

BIOGEOMORPHIC SHIFTS AND STABLE STATES IN INTERTIDAL FLATS AND MARSHES

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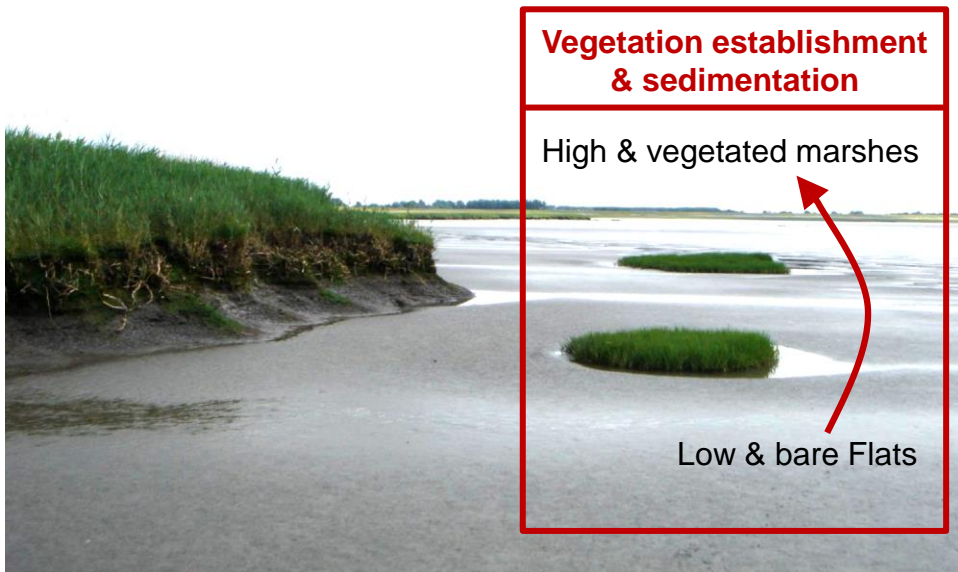
INTRO: **critical shifts** between
intertidal ecosystem states in deltas & estuaries...

High & vegetated marshes

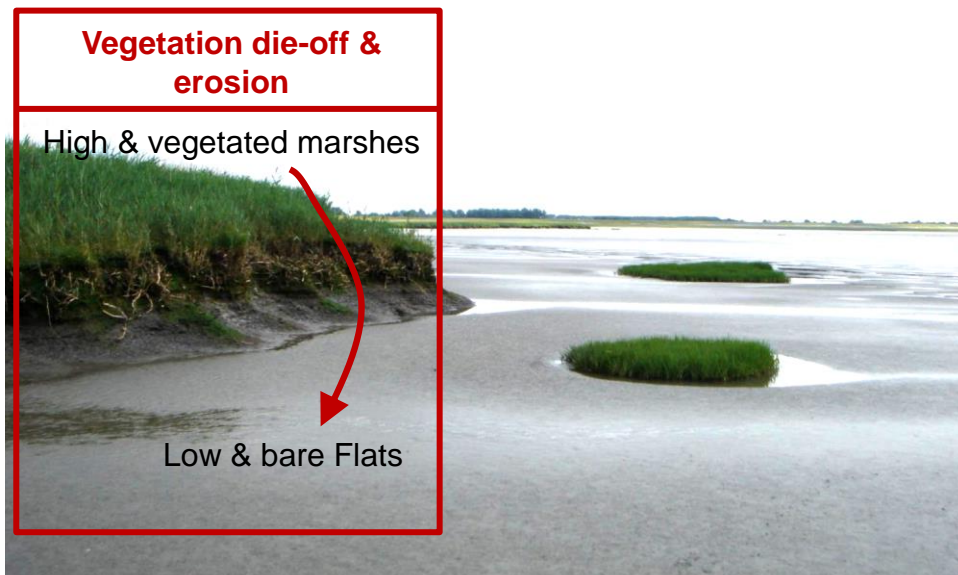


Low & bare Flats

INTRO: such critical shifts are related to
bio-geomorphic feedbacks...

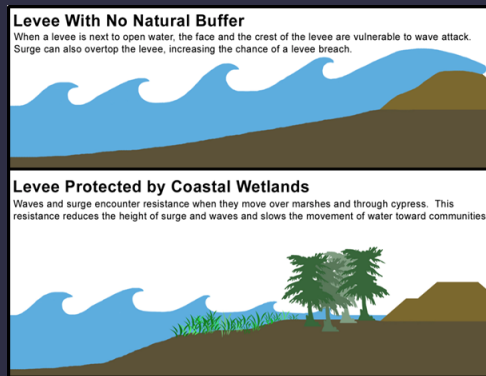


INTRO: such critical shifts are related to
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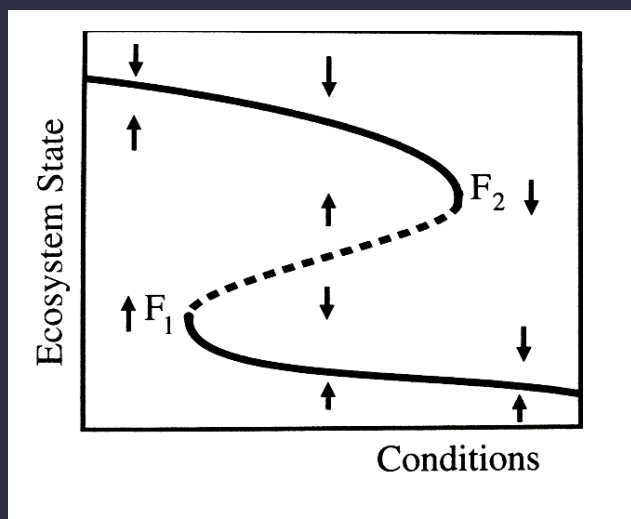
**INTRO: such critical shifts cause
loss of important ecosystem services**

coastal protection
water quality regulation
climate regulation (C sequestration)
etc.



RESEARCH QUESTION:

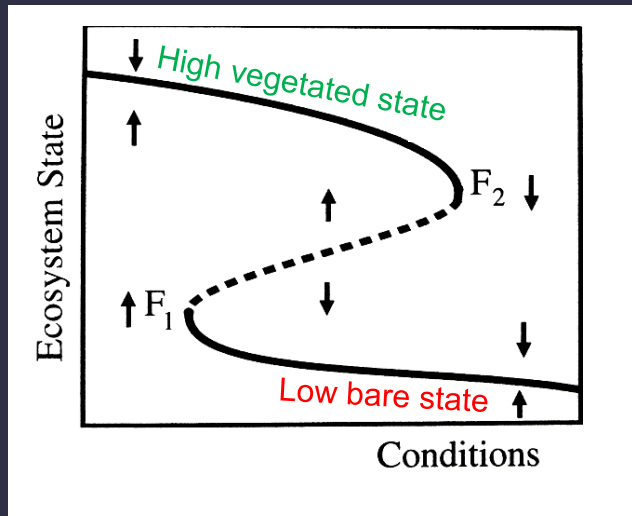
**Do biogeomorphic feedbacks cause
rapid shifts between multiple (alternative?) stable states ?**



Adapted from Scheffer et al. (2009) Nature

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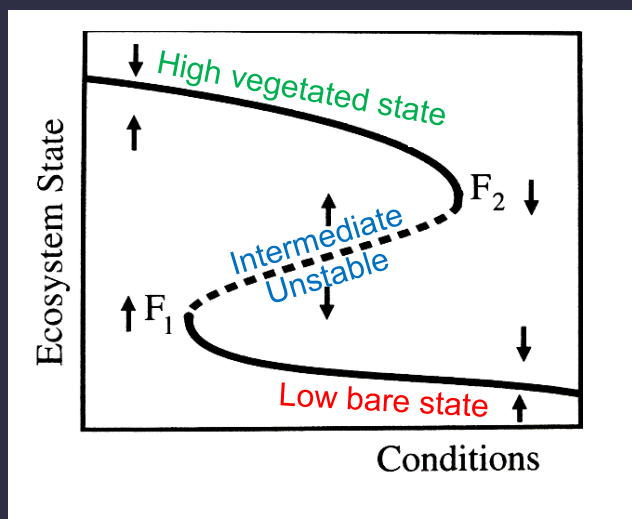
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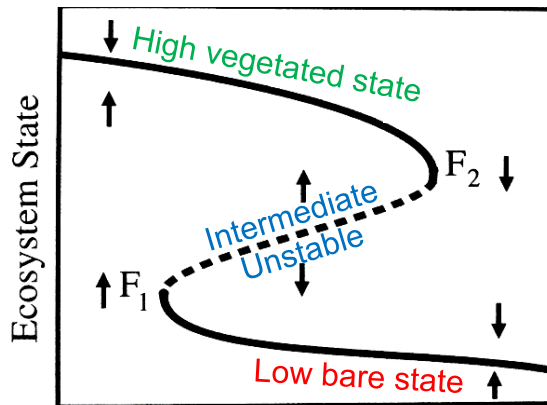
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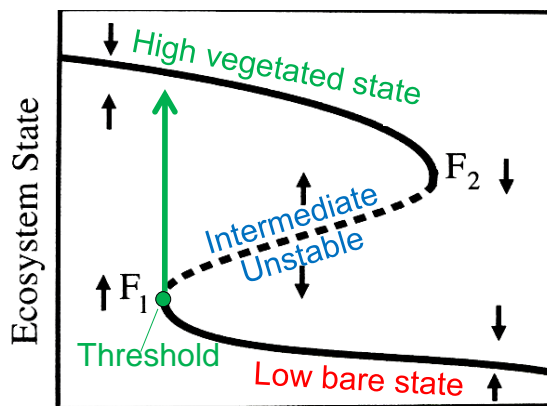


Conditions

E.g. Sediment supply, Tidal range,
Sea level rise rate, wave climate

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Do biogeomorphic feedbacks cause
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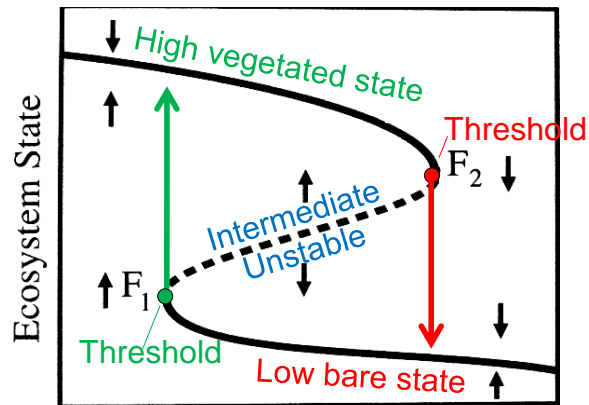


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RESEARCH QUESTION:

Do biogeomorphic feedbacks cause
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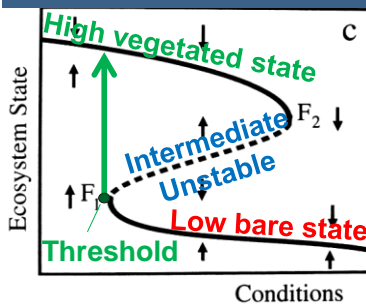
Do biogeomorphic feedbacks cause
rapid shifts between multiple (alternative?) stable states ?

Has indeed been suggested by conceptual models
(Marani et al. 2007; 2010; 2013)

Empirical evidence ???

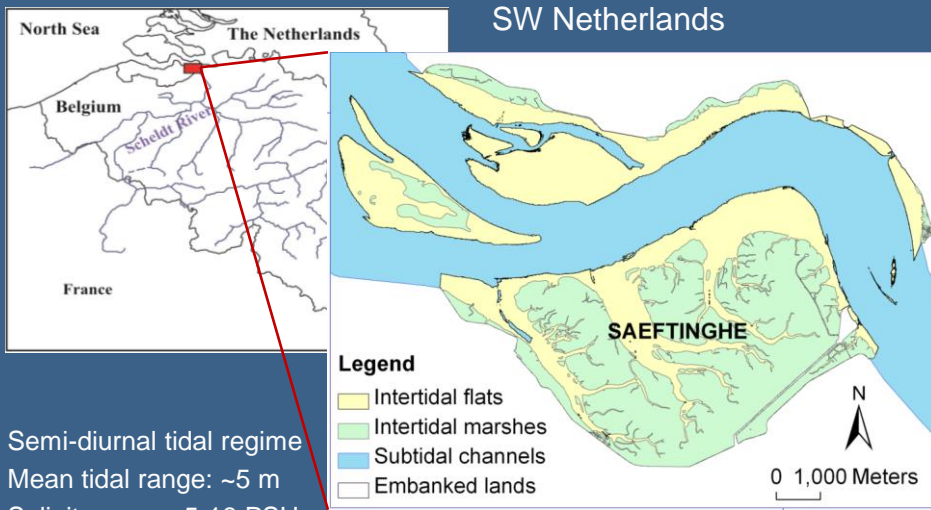
RESEARCH QUESTION:

- 1) Is there a **bimodal distribution** of intertidal elevations & of intertidal vegetation biomass?
- 2) Do the elevation and biomass distributions **shift abruptly** as soon as bare flats get vegetated?
- 3) Are there **threshold** conditions that allow **prediction** of where and when the shifts occur?



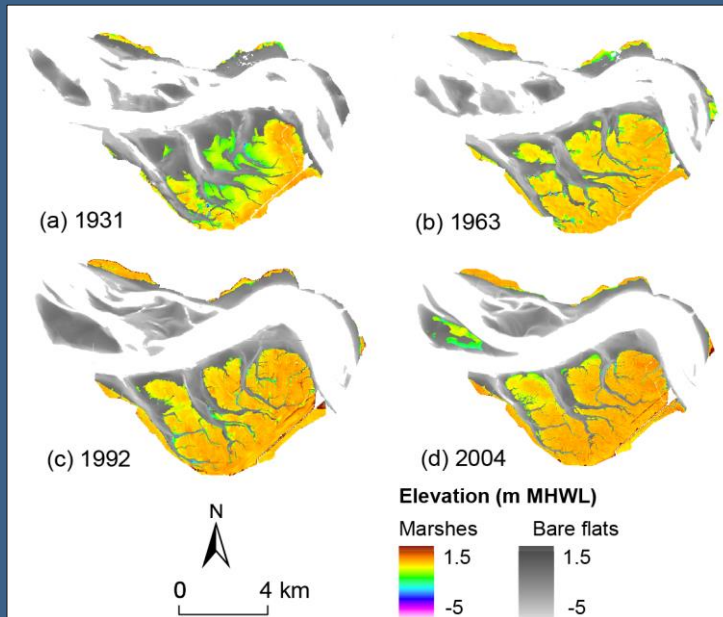
Study area

Westerschelde estuary,
SW Netherlands

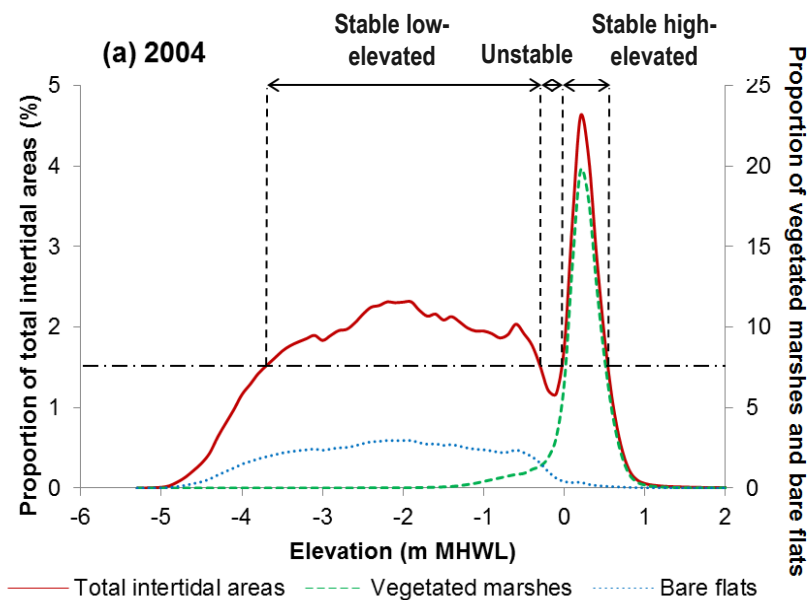


Semi-diurnal tidal regime
Mean tidal range: ~5 m
Salinity range: 5-18 PSU
Mean SSC: ~ 30-60 mg/l

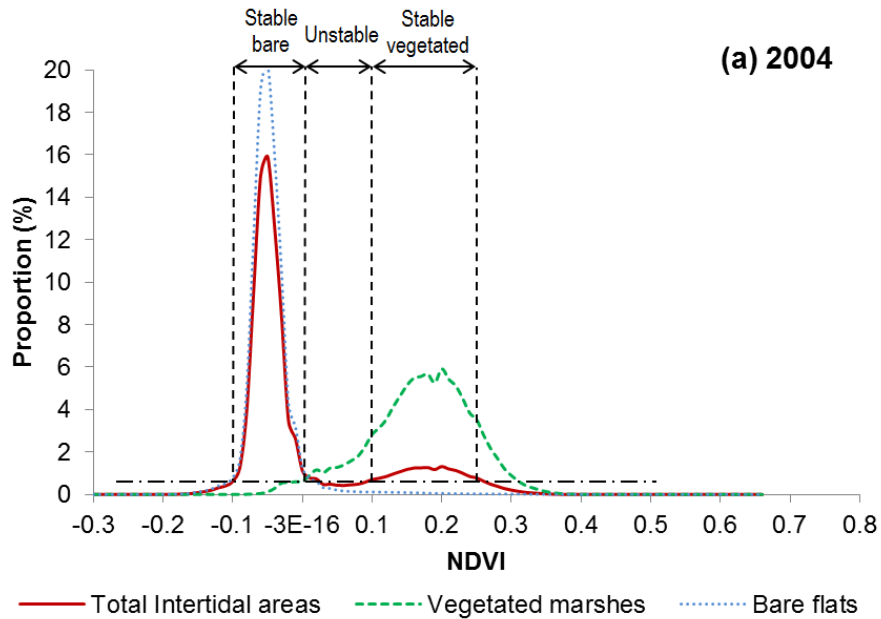
GIS analyses of aerial photos & Digital Elevation Models



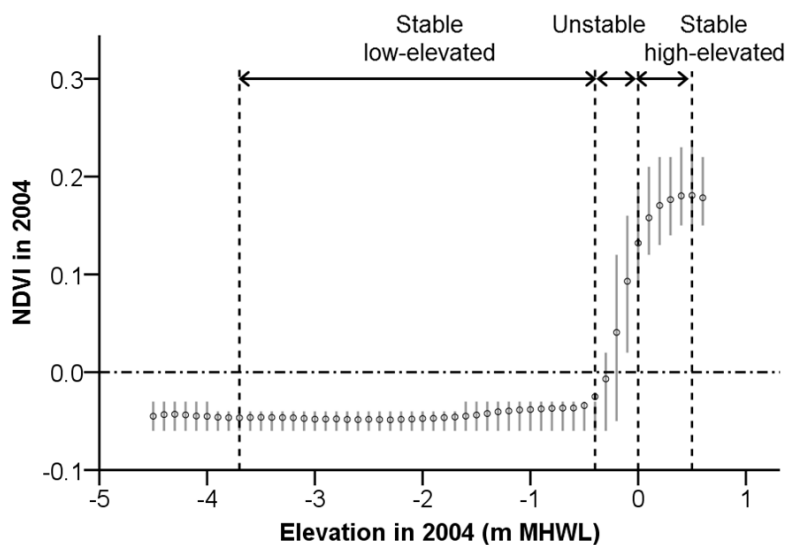
Bimodal distribution of elevations



Bimodal distribution of biomass



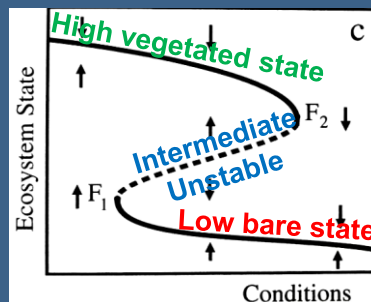
Co-occurring bimodal distributions of biomass & elevation



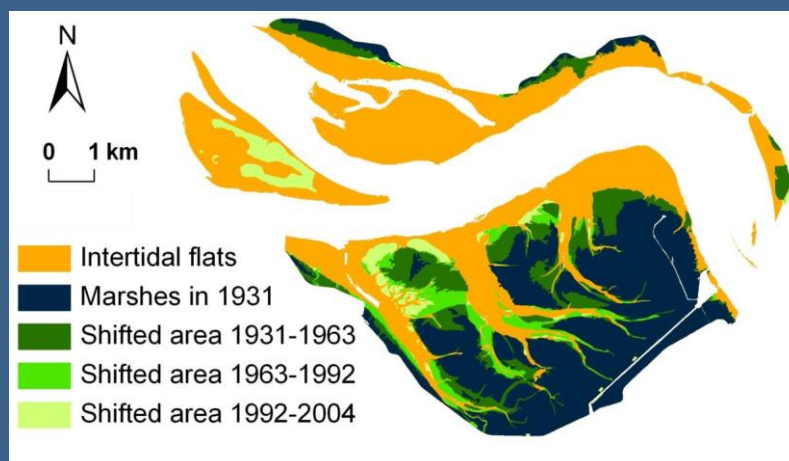
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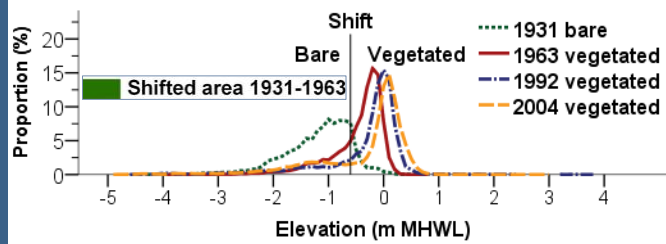
Indication of **two stable states** & **intermediate unstable state**



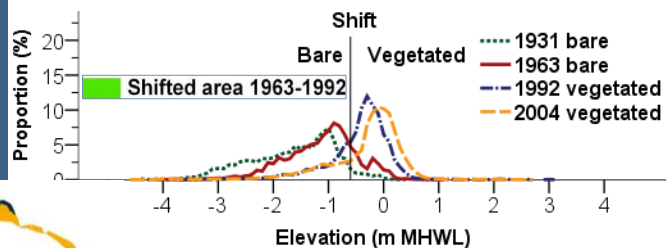
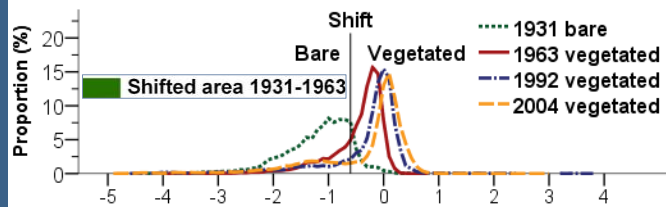
Rapid elevation shifts from bare flats to vegetated marshes?



Rapid elevation shifts?

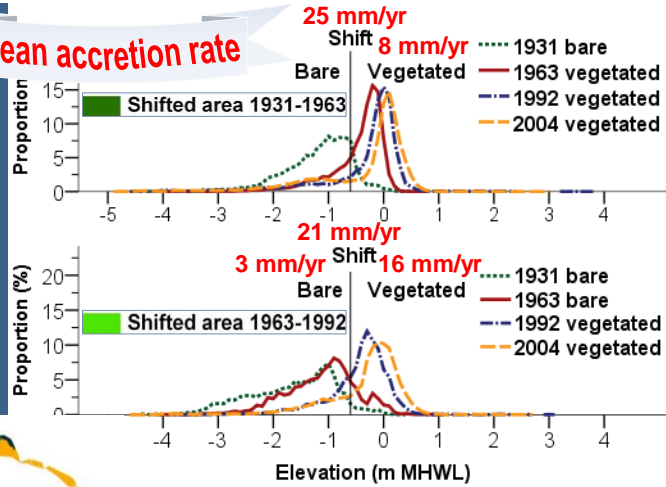


Rapid elevation shifts?



Rapid elevation shifts?

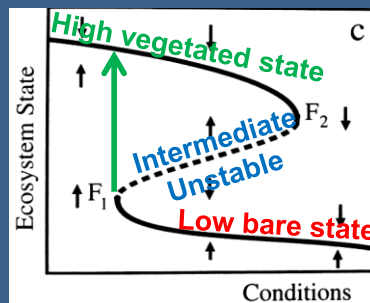
Mean accretion rate



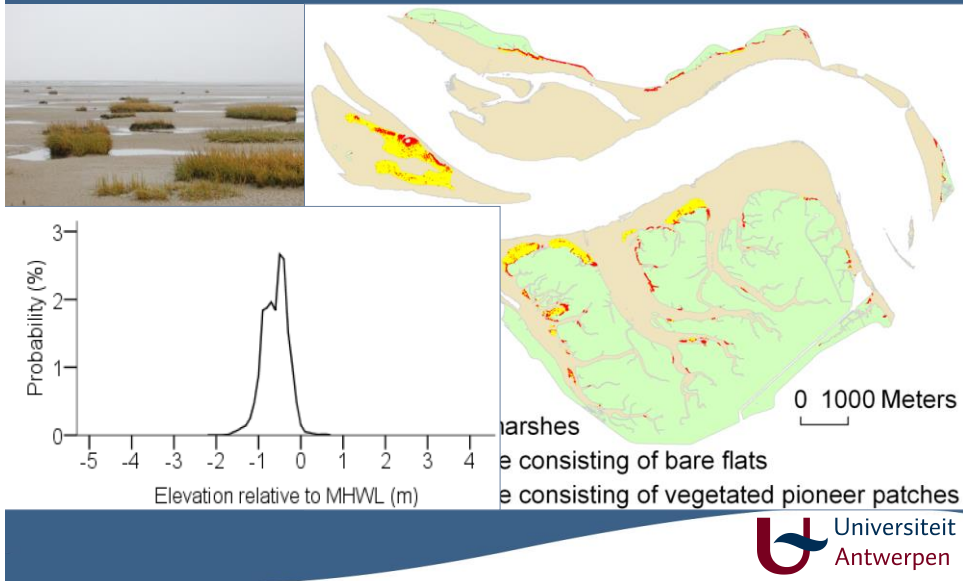
Rapid elevation shifts from bare flats to vegetated marshes



Indication of catastrophic, abrupt, critical transition

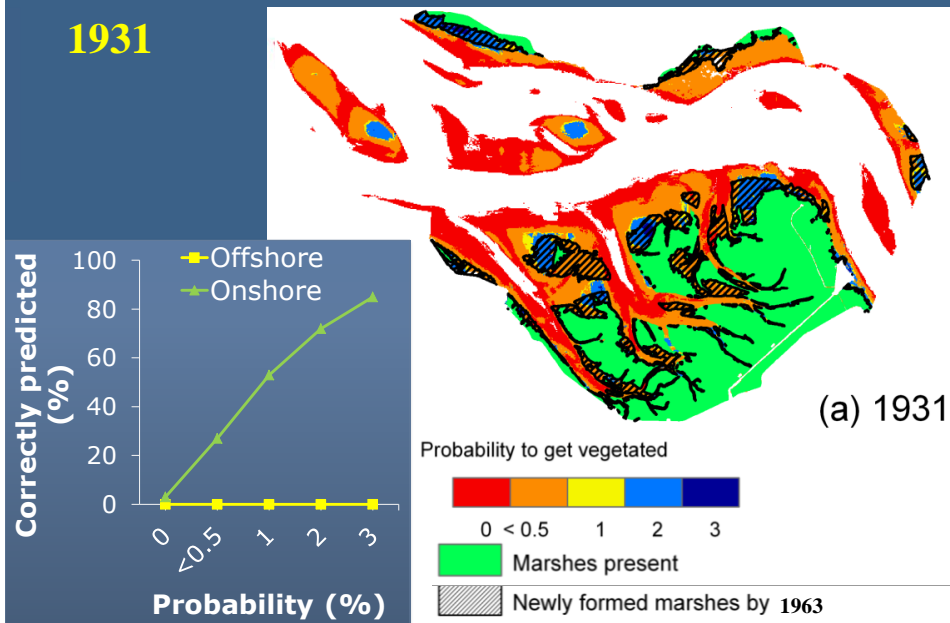


Predicting shifts from bare to vegetated state based on threshold elevation



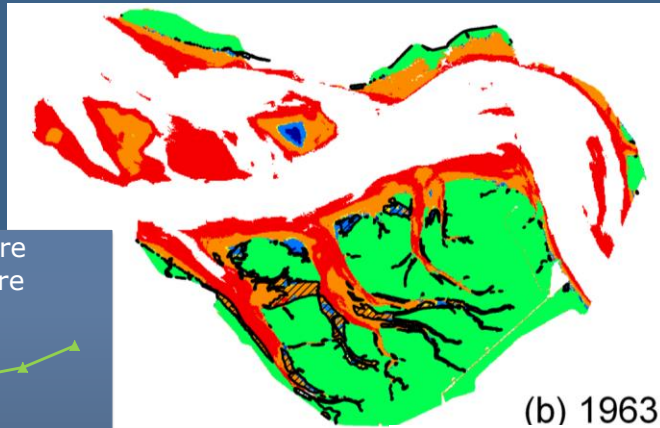
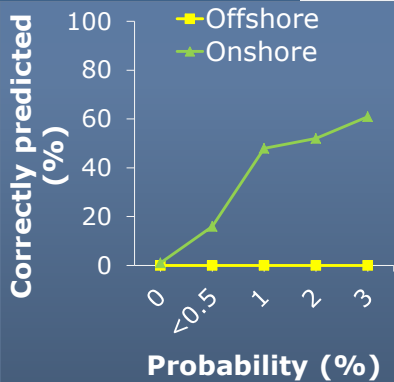
Predicting shifts from bare to vegetated state based on threshold elevation

1931



Predicting shifts from bare to vegetated state based on threshold elevation

1963



Probability to get vegetated:

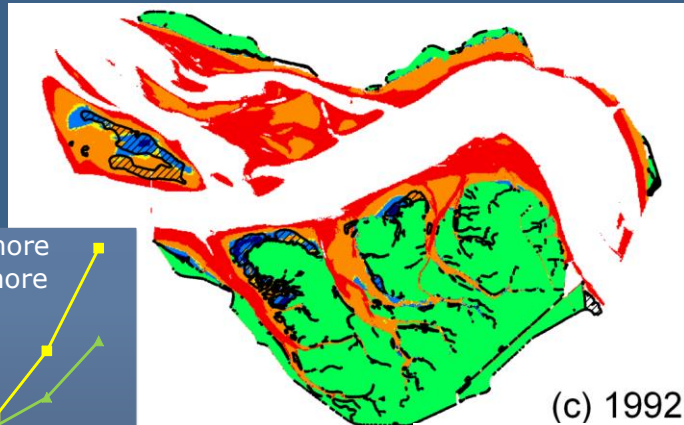
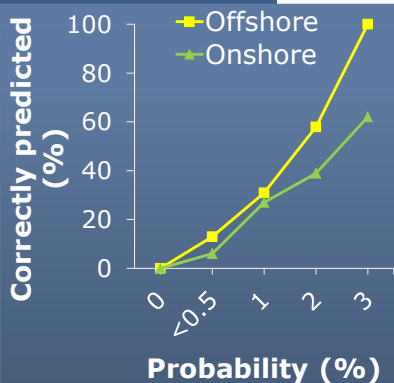


Marshes present

Newly formed marshes by 1992

Predicting shifts from bare to vegetated state based on threshold elevation

1992



Probability to get vegetated:



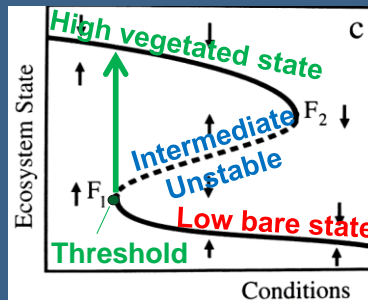
Marshes present

Newly formed marshes by 2004

Predicting shifts from bare to vegetated state based on threshold elevation



Indication of **threshold behavior**



Conclusions

Increasing evidence for multiple stable states & critical transition in intertidal ecosystems

- Bimodal elevation & biomass distribution
- Rapid shift
- Threshold behavior

But also still much uncertainties

- Are stable states alternative?
- Can we predict pending transitions?
- Implications for ecosystem management & restoration?

Want to read more ?:

Wang & Temmerman 2013, J. Geophys. Res.

Thank you !

