

From Polder to Salt Marsh: Evaluation of a 10-year restoration process

Peter Esselink



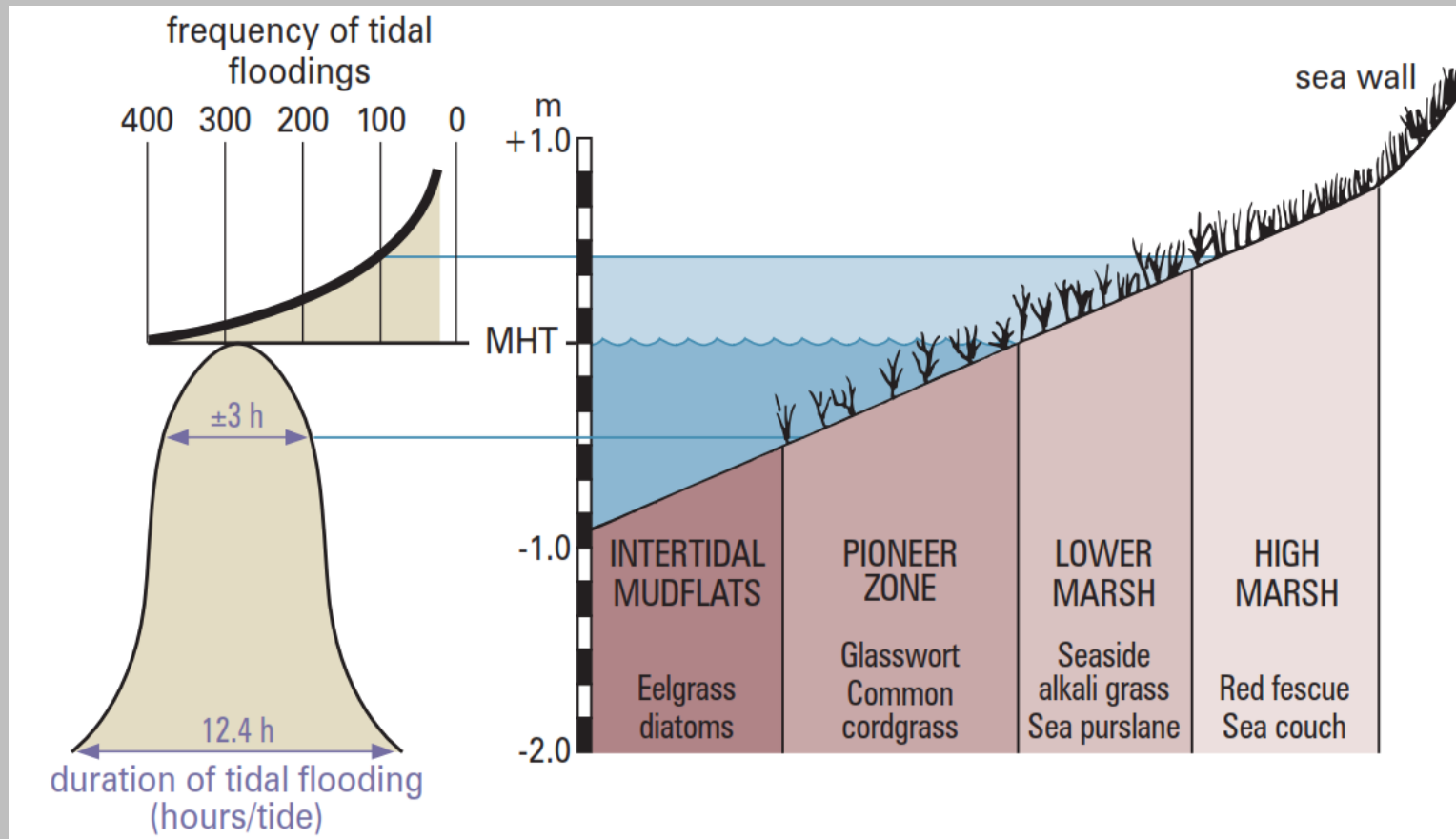
P U C C I M A R



Presentation

- Salt marshes and their conservation value
- Reference states and target states
- Bird's-eye view 10-yr restoration project Netherlands' mainland coast
 - a) Marsh elevation and sea-level rise
 - b) Salinization
 - c) Vegetation development
 - d) Birdlife
- Evaluation / Summary

Coastal salt marsh



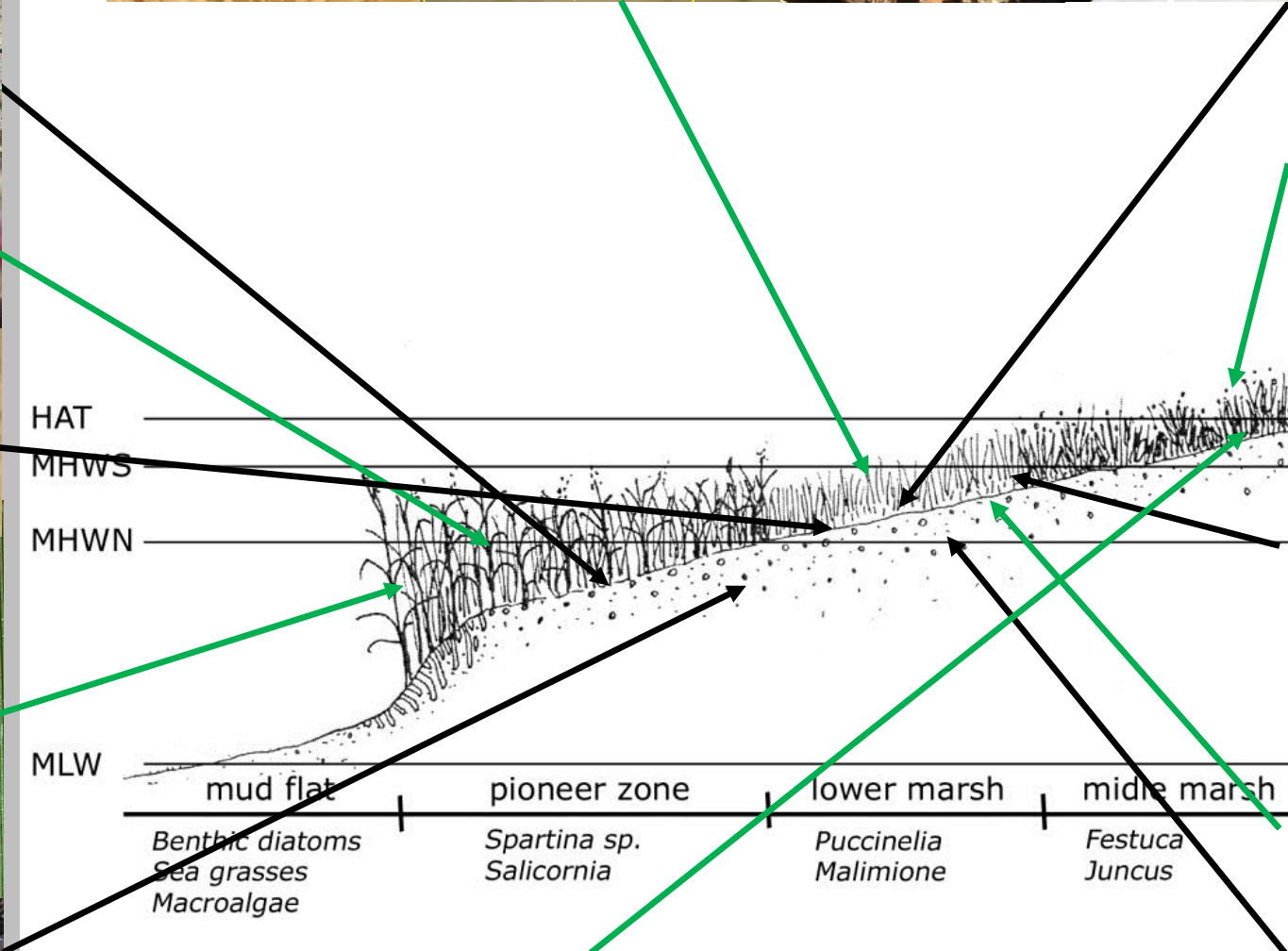
- Area vegetated by higher plants (herbs, grasses or low shrubs)
- subject to periodic flooding with saline water

➔ Extreme environment for plants and animals

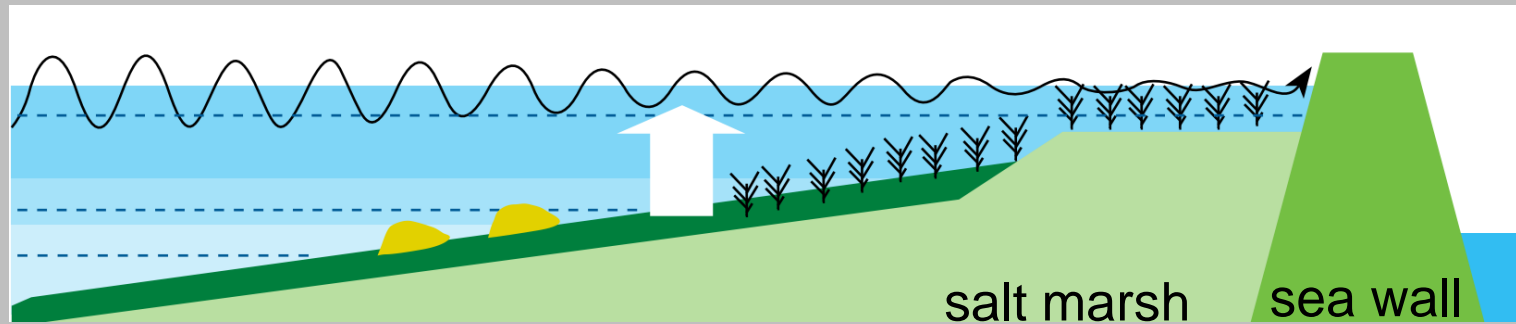
Conservation value of salt marshes

- Plant species (NW Europe): *ca.* 30 species restricted to salt marshes; outcompeted in other environments
- Invertebrates (Insects, spiders, *etc.*): a few hundred species restricted to salt marshes, because, e.g. their dependence to a single host plant
- Plants and invertebrates: often specialized to survive in saline environment and submergence with salt water
- Also a few bird species dependent on salt marshes, *e.g.* : Barnacle goose and Brent goose



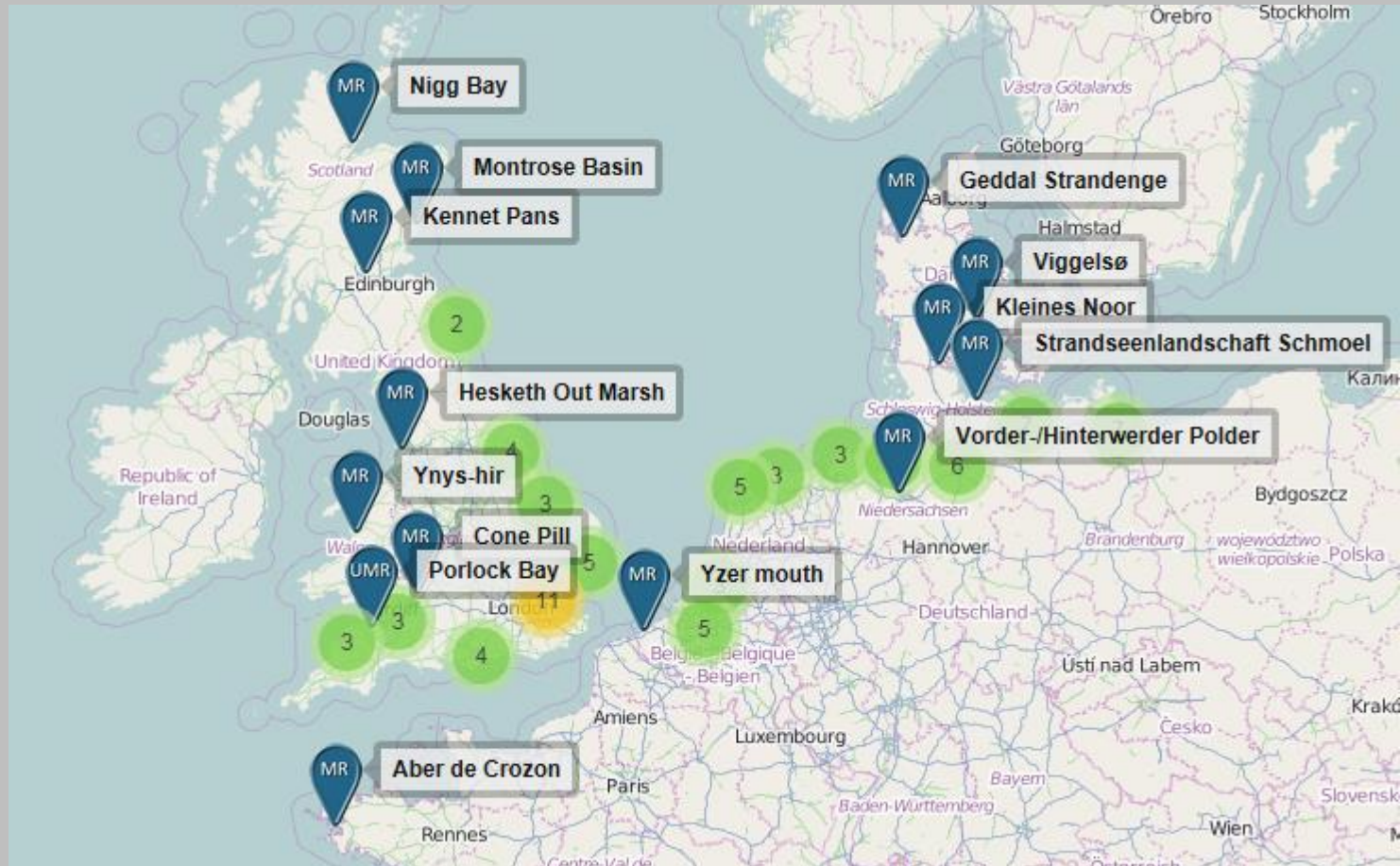


Ecosystem services of salt marshes



- Wave attenuation (cost reduction in coastal defence)
- Nursery ground of several fish species
- Cultural values (including recreation)
- Carbon sequestration (global change)

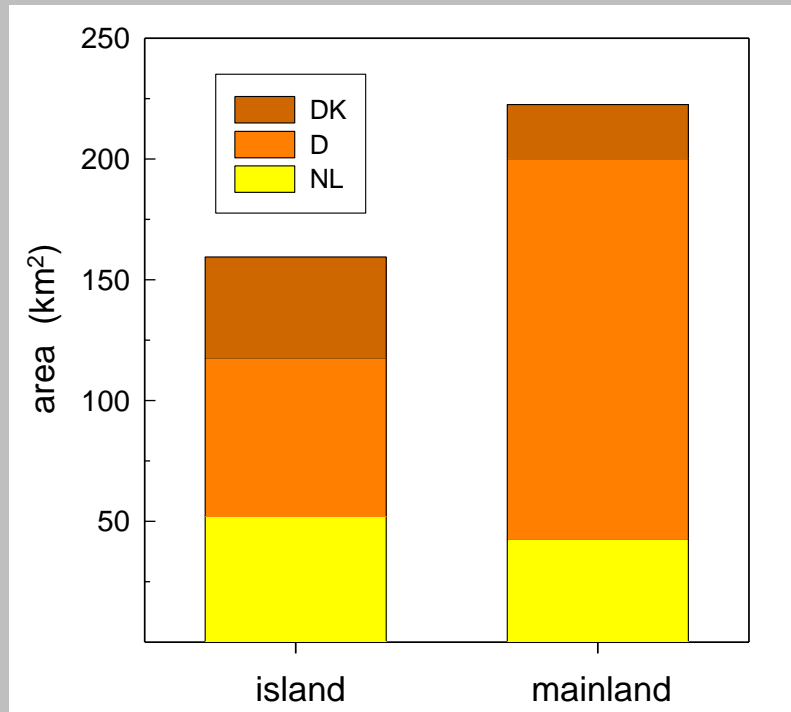
Managed realignment in NW Europe



Source: <http://www.omreg.net/view-maps/>

- approx. 100 sites (50% in UK)

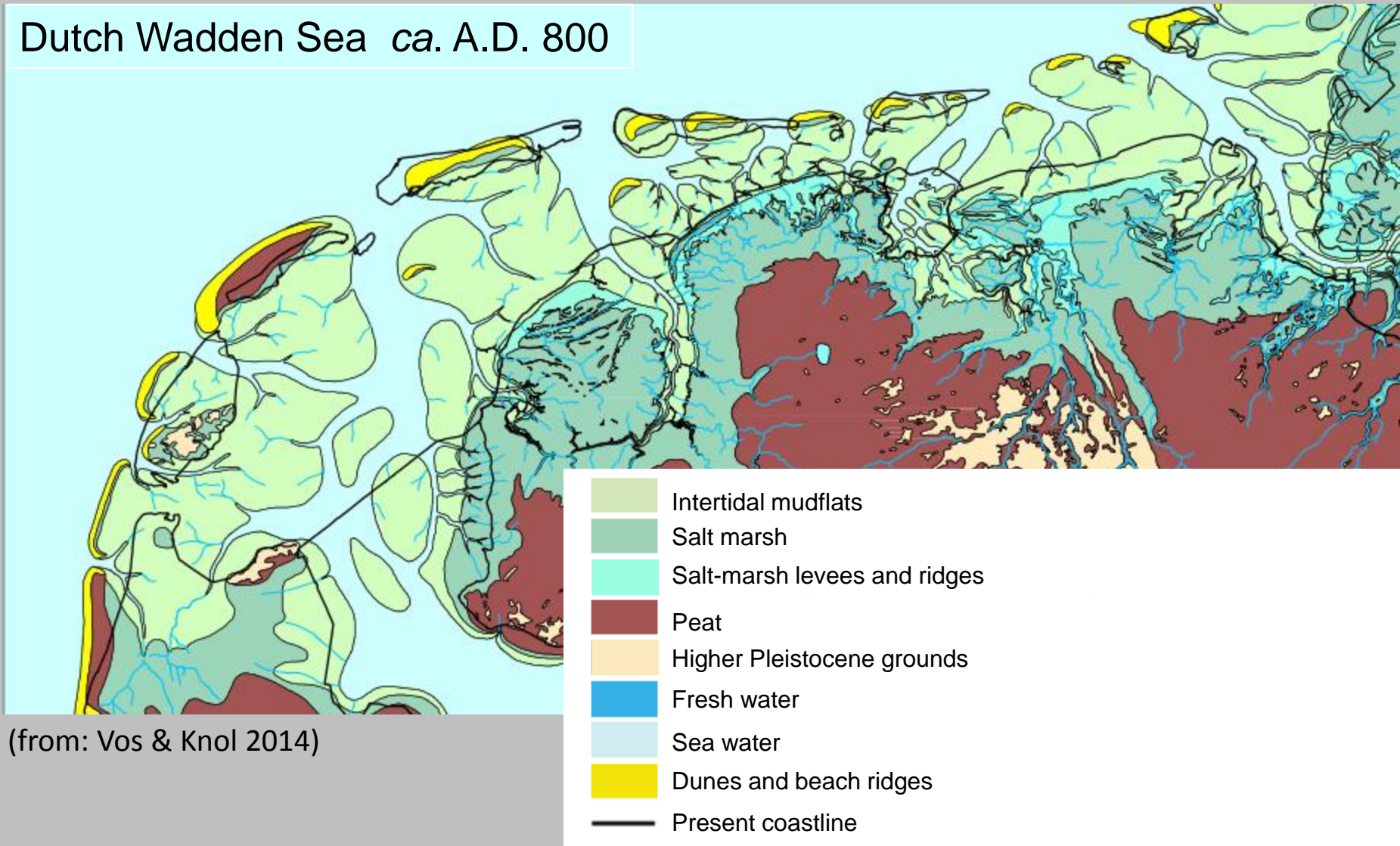
Salt marshes of the Wadden Sea



- 400 km² or
≈ 20 % total area in Europe
- of great value for nature conservation !

Historic reference

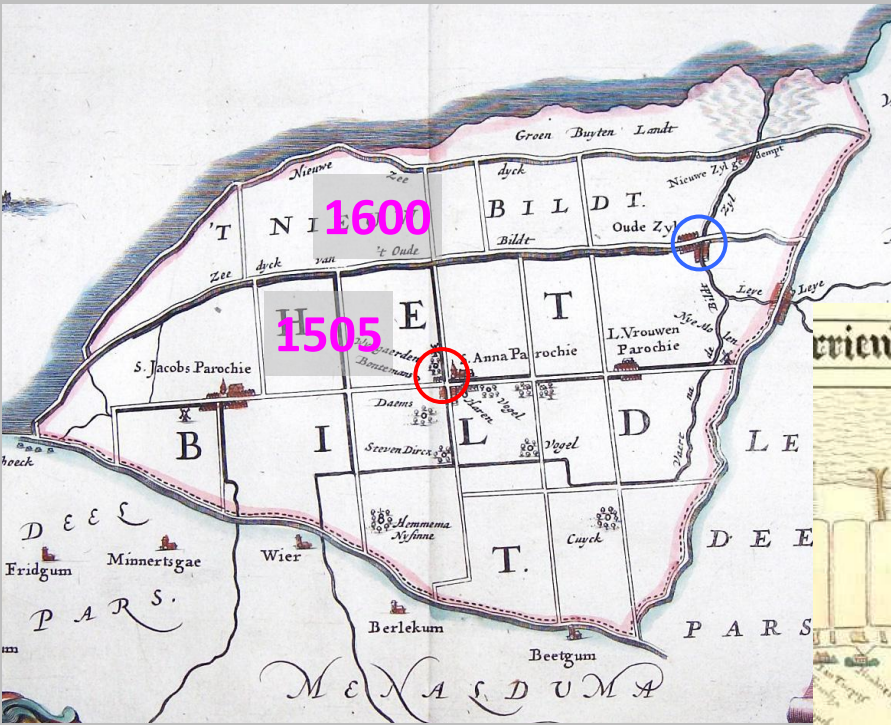
Dutch Wadden Sea ca. A.D. 800



(from: Vos & Knol 2014)

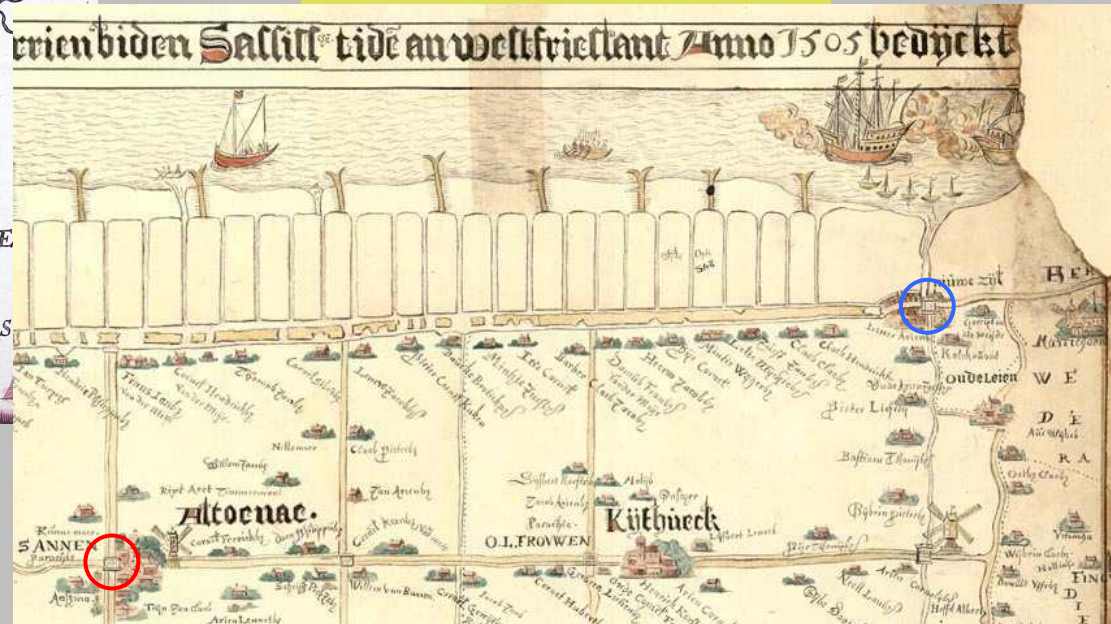
- Vanished landscape; not restorable

Historic reference



(Schotanus 1664)

Salt-marsh works 1570

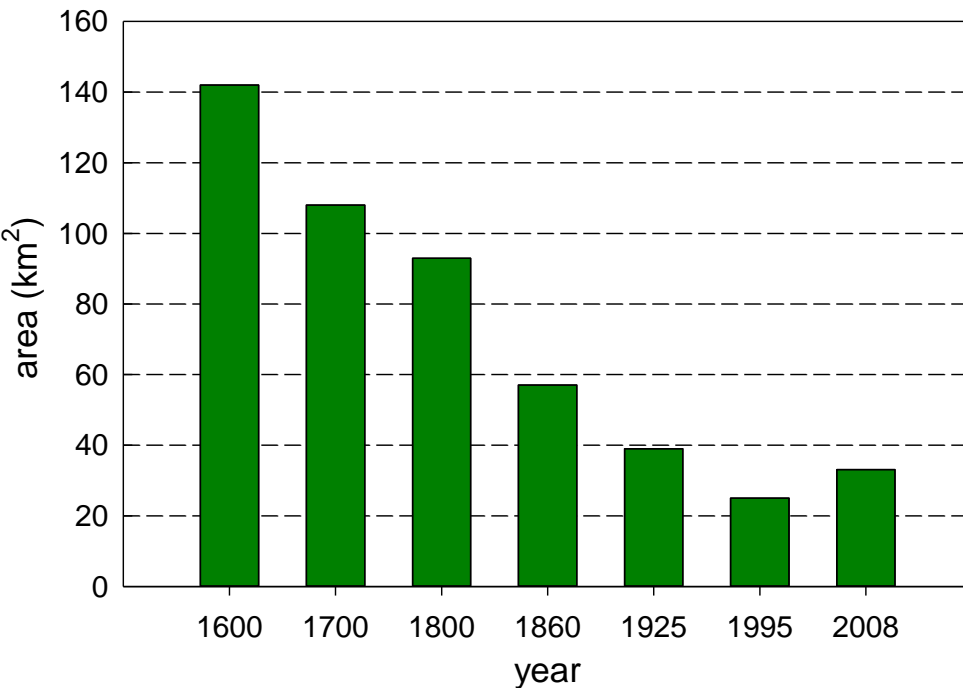


(from: De Rijcke 2001)

Rate of embankments faster than development of new (artificial) salt marshes

Historic development

Decrease NL mainland salt marshes Wadden Sea

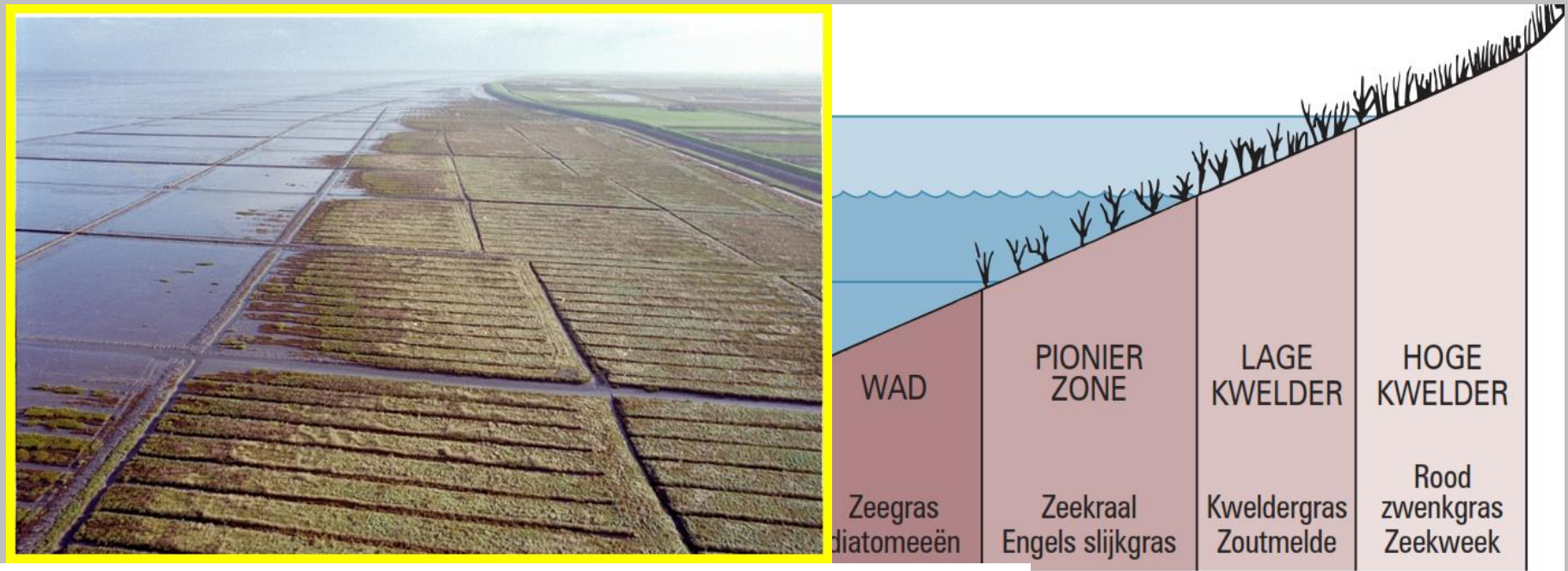


(After Dijkema 1987; Dijkema *et al.* 2011)



- Present state: Size << historic references
- ➔ Recommendation Int. Wadden Sea Symposium (1993): Salt-marsh restoration by experiments with realignment of summer-polder banks

Present state mainland salt marshes



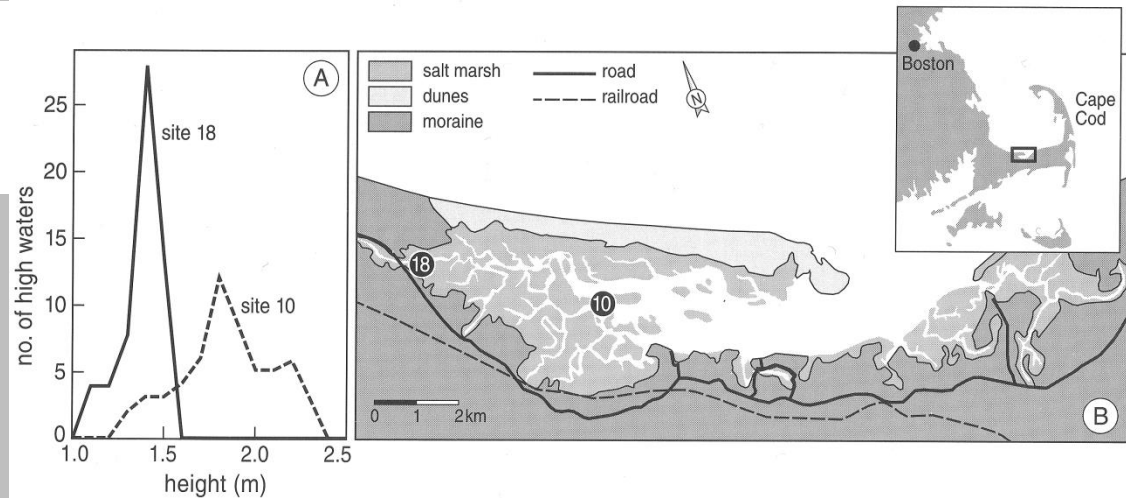
- Semi-natural
- a shadow of the past
- **narrow zone** (without natural hinterland)
 - ☛ high sedimentation rates
 - ☛ high succession rates(from pioneer marsh to climax of *Elytrigia* < 40 year)
- Wadden Sea “amputated landscape” without a natural hinterland



Geographic reference state (1/1)

Hydrodynamic gradient:

4 km → 0.4 m reduction local MHT
(van der Molen 1997)



“The current shape of the mainland salt marshes in the Wadden Sea has strongly been determined by a history of successive land claims and sedimentation works. Consequently, the grand majority of the mainland marshes are not more than a narrow fringe along the seawalls. It follows that in very few situations these marshes feature a complete hydrodynamic gradient of natural wide salt marshes. Nature conservancy should give priority to conserve and restore wide salt marshes wherever this is attainable.”

(QSR 2009)

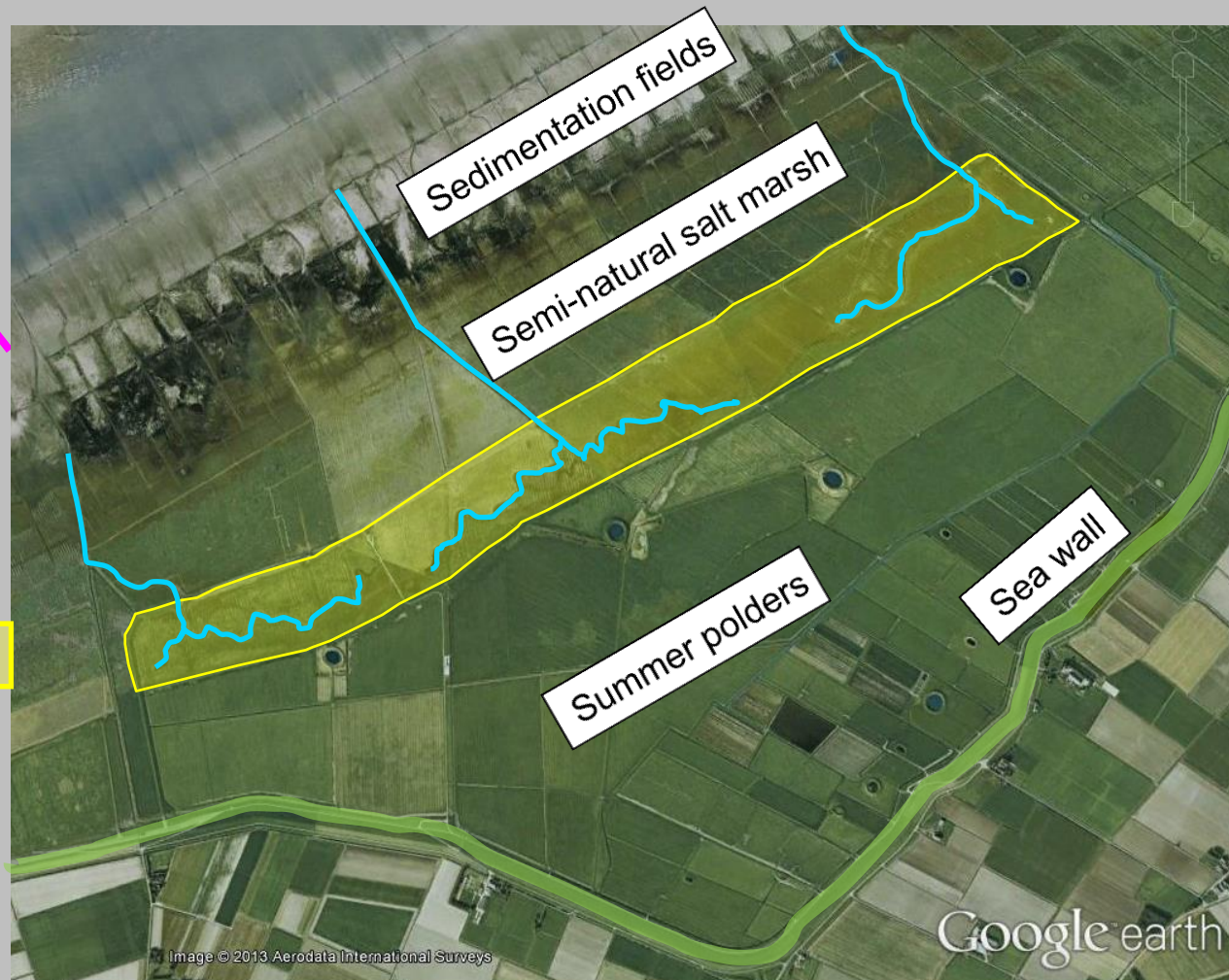
Restoration site Noard-Fryslân Bûtendyks



Restoration site (117 ha)

Target:

“grazed salt marsh”



Main measures:

- three breaches in the seaward summer bank
- 2001
- digging artificial creeks; rewetting by filling of ditches
- continuation of livestock grazing

Monitoring research 2000 – 2011/12

Aim:

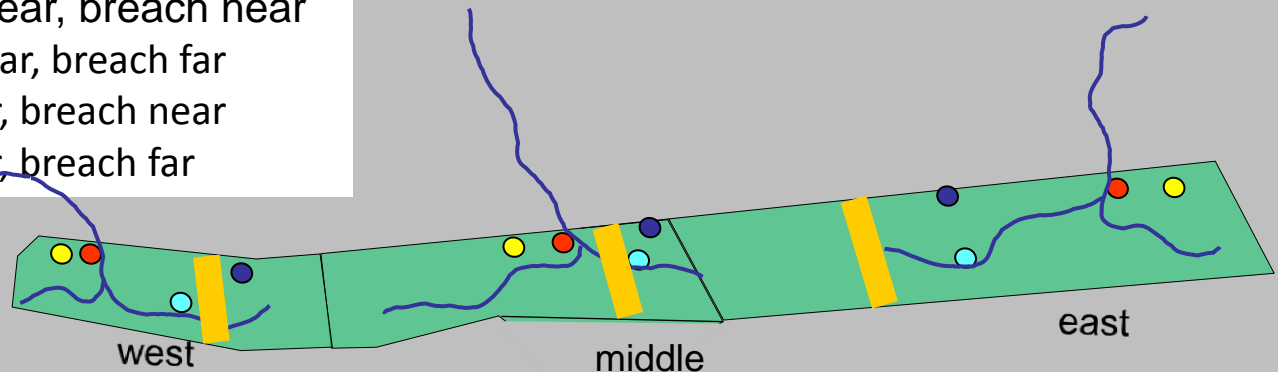
- Study abiotic and biotic changes after de-embankment (2000 – 2011/12)
- Evaluation of ecological success (2006, 2012/13)

Approach: Combination of

- 1) Descriptive fieldwork (monitoring)
- 2) Field experiments (2001-2011/12), full-factorial design

Factors: - distance to breaches
distance to creeks
surface elevation
livestock grazing (exclosure)

- Creek near, breach near
- Creek near, breach far
- Creek far, breach near
- Creek far, breach far



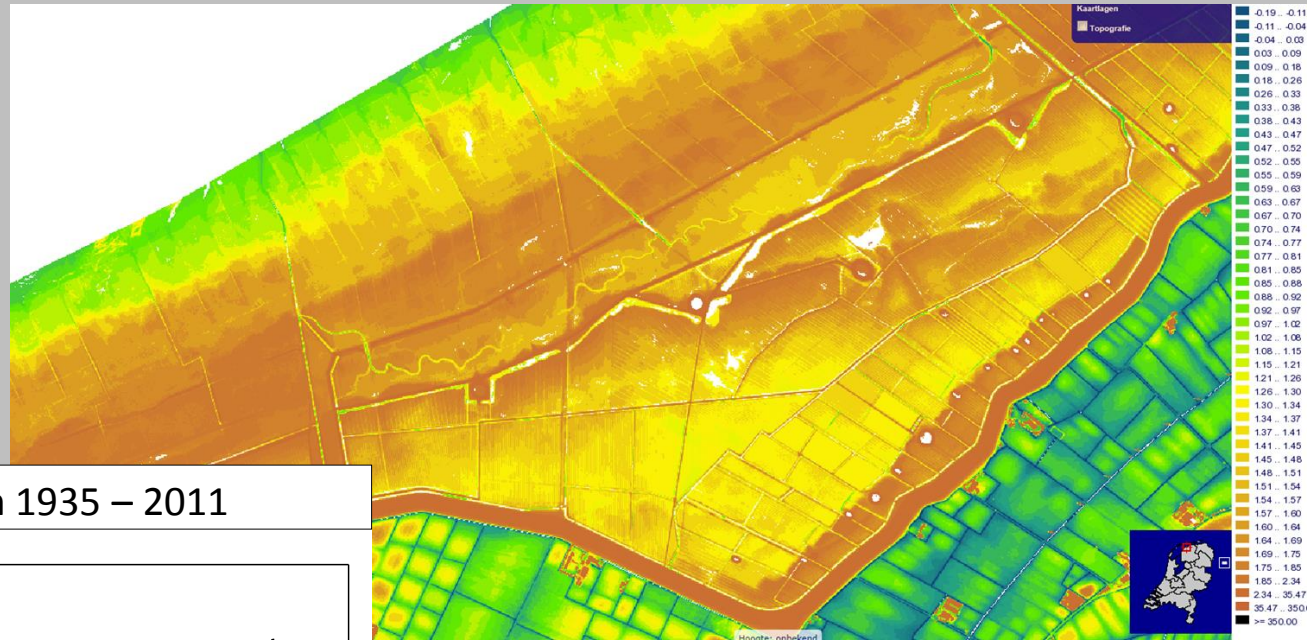
High elevation, creek far, breach far



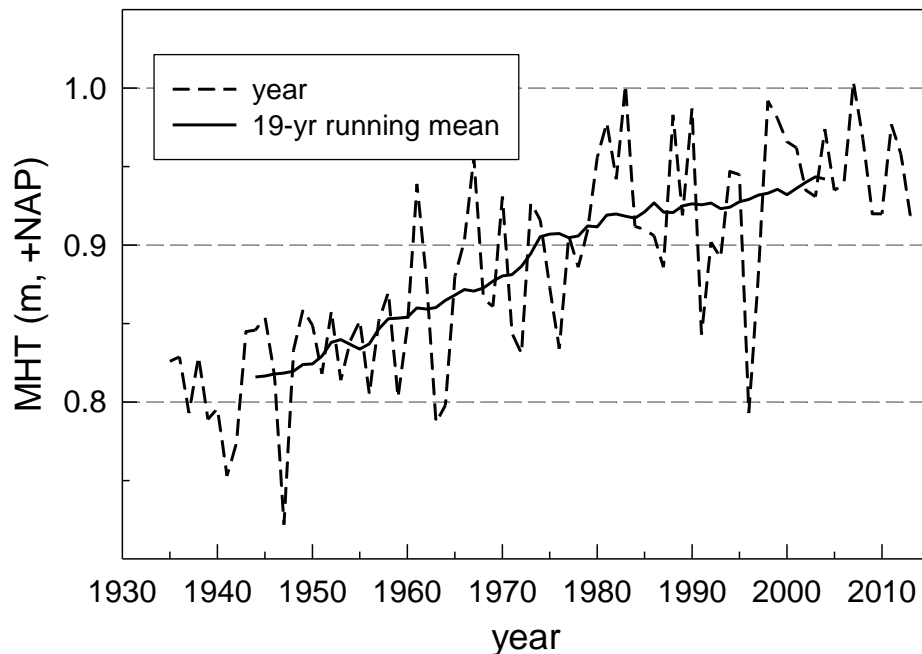
Low elevation, creek far, breach far



Sea-level rise and surface elevation



Mean high tide Harlingen 1935 – 2011



Sea-level rise 2.2 mm/year

Restoration of tidal influence:

• can the area keep pace with SLR ?

Summer polders: any elevation change ?

Surface elevation restoration site (methods)

- Accretion (mm/yr):

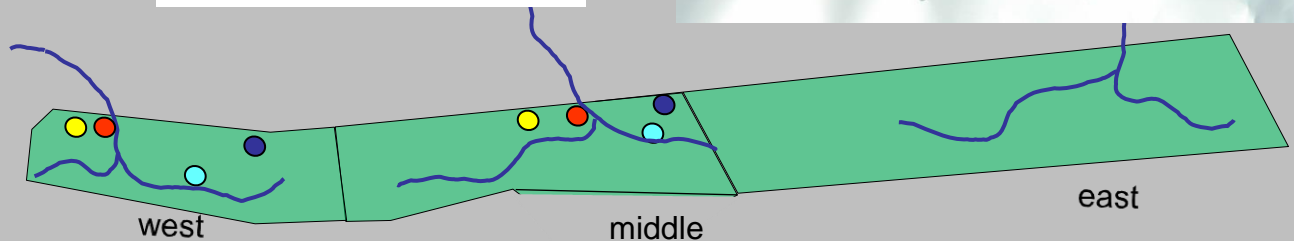
- Sedimentation plates buried 10 cm deep
- 8 stations inside and outside exclosures
- depth monitored during 10-yr period

- Sedimentation (kg/m²/yr):

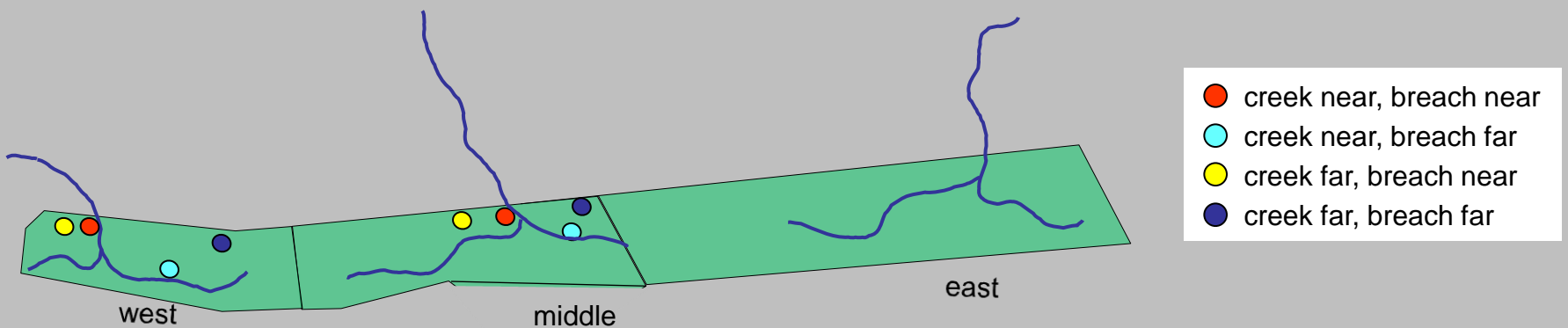
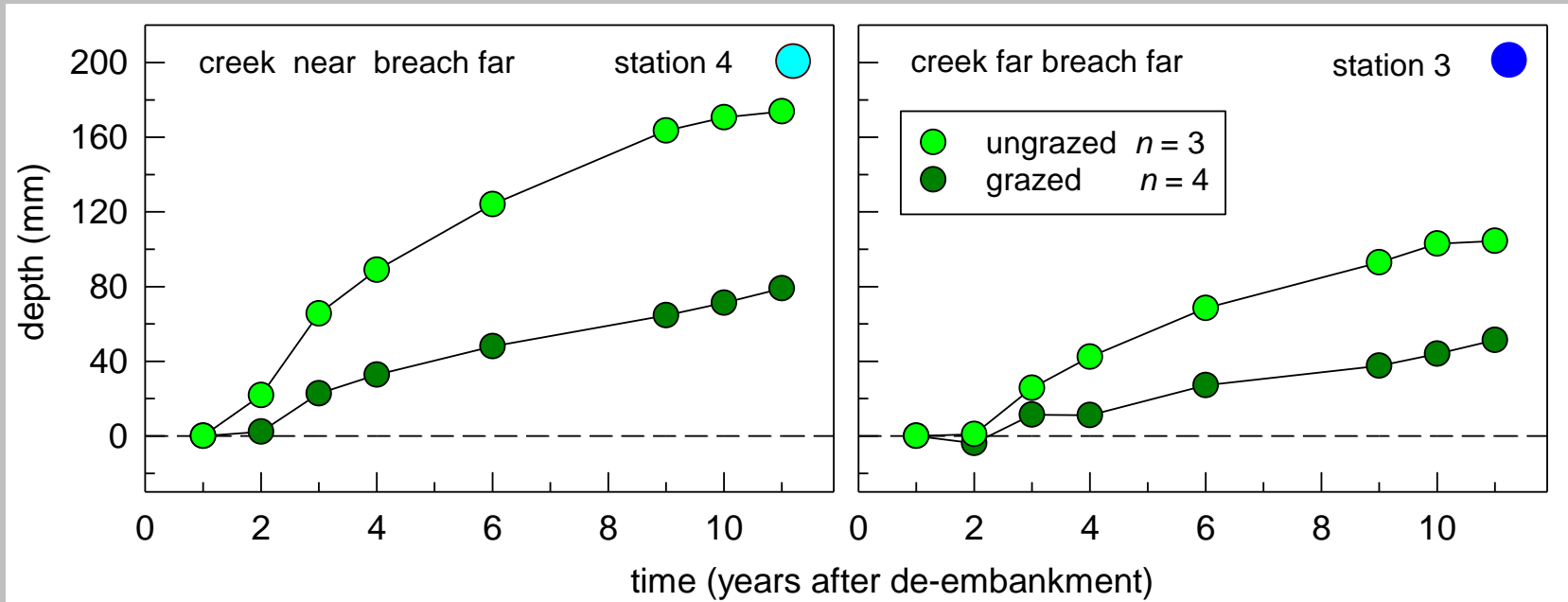
- Sediment accumulation above the plates
- 10-yr period
- soil cores Ø 8 cm, drying & weighing



- creek near, breach near
- creek near, breach far
- creek far, breach near
- creek far, breach far

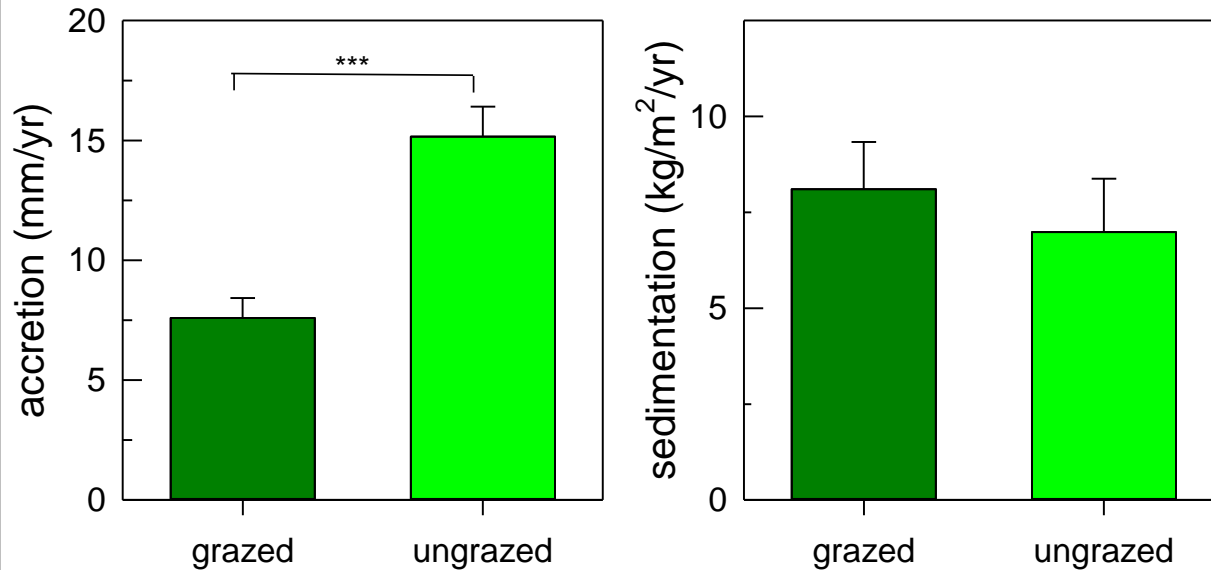


Accretion restoration site



- Effect of creeks and livestock grazing

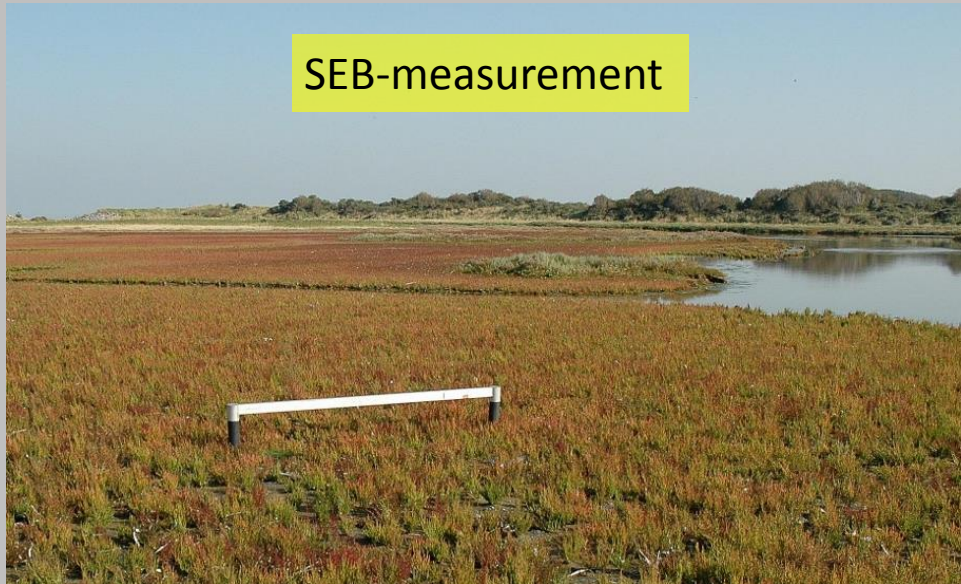
Surface elevation restoration site



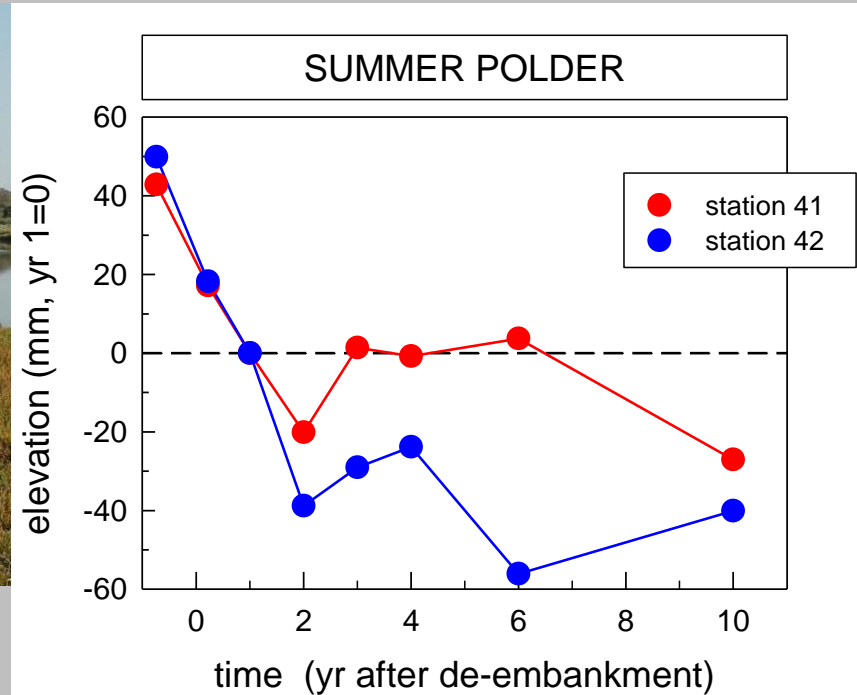
Restoration site:

- Elevation increase: 7.6 mm/ year
- Grazing retards accretion (compaction)
- No effect of grazing on sedimentation
- Site is catching up with sea-level rise

Surface elevation summer polder (1/2)



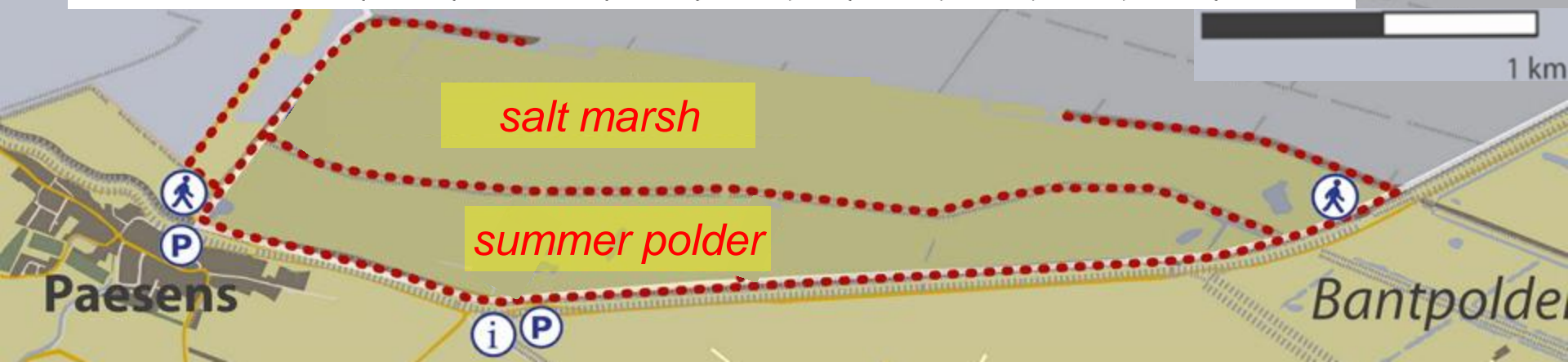
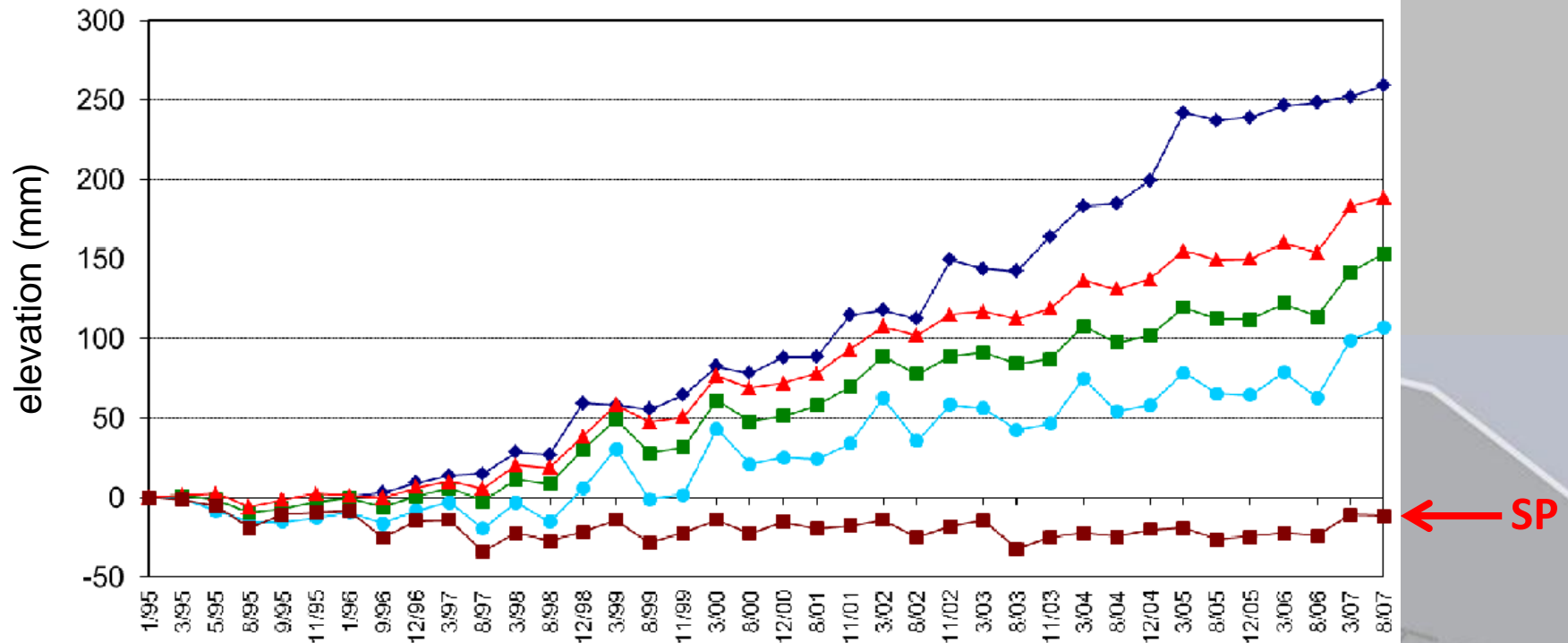
SEB-measurement



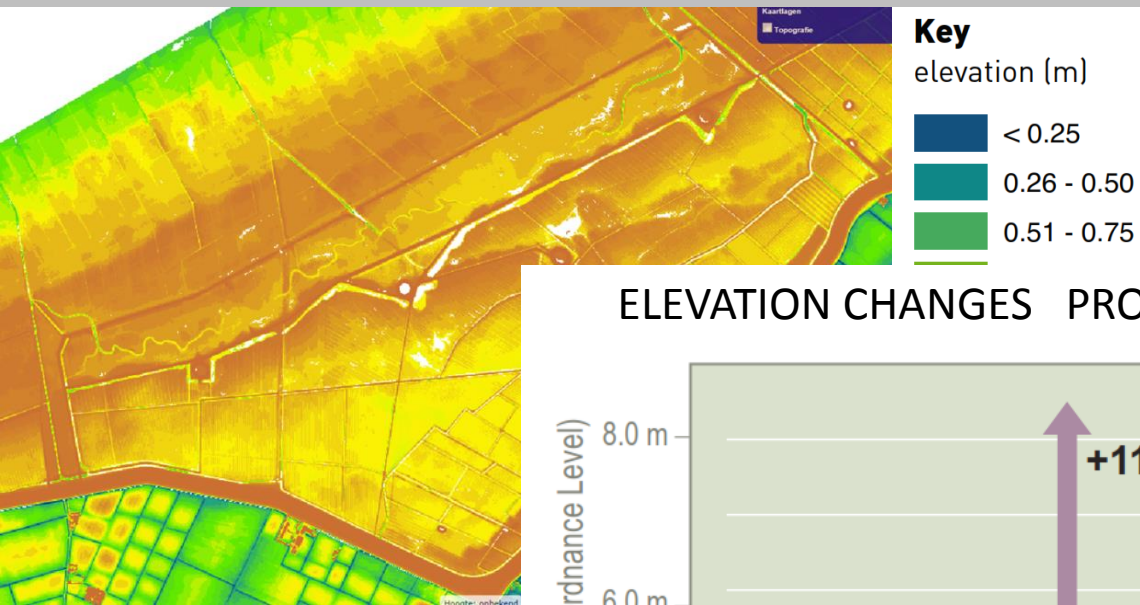
- No indication of any significant accretion.
This holds also for years with a high storm activity (years 6 and 7).
- ☛ Elevation deficit; not resilient to climate change

Surface elevation Summer Polder (2/2)

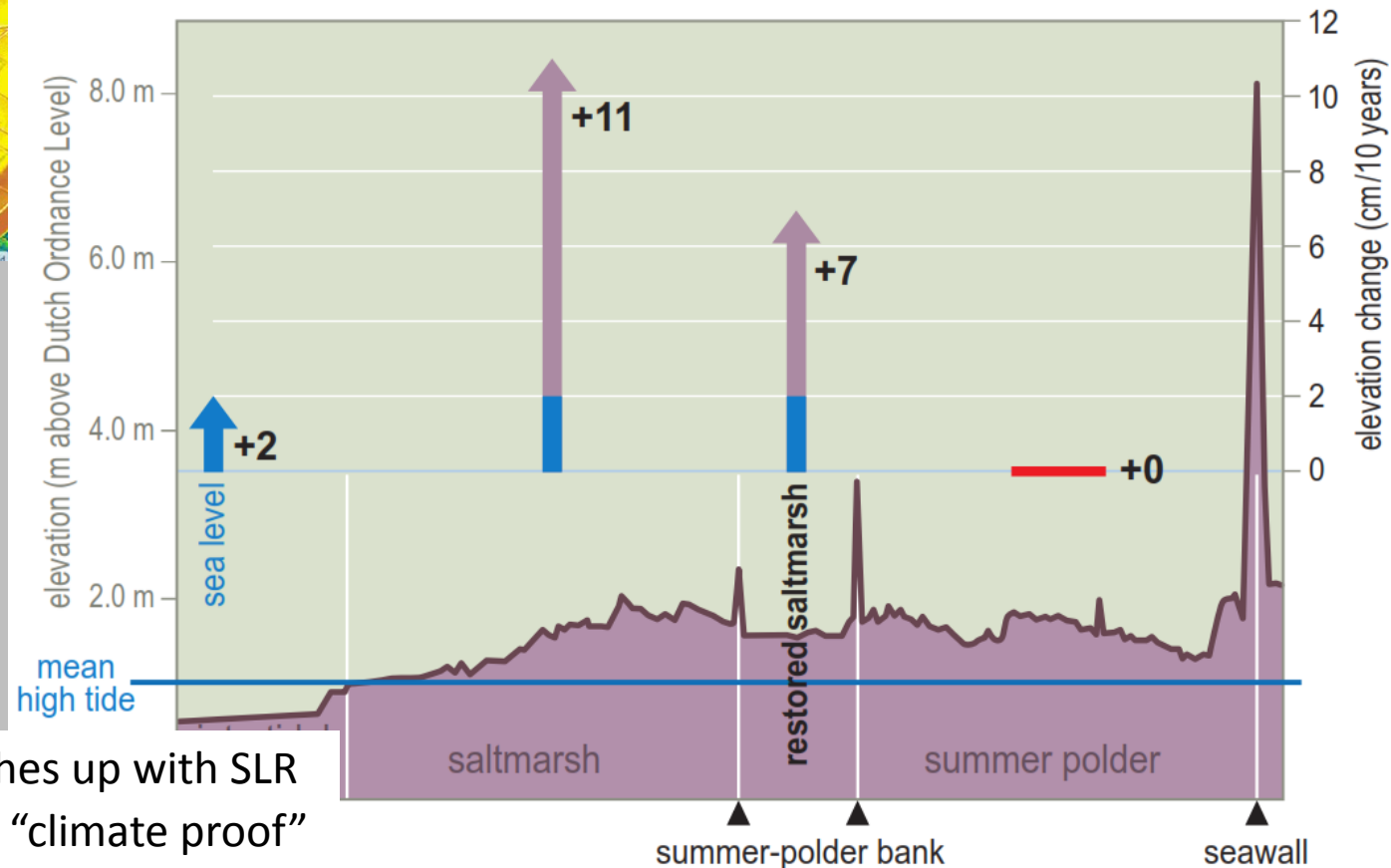
Peazemerlannen 1995 – 2007 SEB-monitoring (van Duin et al. 2011)



Sea-level rise and Elevation change



ELEVATION CHANGES PROFILE INTERTIDAL FLAT – SEA WALL



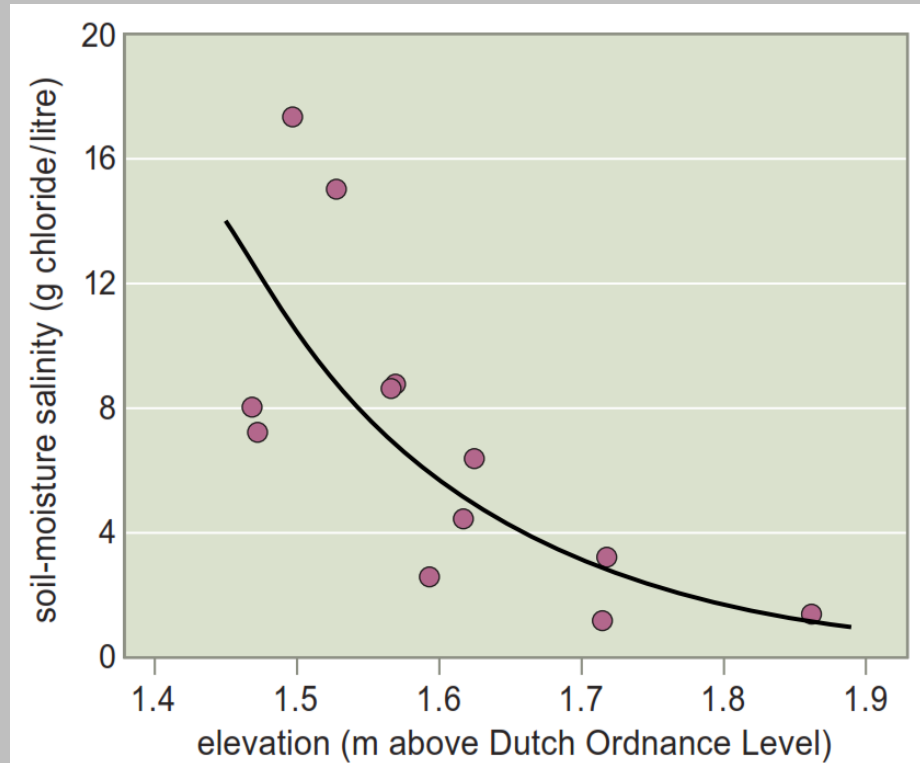
- Restoration site catches up with SLR
- Summer polders not “climate proof”

Salinization

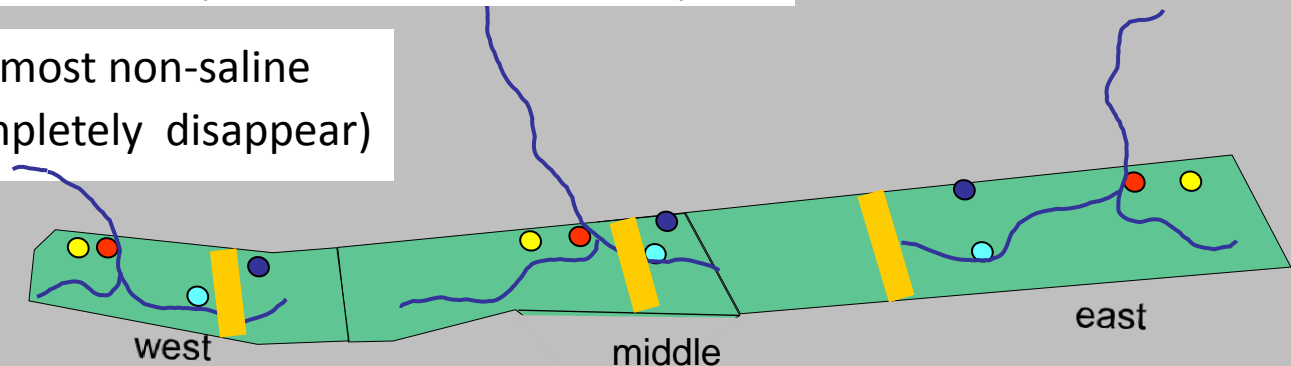


- Dependent on frequency of tidal inundations
(and thus position in tidal frame)
- Restoration site: lower area 100× per year
 higher area 12× per year
- Salinity measured in: upper 5 cm of marsh bed
 groundwater

Salinization marsh soil (0 – 5 cm)

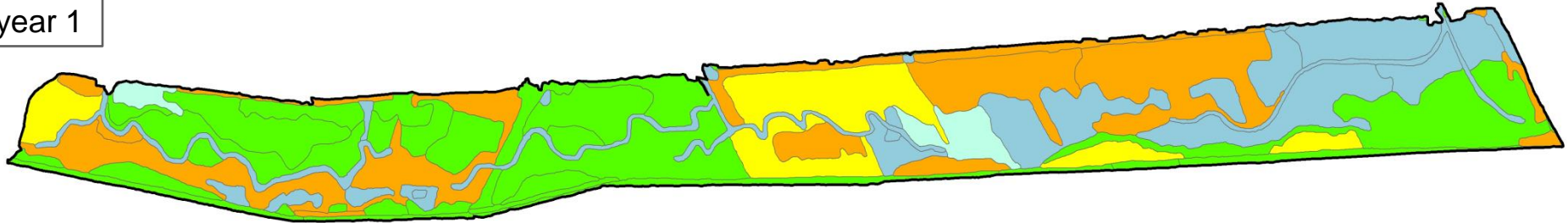


- Gradient from saline to almost non-saline (earth worms did not completely disappear)

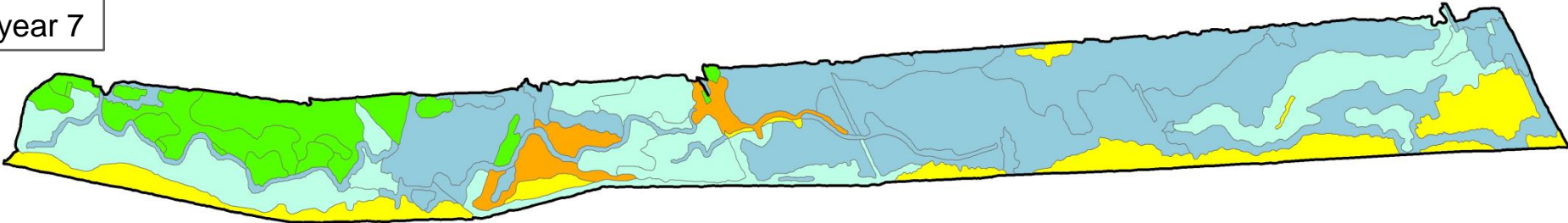


Vegetation development

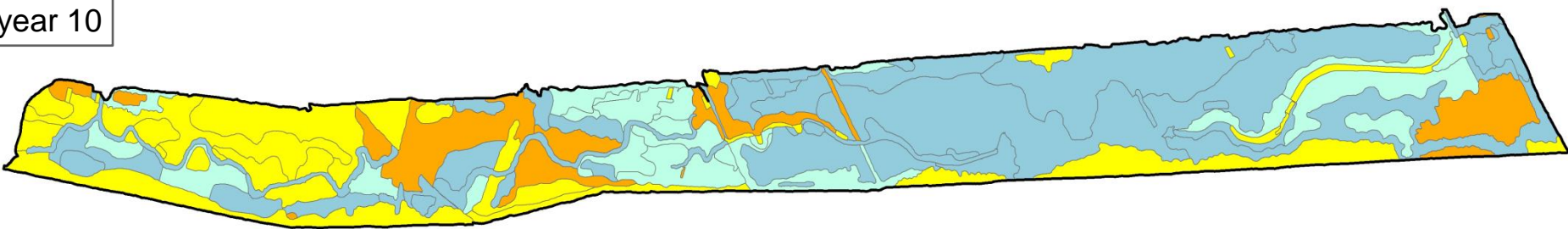
year 1








year 7



year 10



Legend

- | | |
|--|---|
|  secondary pioneer vegetation |  brackish-marsh vegetation |
|  low-marsh vegetation |  fresh grassland |
|  high-marsh vegetation | |



0 250 500 m

- Fresh grassland completely replaced ; high incidence of sec. pioneer vegetation

HIGH ELEVATION / BACK MARSH

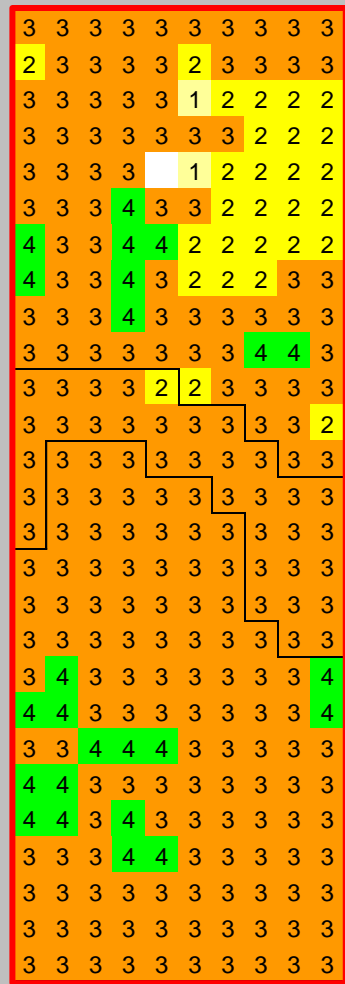


LOW ELEVATION / BACK MARSH





Vegetation development *Species mapping permanent transects*

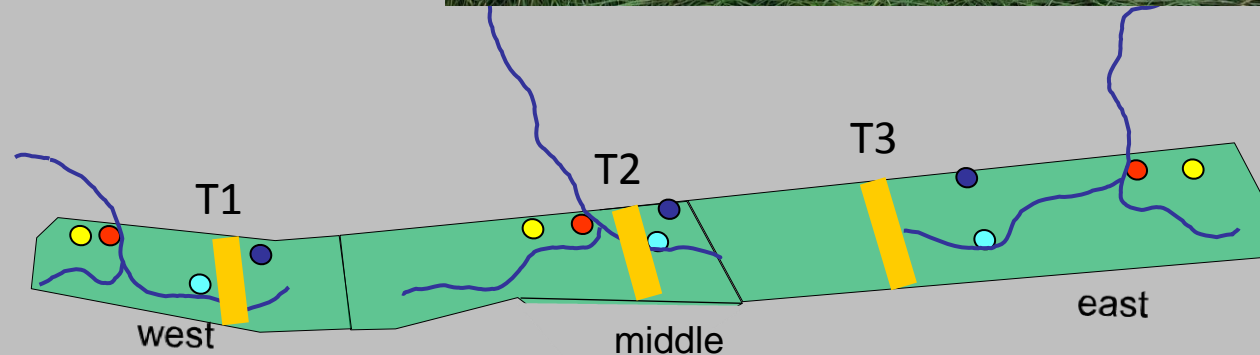


year +1

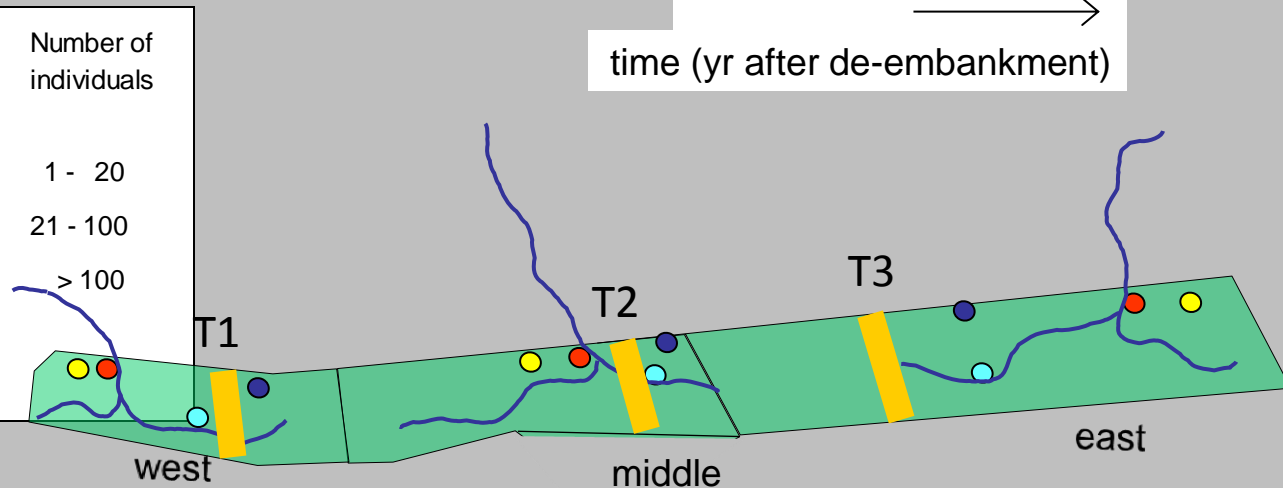
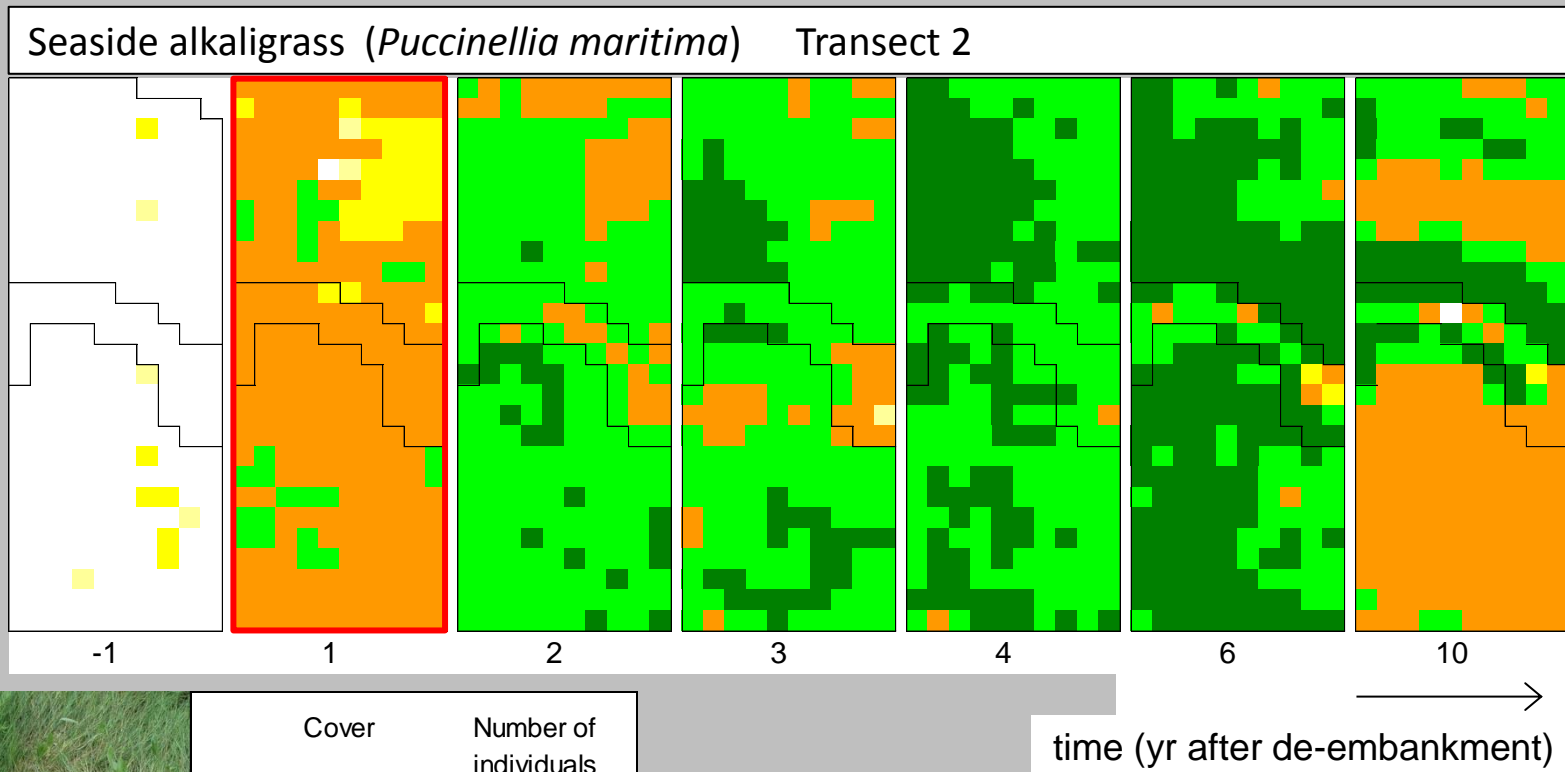
50 100 m

- Three 100-m wide transects; grid cells of 10 m × 10 m
- 40 plant species, simple abundance scale

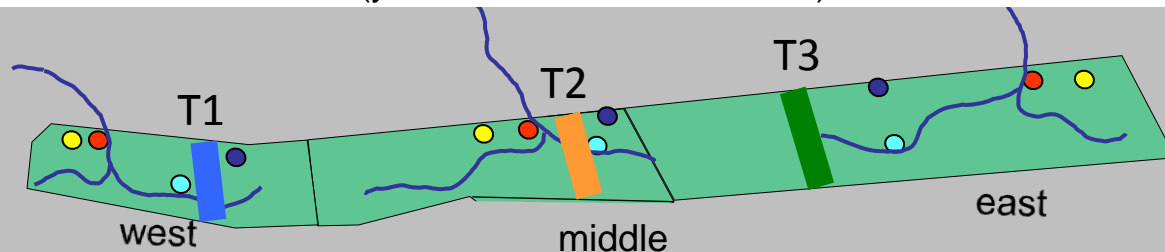
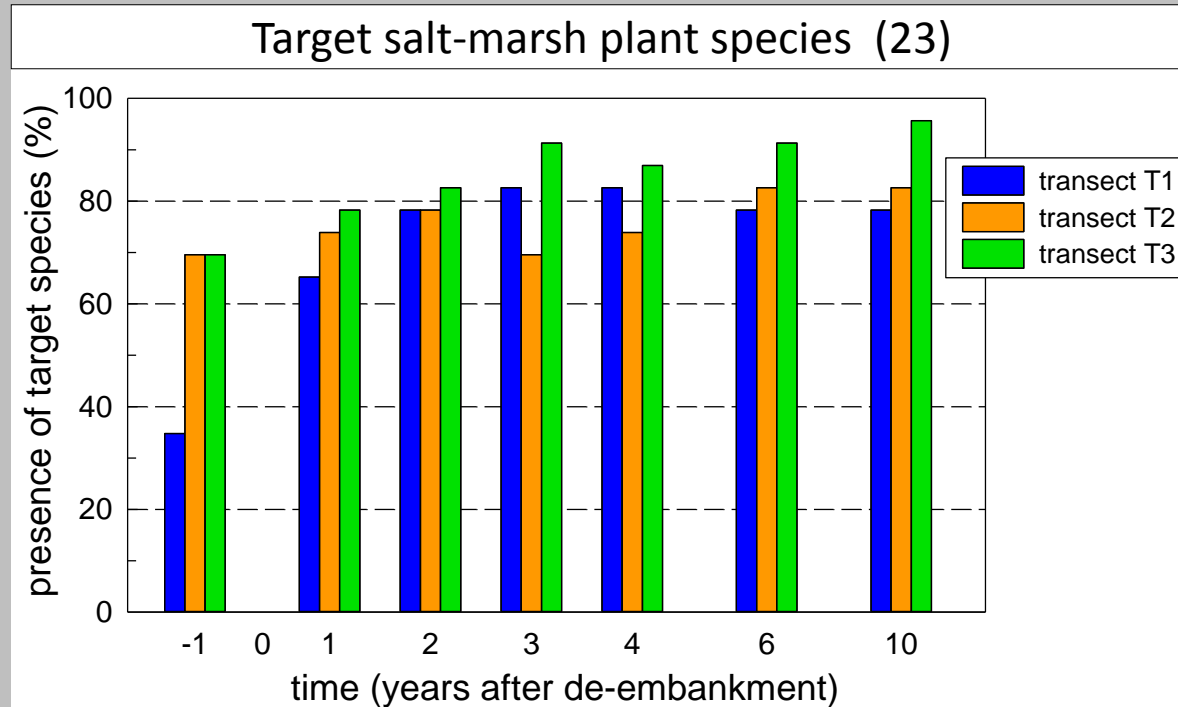
	Cover	Number of individuals
	not present	
	< 10 %	1 - 20
	< 10 %	21 - 100
	< 10 %	> 100
	10 - 50 %	
	> 50 %	



Vegetation development *Species mapping permanent transects*



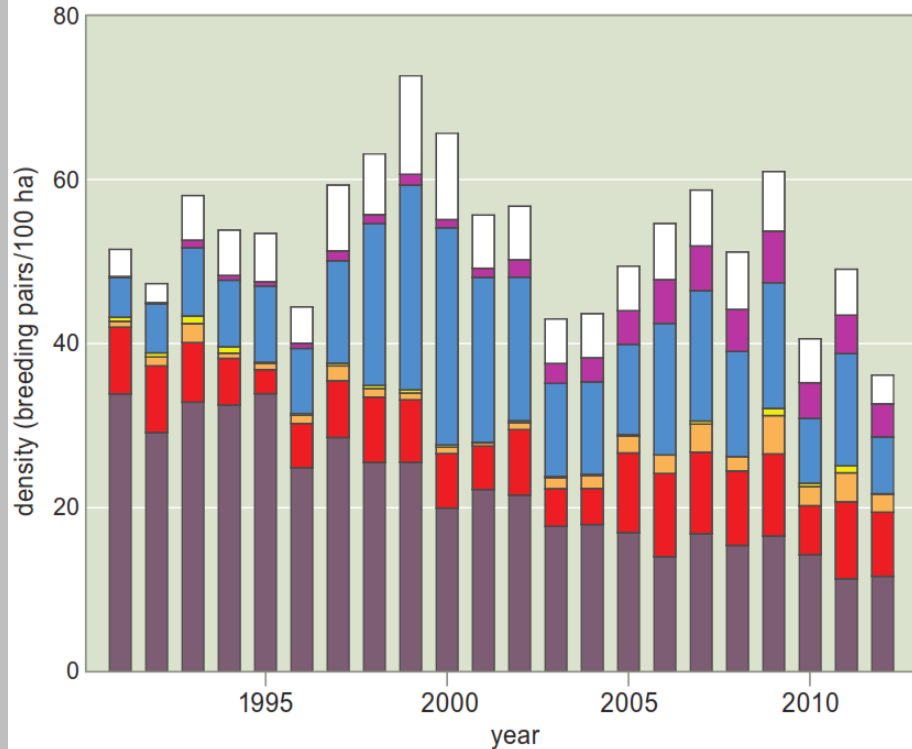
Vegetation development *Species mapping permanent transects*



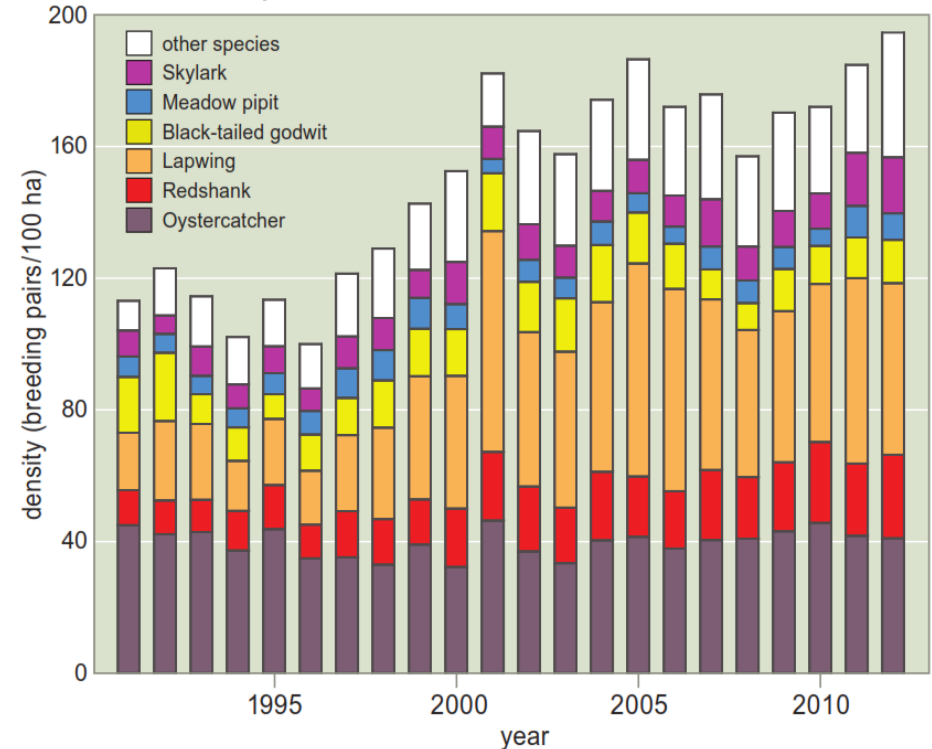
- Selection target species based on phytosociologically criteria
Almost all species present

Breeding birds

SALT MARSH



SUMMER POLDER



- Lower densities on salt marshes than in summer polders
- Conservation conflict



Evaluation / Summary

Criteria	Salt marsh (target)
Vegetation	
Suitability for livestock grazing	----->
Establishment of salt-marsh vegetation	—————>
Development of main zonation	—————>
Establishment of target plant species	—————>
Abiotics	
Accretion	—————>
Soil salinity	—————>
Creek development / drainage	————>
Gradient of local MHT level	?
Staging geese	
Food supply	————>
Utilisation during autumn	—————>
Utilisation during spring	—————>
Breeding-bird population	
Grassland birds	—————>
Colonial birds	-

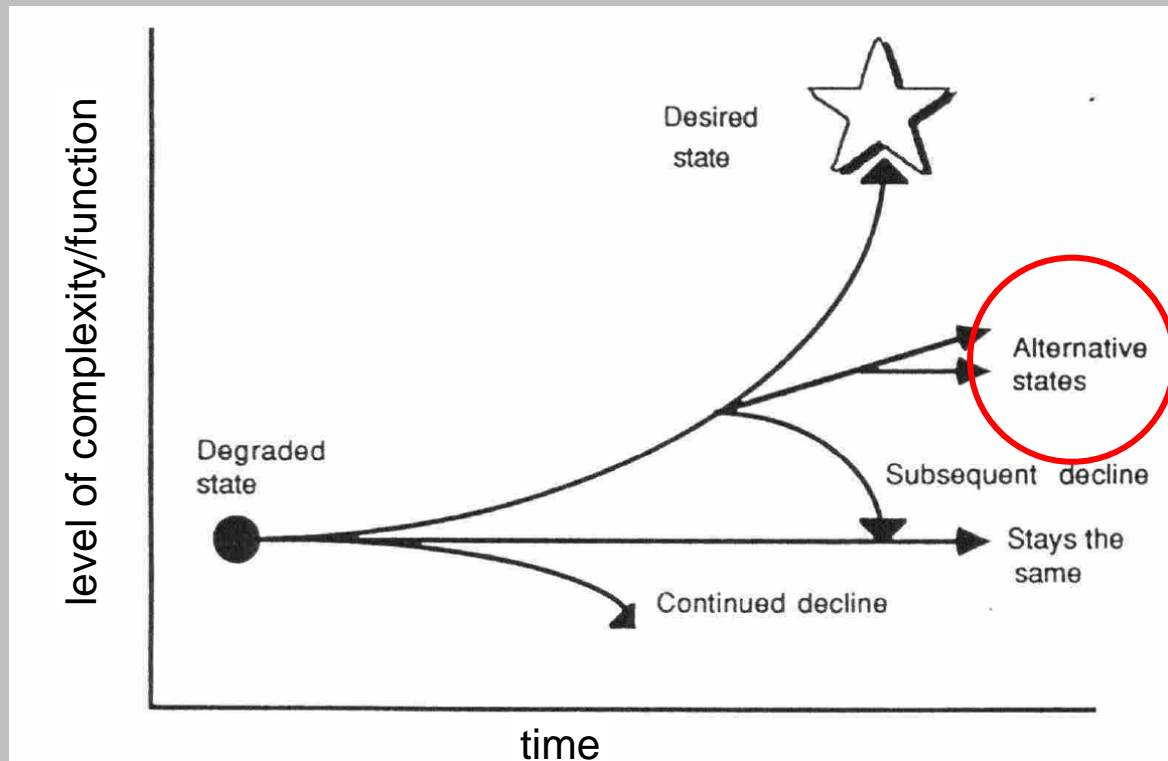
ambiguous criterium

a posteriori criteria

a posteriori criteria
restoration site < summer polders

Recommendations

- Historic reference state not attainable; consider alternative states
- Define clear restoration targets



(Hobbs & Norton 1996)

Acknowledgements



provinsje fryslân
provincie fryslân



Rijkswaterstaat



koeman en bijkerk bv
ecologisch onderzoek en advies



ECOLOGISCH ONDERZOEK



Fryske Feriening foar Fjildbiology



Prins Bernhard Cultuurfonds



Bosgroep Noord-Oost Nederland



P U C C I M A R

