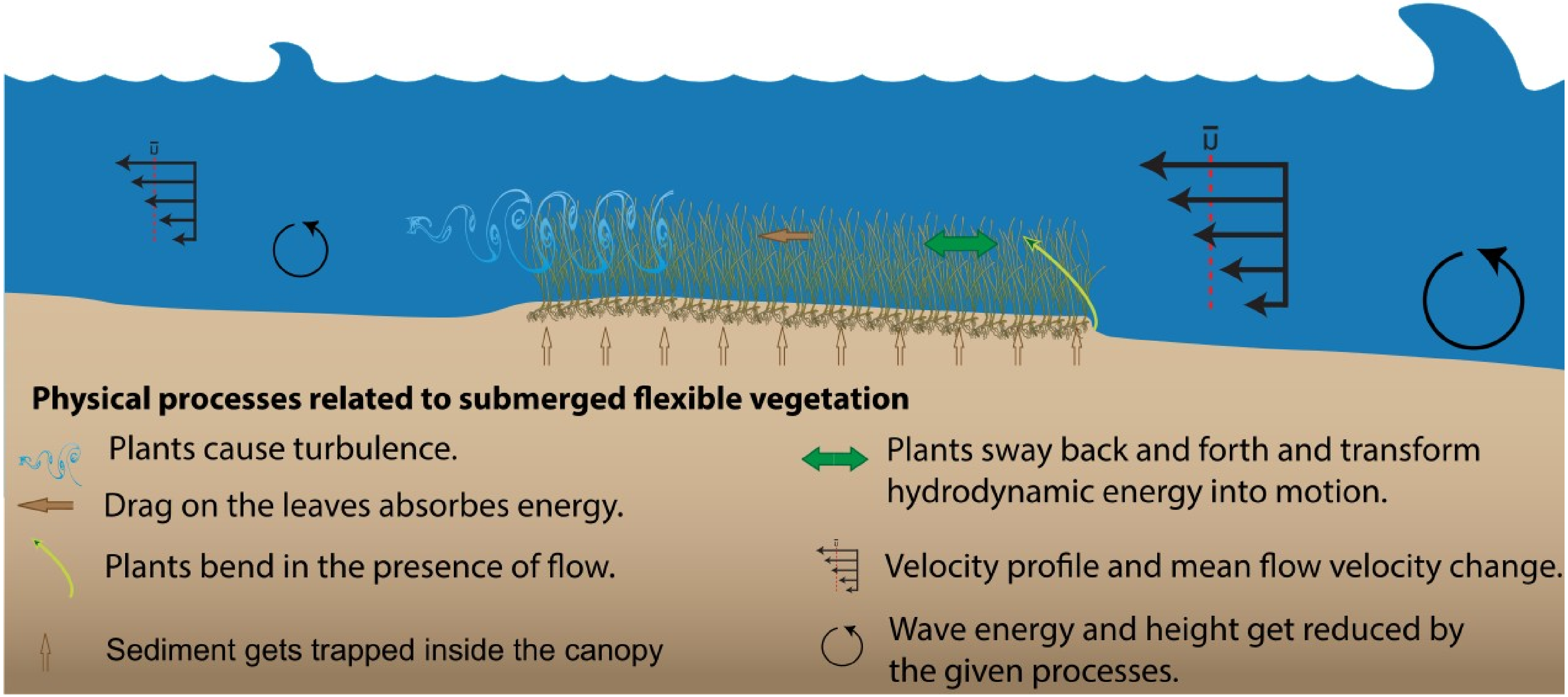
Salt marshes in coastal protection
What to expect in the future?

Maike Paul

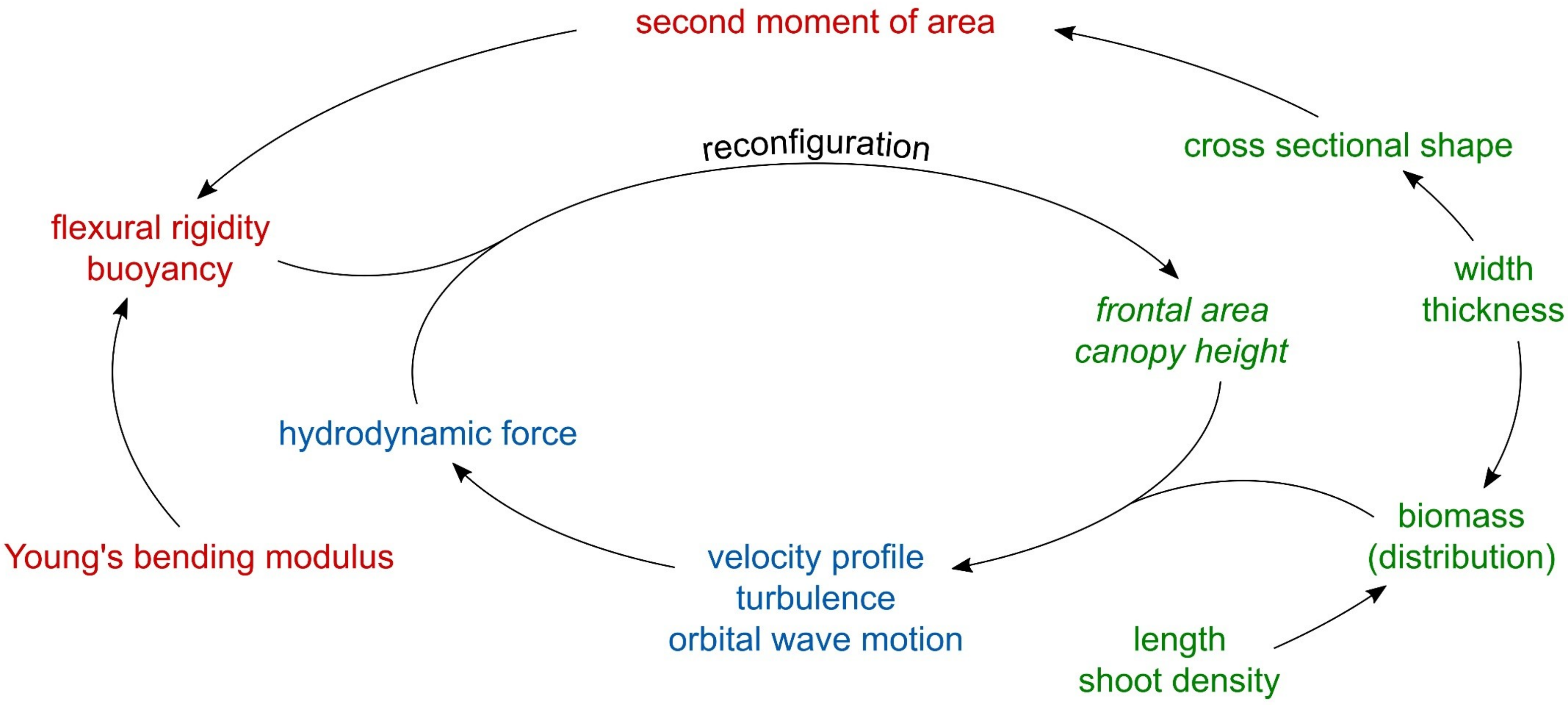
Leibniz University Hannover, Ludwig Franzius Institute of Hydraulic, Estuarine and Coastal Engineering

paul@lufi.uni-hannover.de

Salt marsh affects hydrodynamics (and sediment)

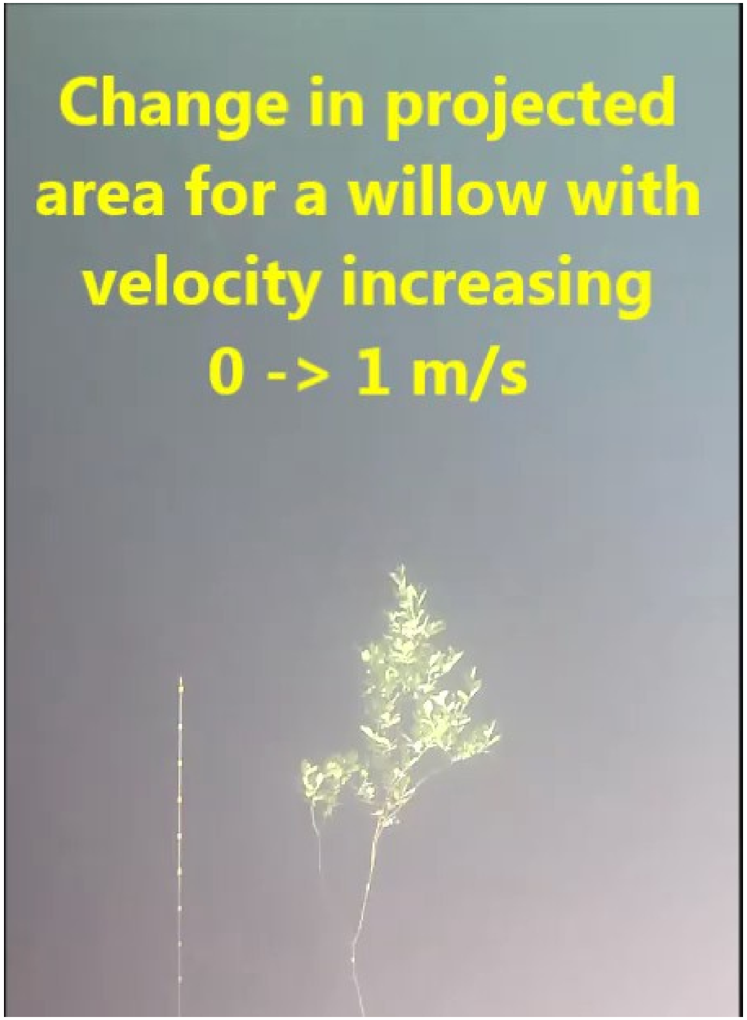


Underlying processes



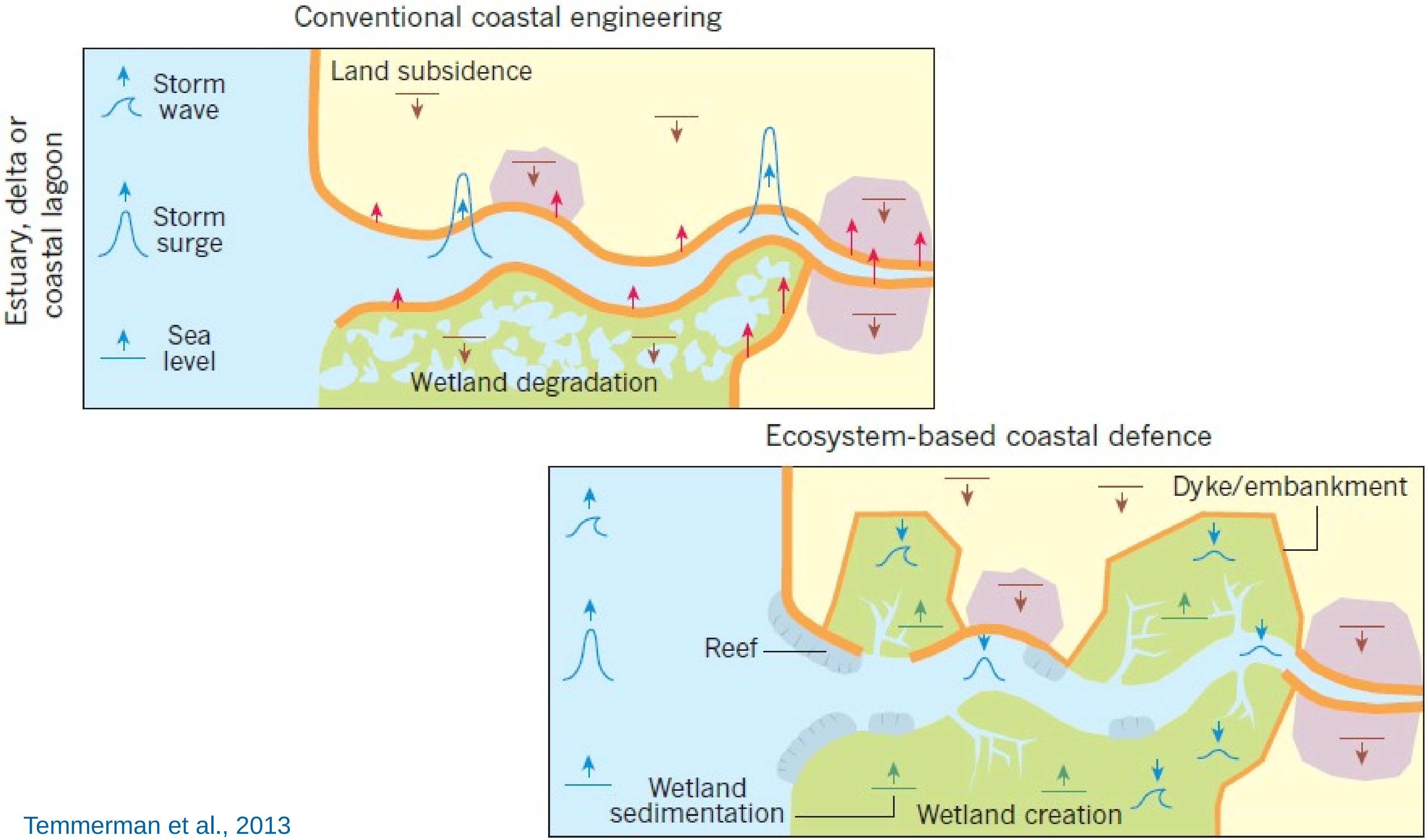
Paul, 2023

Reconfiguration



Aberle & Järvelä (2015)
Video: Juha Järvelä

Flood retention / flow reduction



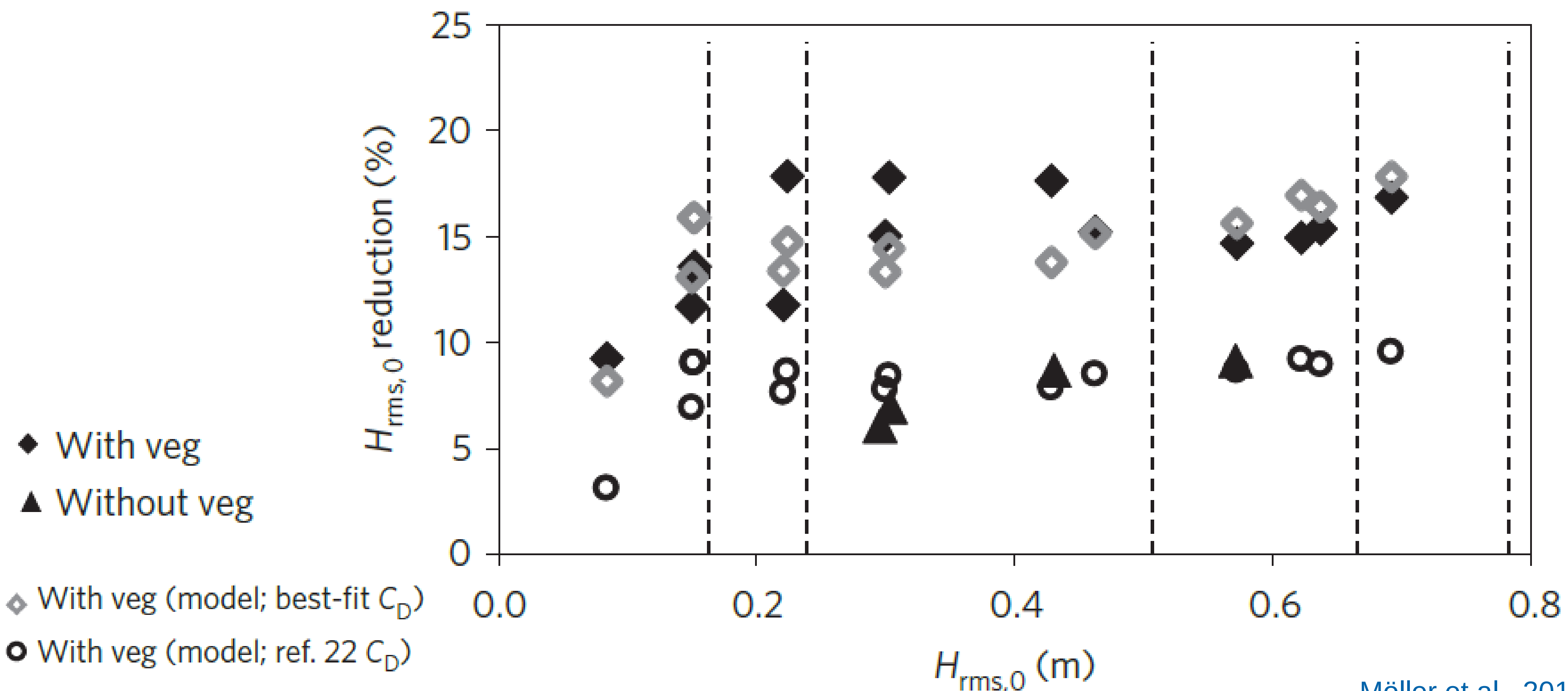
Temmerman et al., 2013

Wave attenuation – summer state

Thanks to James Tempest for the video

Wave attenuation – summer state

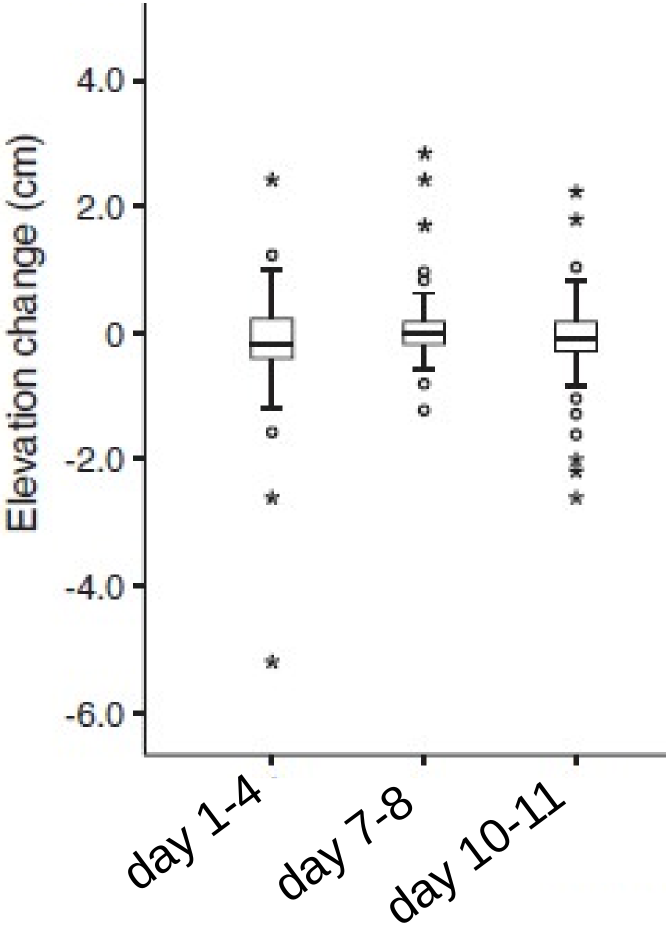
- 40 m length of salt marsh
- 2 m water depth
- Irregular waves of different wave height



Möller et al., 2014

Sediment stabilisation – summer state

- Live and healthy salt marsh
- 2 m water depth
- Significant wave heights up to 0.7 m



Spencer et al., 2015

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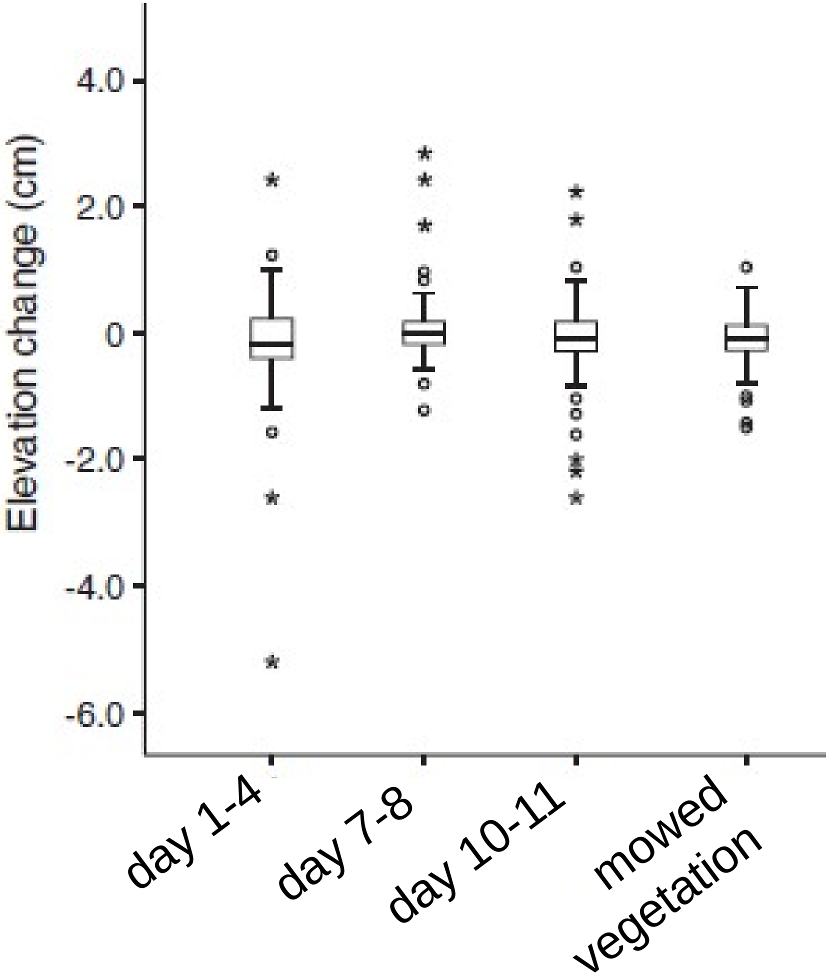


Spencer et al., 2015

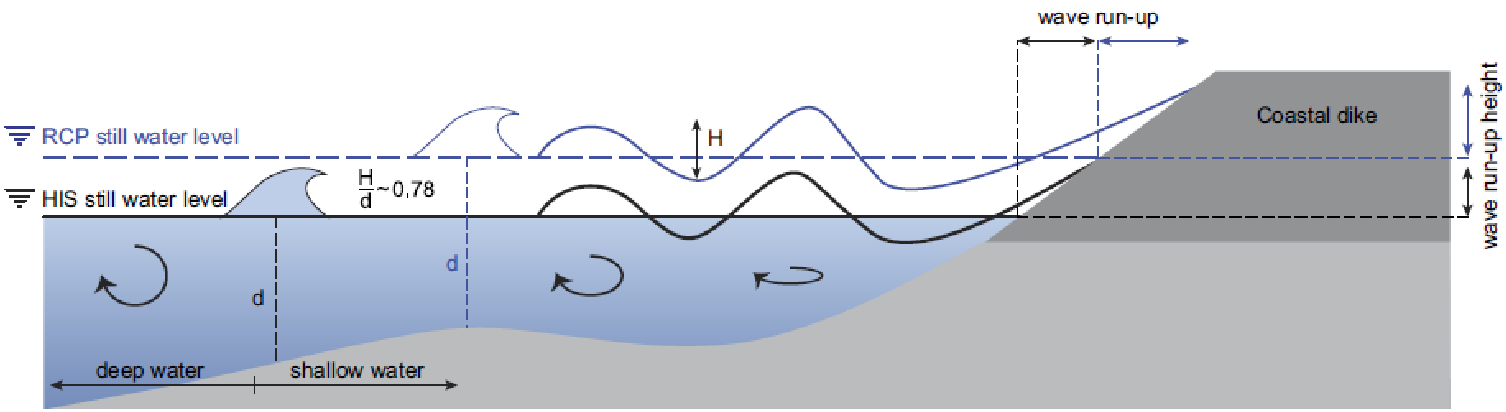
Future changes

- Change in weather and seasonal patterns
- Increase in CO_2 content of air and water
- Increase of mean temperature
- Sea level rise

© unknown

Additional effects of sea level rise

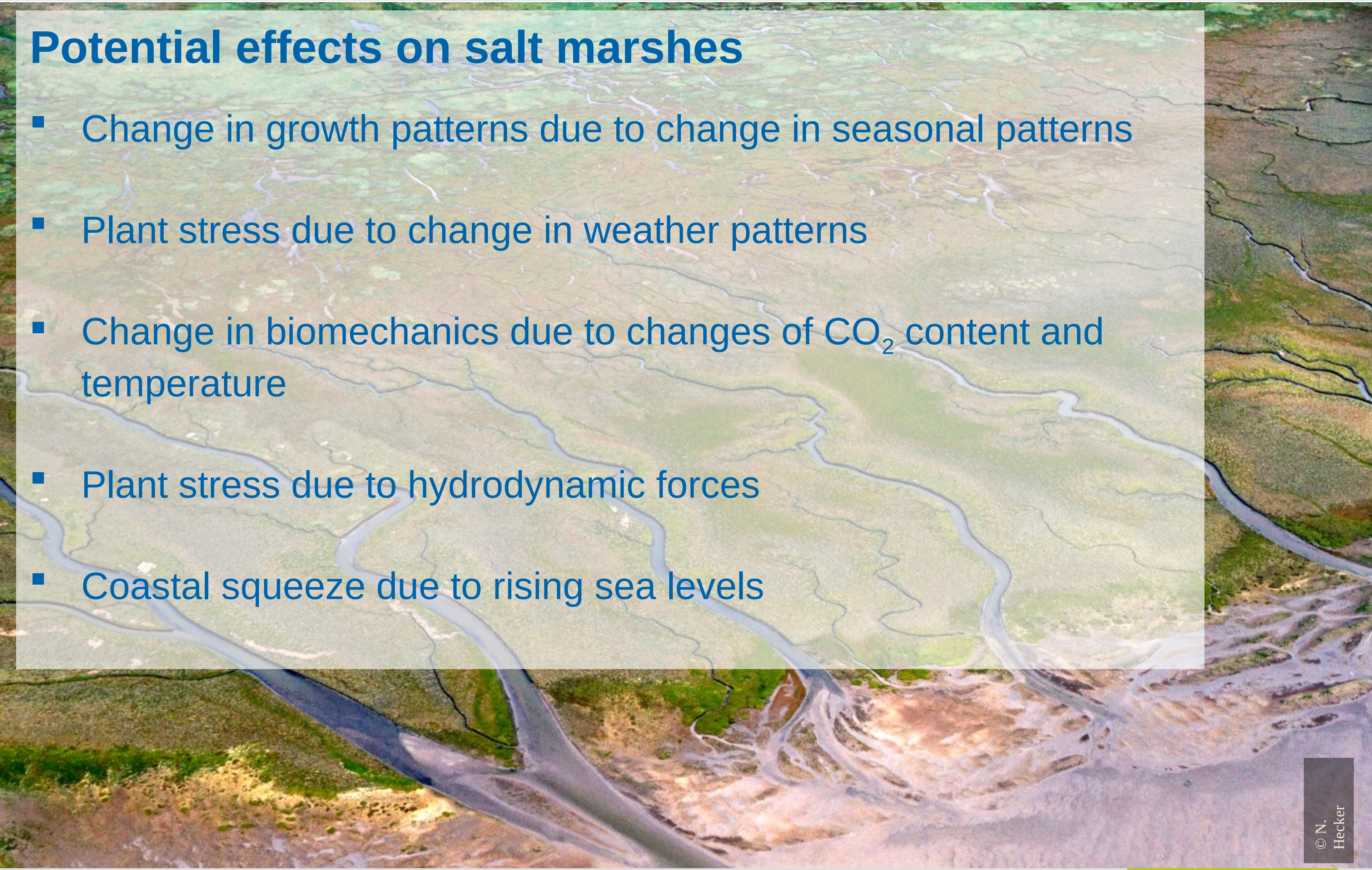
- Deeper water resulting in higher waves under the same wind forcing
- Increase in turbulence
- Increasing flow velocities
- Increase of tidal range up to 30% (for SLR < 2m)



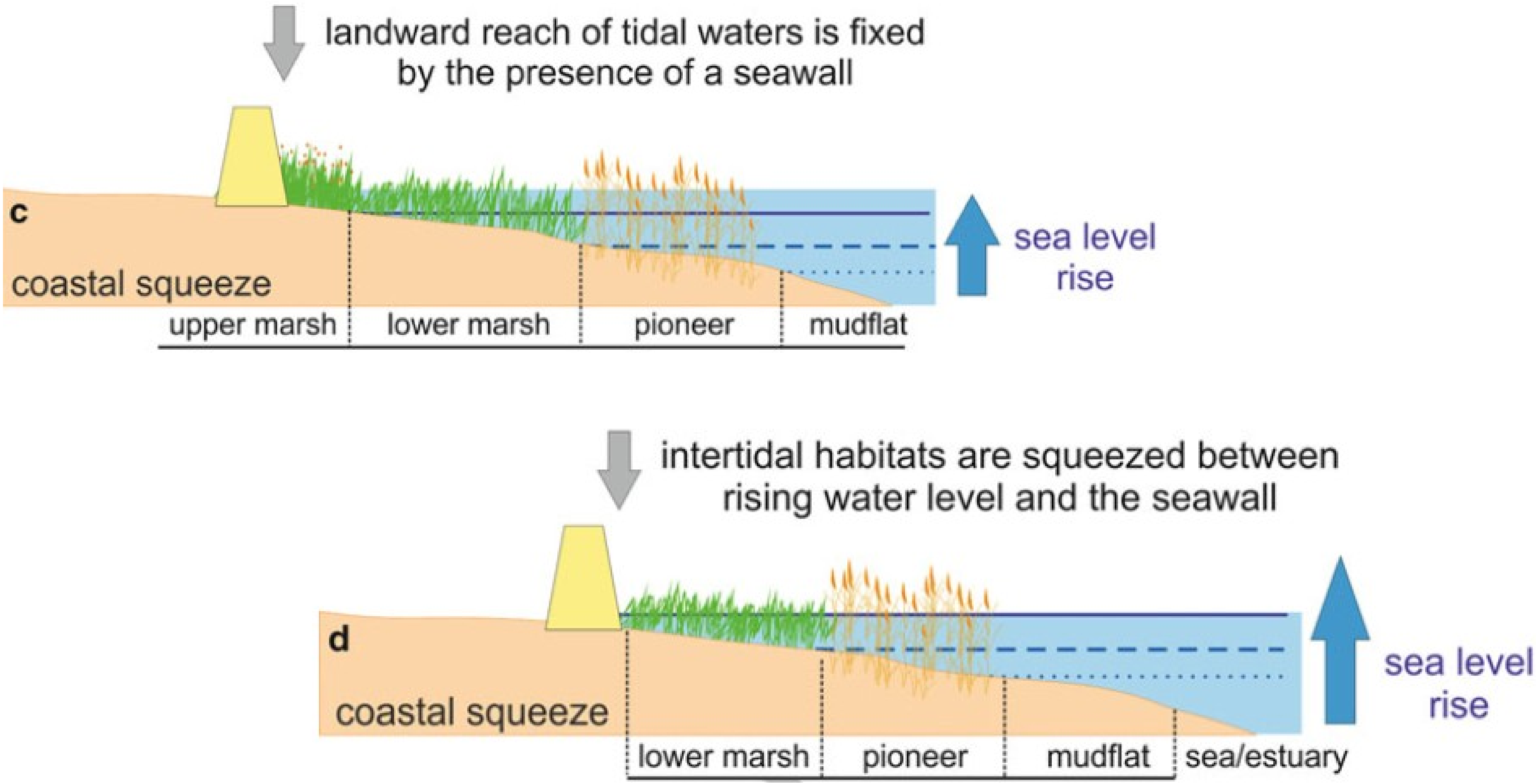
Arns et al., 2017

Potential effects on salt marshes

- Change in growth patterns due to change in seasonal patterns
- Plant stress due to change in weather patterns
- Change in biomechanics due to changes of CO_2 content and temperature
- Plant stress due to hydrodynamic forces
- Coastal squeeze due to rising sea levels



Coastal squeeze



Esteves, 2016

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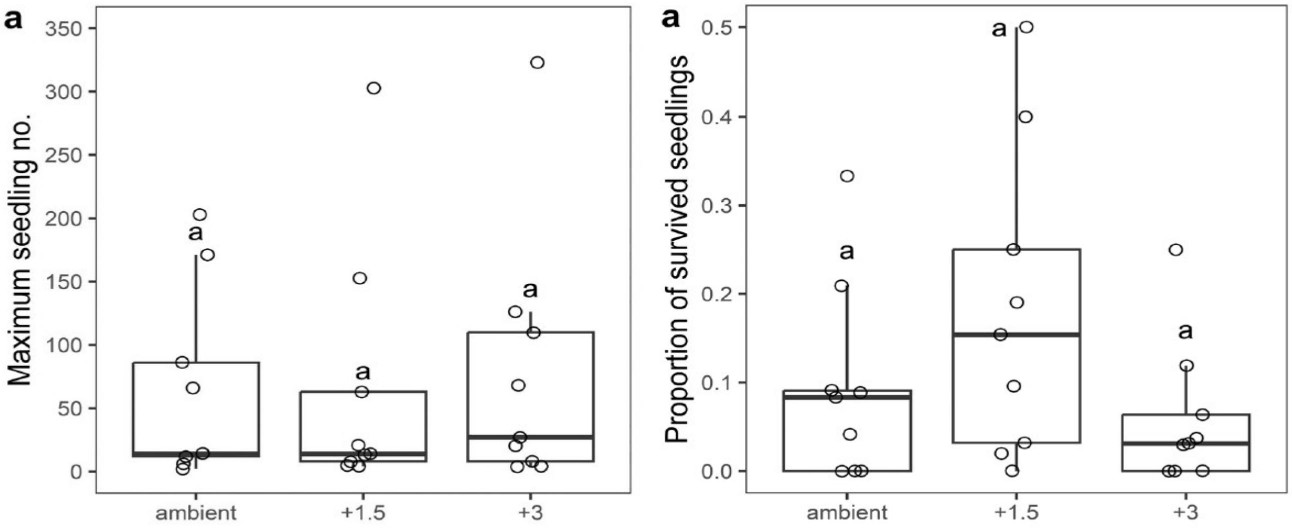
Growth pattern

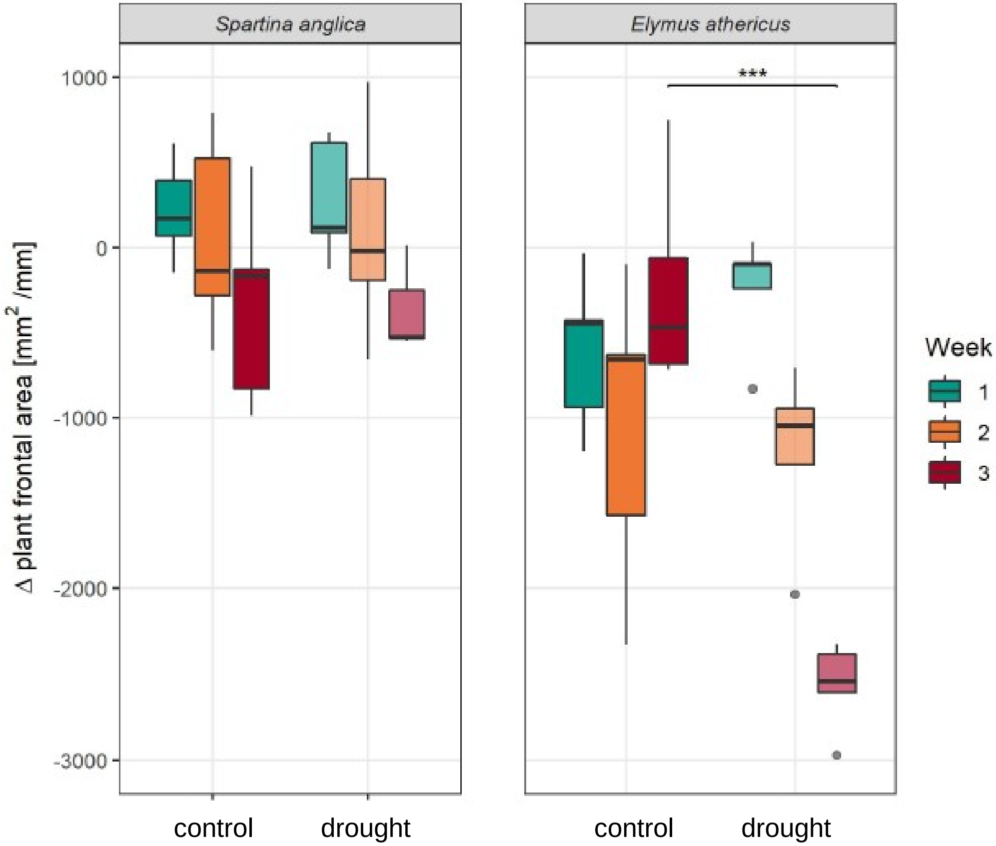
- No clear effect on seedling establishment
- Small changes between zones
  - Shorter WoO required in pioneer zone
  - Increased risk of drought in high marsh



Ostertag et al., 2023

Weather patterns

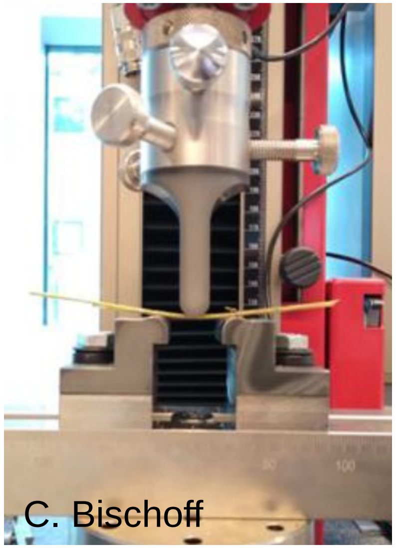
- *Spartina anglica* (C4) remained unaffected by the drought treatment
- *Elymus athericus* (C3) lost more biomass under wave forcing after a 6 week drought treatment
  - Biomass loss occurred in the top third of the canopy and not on shoot level

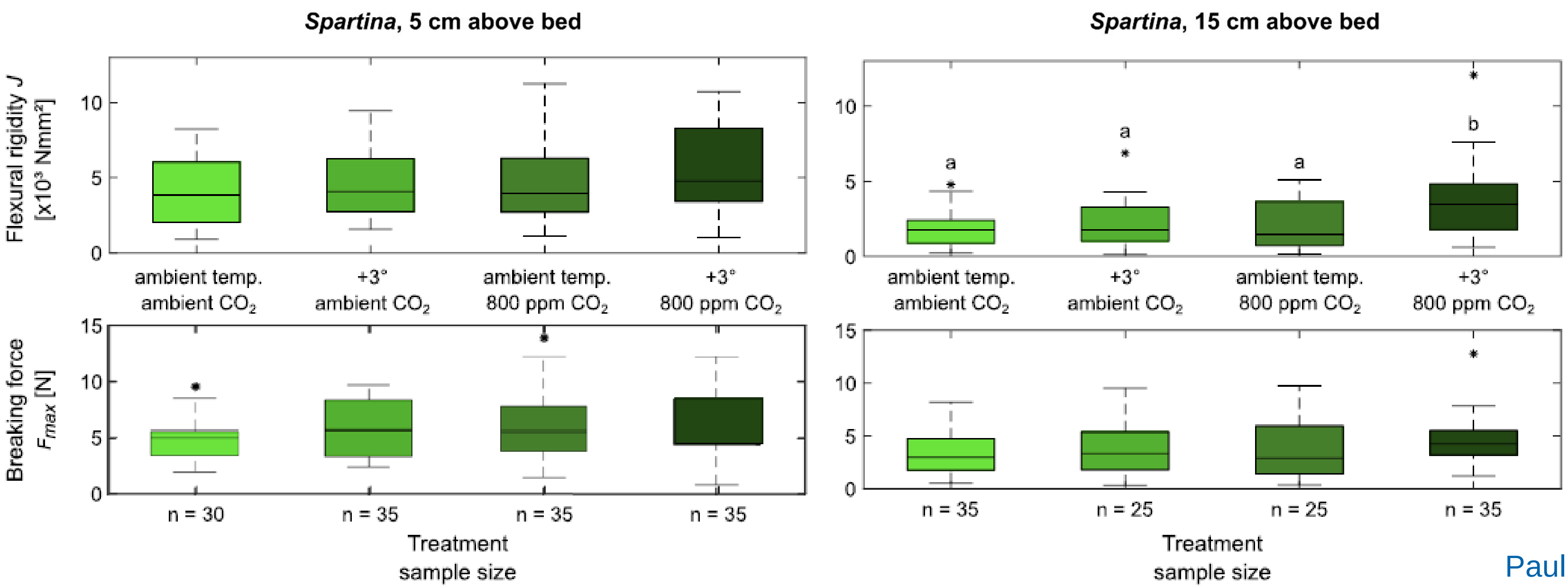


Reents et al., 2022

Biomechanics

- *Elymus athericus* (C3) morphology and biomechanics did not respond to any of the treatments
- *Spartina anglica* (C4) showed some differences, statistical significance only occurred 15 cm above bed

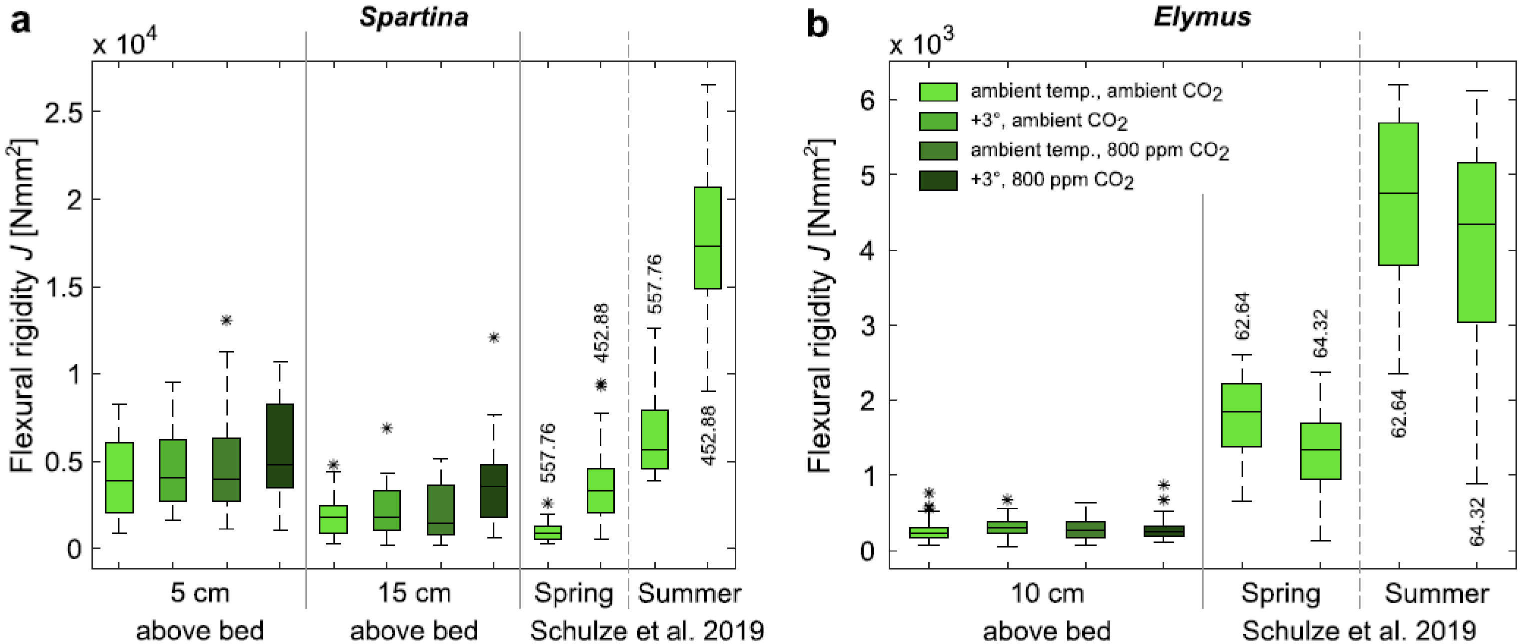




Paul et al., 2022

Biomechanics

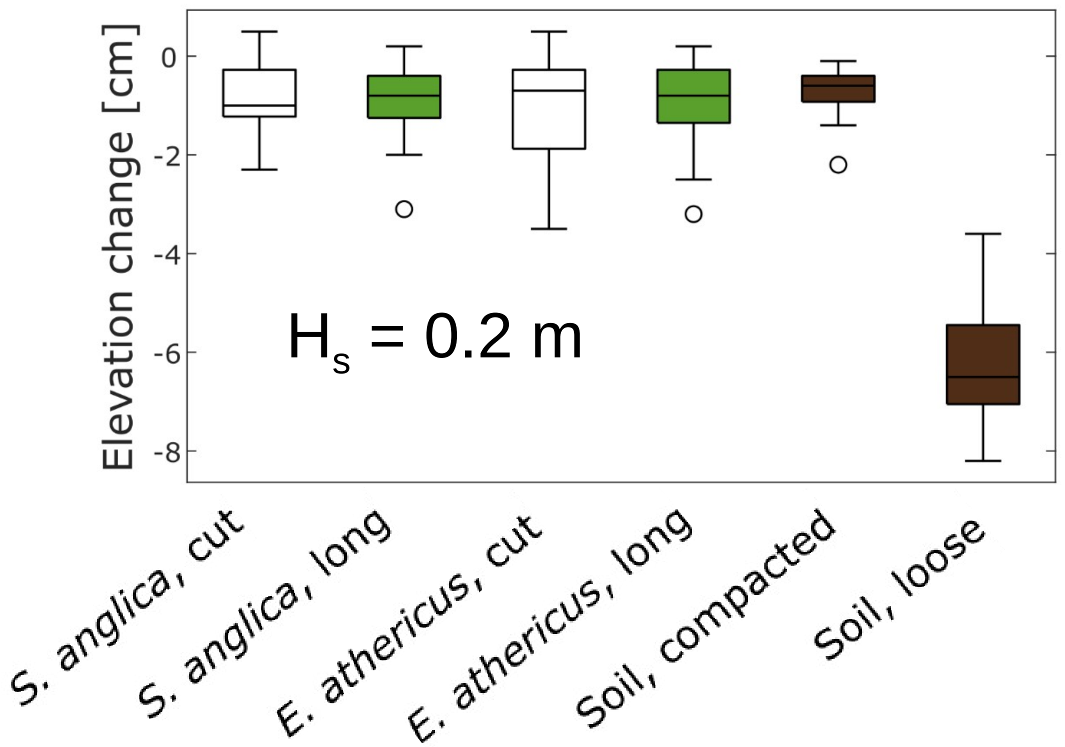
- Even significant differences fall within natural trait ranges found for *Spartina*
- Both species appear to be insensitive to future increase in water temperature and CO_2 content.
  - At least for the treatment duration tested here

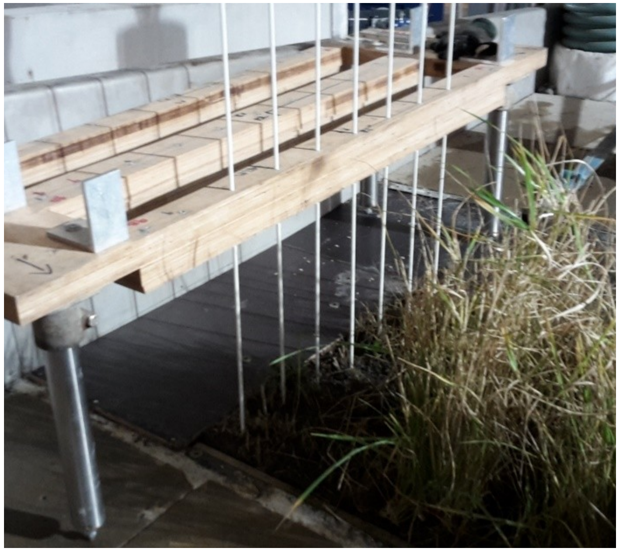


Paul et al., 2022

Hydrodynamic forcing – winter state

- Belowground biomass is the relevant component
- Effect is independent of species
- Higher erosion than under fully submerged conditions



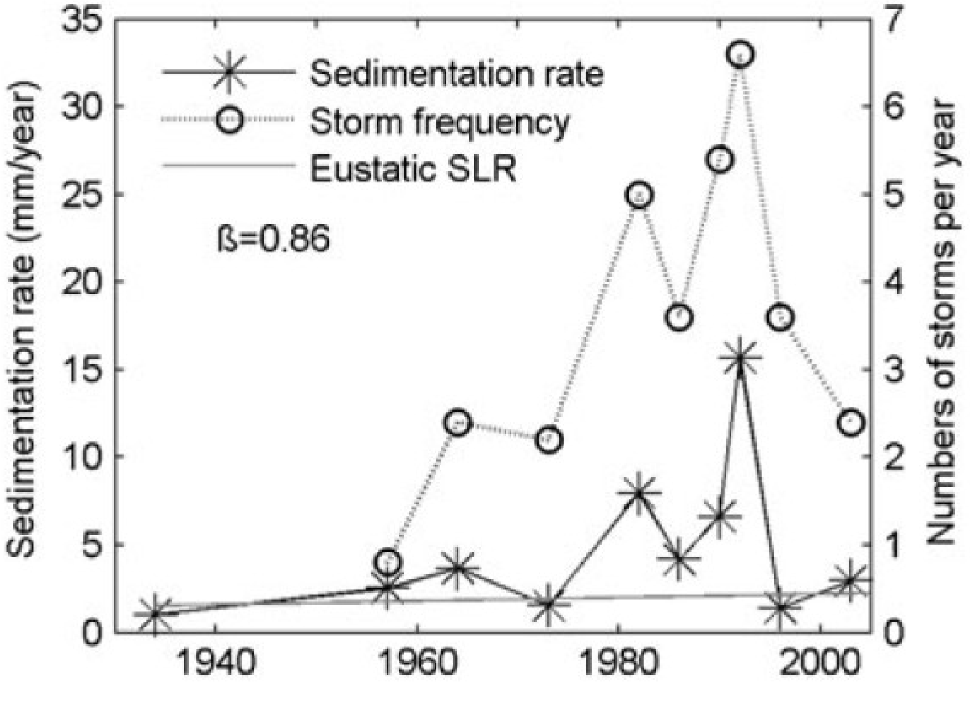


Paul and Kerpen, 2022
JoE Best Paper Award 2023

Breaking under H_s = 0.2 m

Coastal squeeze

- Precondition: Suspended sediment reaches the areas
  - Storms stirr up sediment from tidal flats
  - Tides and surge transport sediment into shallow waters
  - Sediment gets trapped by vegetation



Schürch et al., 2012

Potential effects on salt marshes

- Change in growth patterns due to change in seasonal patterns
  - No effect on seedling establishment, little difference between species
- Plant stress due to change in weather patterns
  - No full shoot loss, some plant damage
- Change in biomechanics due to changes of CO_2 content and temperature
  - No change beyond natural variability
- Plant stress due to hydrodynamic forces
  - No short-term effects observed
- Coastal squeeze due to rising sea levels
  - No squeeze if enough sediment is supplied

Is everything truly good?

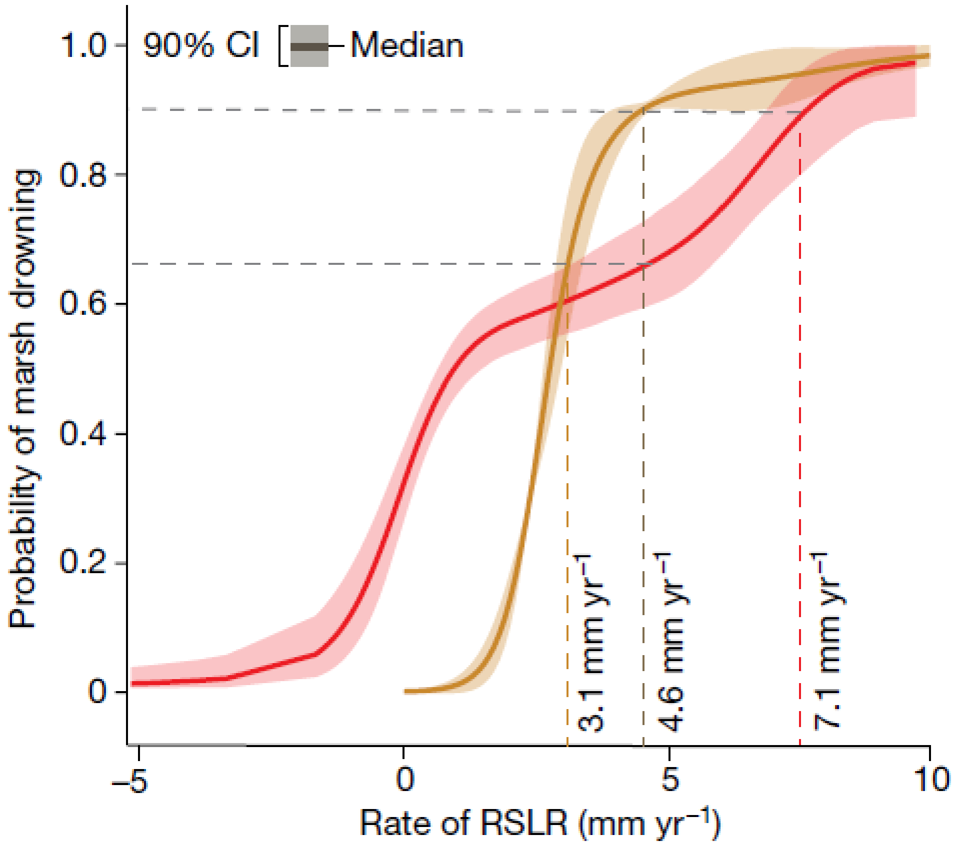
- Will salt marshes cope with future sea level rise?

- How stable does the sediment stay?
- How much coastal protection can we attribute to salt marshes in planning of infrastructure?

- What impact do the effects resulting from sea level rise (turbulence, tidal range) have?
- What can we do, if they struggle?

Coastal squeeze

- It depends on the rate of sea level rise



red = minerogenic UK marshes
orange = organic marshes of the Mississippi Delta

Saintilan et al., 2023

Generating knowledge for answers - NOW

- What is the wave height reduction under medium and extreme conditions?
- How much erosion, both horizontal (i.e. cliff) and vertical (i.e. surface) can be expected under annual, medium and extreme conditions?

- Willemsen et al. (2024): De kracht van kweldergras. Civiele Techniek no. 1/2, p. 36-39

LIVING DIKES

Generating knowledge for answers – now (2022-2025)

- Understanding turbulence and its impact on sediment transport and distribution
- Understanding the impact of brushwood fences on salt marsh development
- Improve brushwood fence design to promote salt marshes

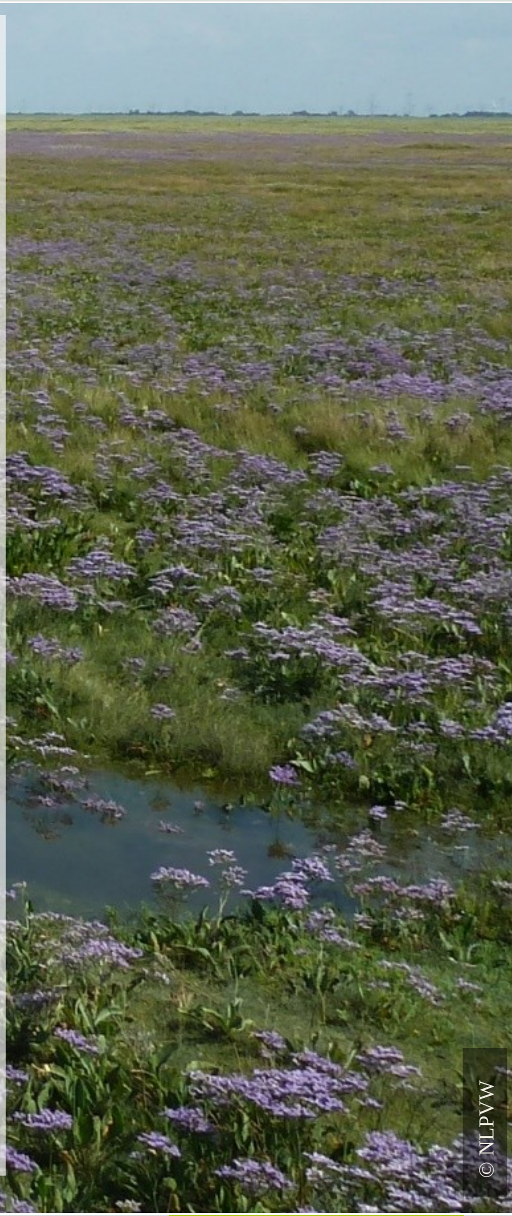
So what can we expect in the future?

- Species composition may change
  - Not abruptly, but slowly and steadily
  - Hardly any effect on coastal protection

- Biomechanics are unlikely to change
  - Existing indicators for quantifying coastal protection will apply in the future

- Salt marshes may drown
  - Only if sea level rises too quickly
  - Not if there is space to migrate landwards

- We can rely on salt marshes in the near to mid future
- If we help them to sustain, even beyond that



Thank you for your attention

Maike Paul

Leibniz University Hannover, Ludwig Franzius Institute of Hydraulic, Estuarine and Coastal Engineering

paul@lufi.uni-hannover.de

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