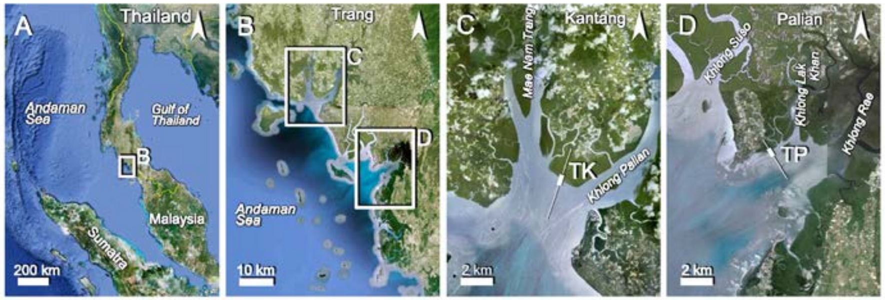
[c] Departamento de Engenharia Civil, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[d] Water Engineering and Management, University of Twente, The Netherlands



province. (C) The Kantang estuary with the position
ct (TP) indicated similarly. (imagery: Google Earth).

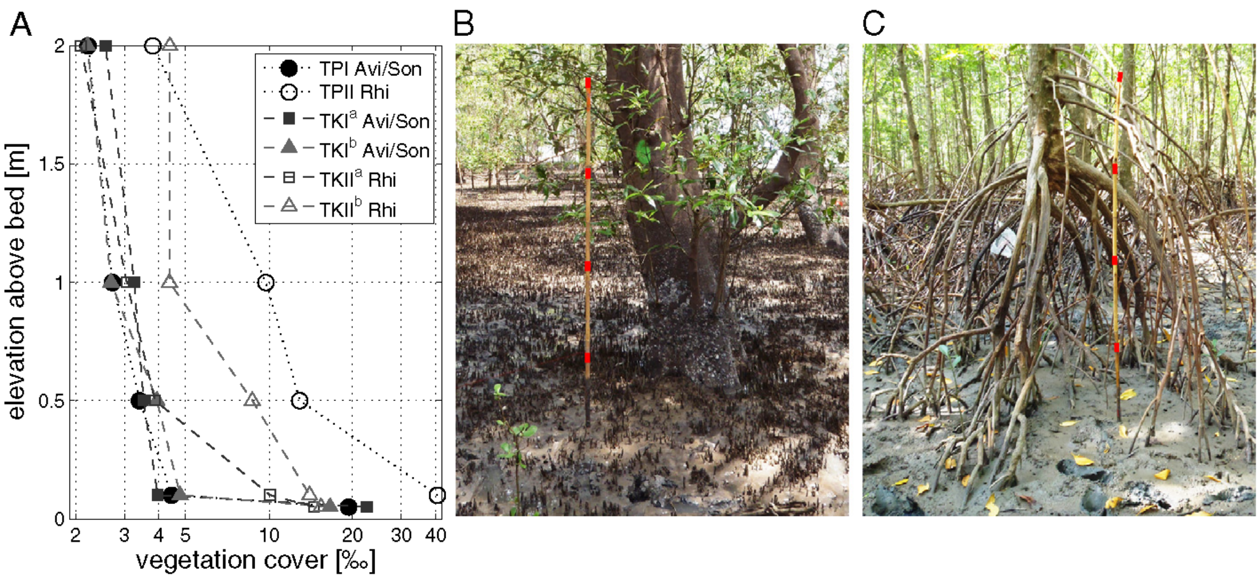
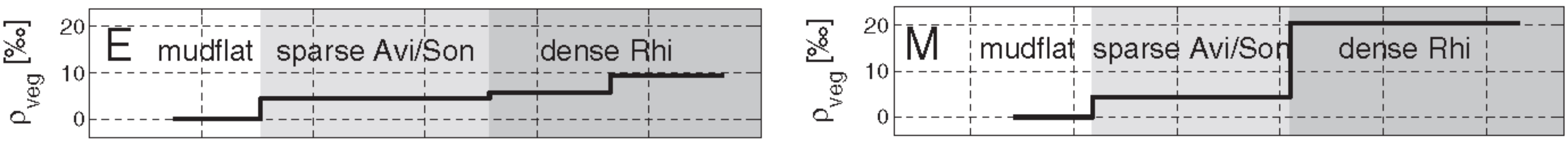
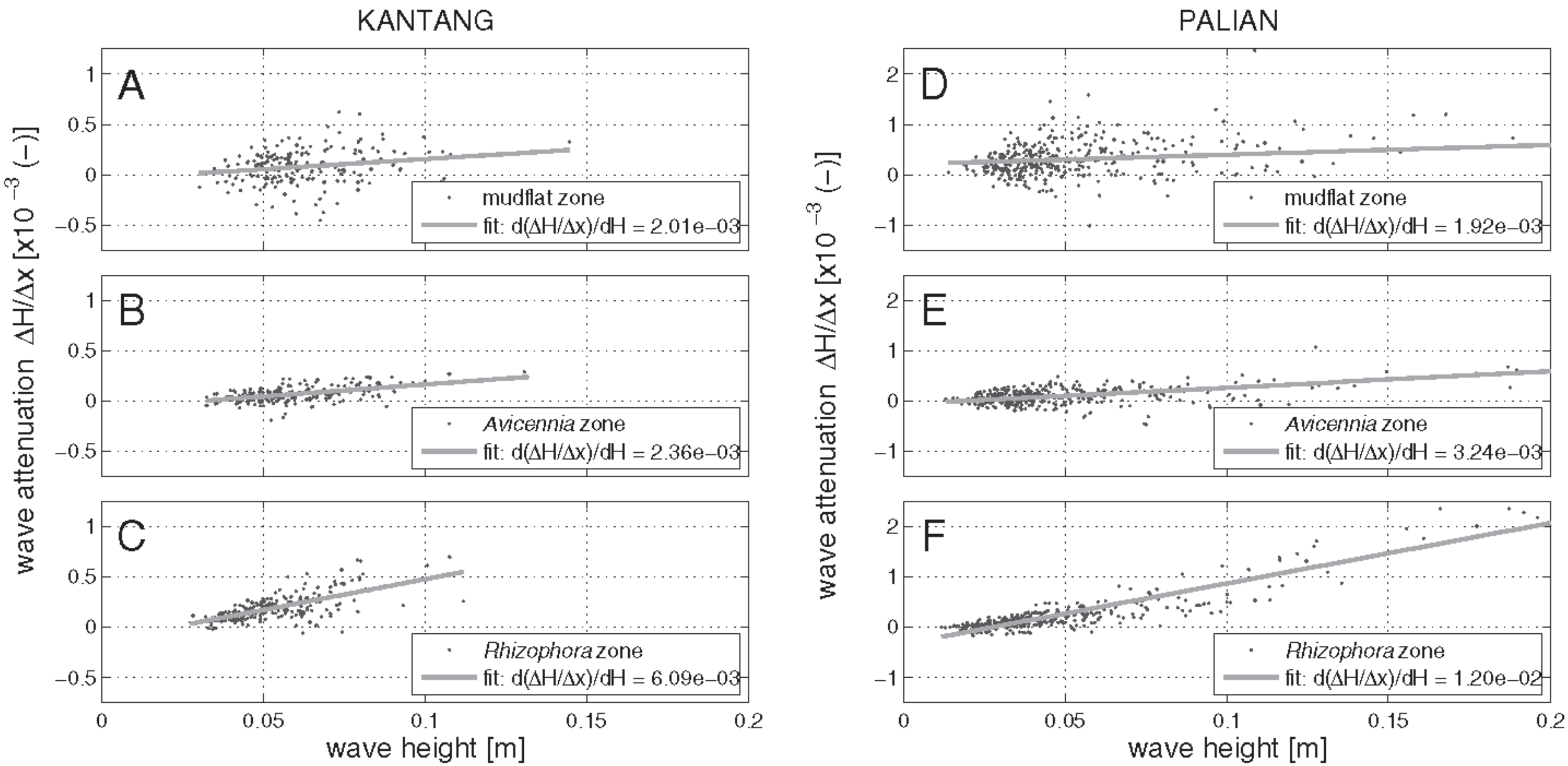


Fig. 4. Variation of the vegetation cover with elevation above the forest floor. (A) Horizontal vegetation coverage [‰] significantly reduces with increasing elevation above the forest floor. (B) Characteristic vegetation in the *Avicennia/Sonneratia* zone (TKI[b]). (C) Characteristic vegetation in the *Rhizophora* zone (TKII[b]). The marks on the bamboo in (B) and (C) are 0.50 m apart and start at 0.50 m above the bed.

VEGETATION CHARACTER



WAVE ATTENUATION

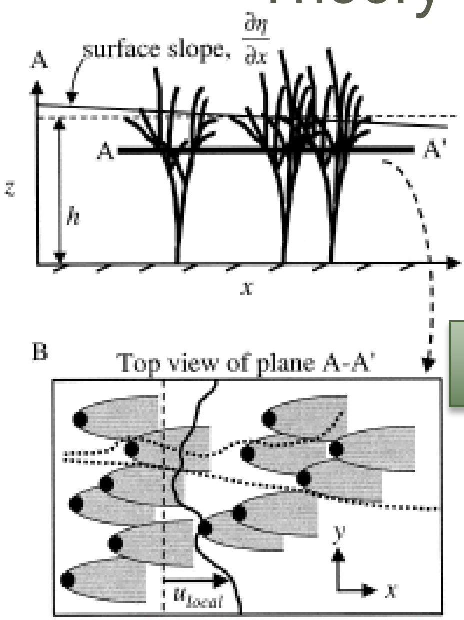


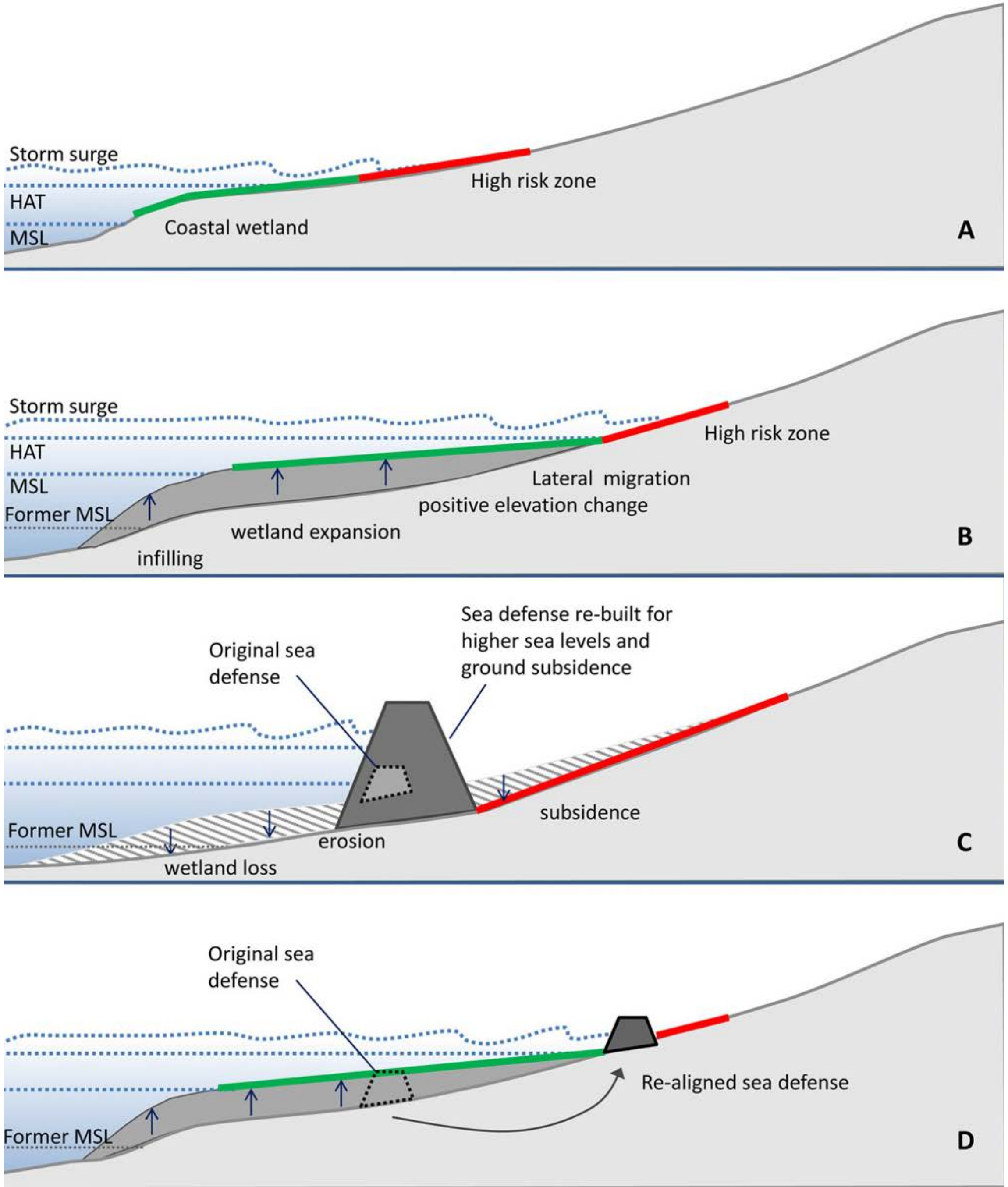
SUMMARY THOUGHTS

- Laboratory studies enable control of waves and detailed measurements
- Limitations on scale
- Marsh vegetation vs. marshes

SUMMARY THOUGHTS

- Scaling up
  - Lab to field
  - Plants to landscapes
  - Point measurements to landscape dynamics
  - Theory to practice





Role of coastal marshes in response to increases in relative sea level.

(A) Contemporary natural shoreline.
(B) Natural shoreline w/SLR.
(C) "Holding the line"
(D) Hybrid interventions where space is allowed for the maintenance of natural coastal defenses

Spalding et al., 2013

TAKE HOME

- The effects are real
  – There is a contribution from nature
- The effects are site/event specific
  – Beware ‘benefits transfer’
- Ecosystem benefits
  – Risk reduction is one of many
  – ‘Lagniappe’…..
- Erosion and flooding are part of nature
  – Our buildings and businesses are not

THANK YOU

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