Soil subsidence as a model for sea level rise

Han van Dobben
Pieter Slim

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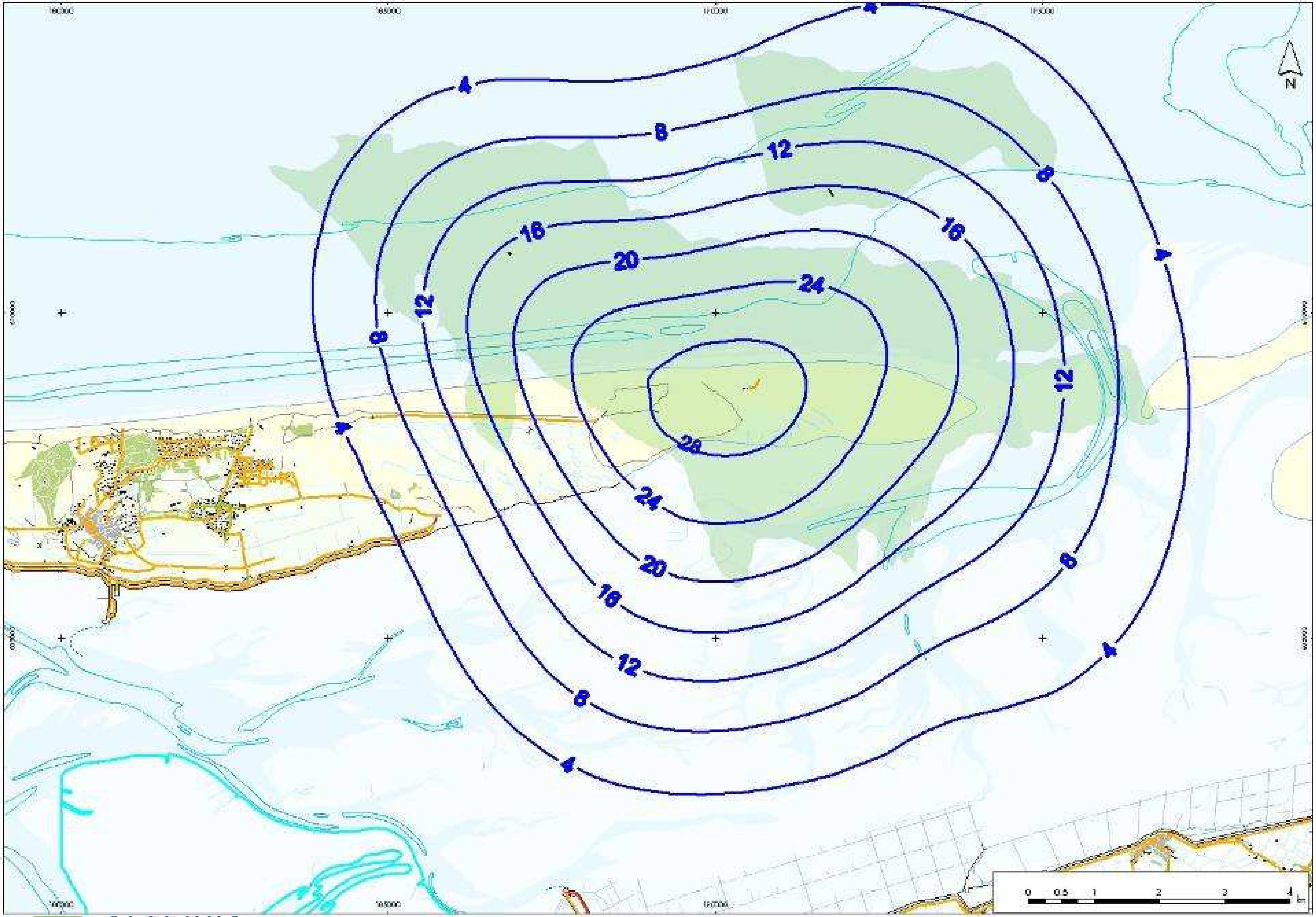
Soil subsidence

- Gas extraction at Ameland-East started in 1986
- Soil subsidence in ~circular area, radius ≈ 6 km
- Subsidence increased ~linearly over time
- Max. subsidence ~38 cm in 2008
- No coastal defence



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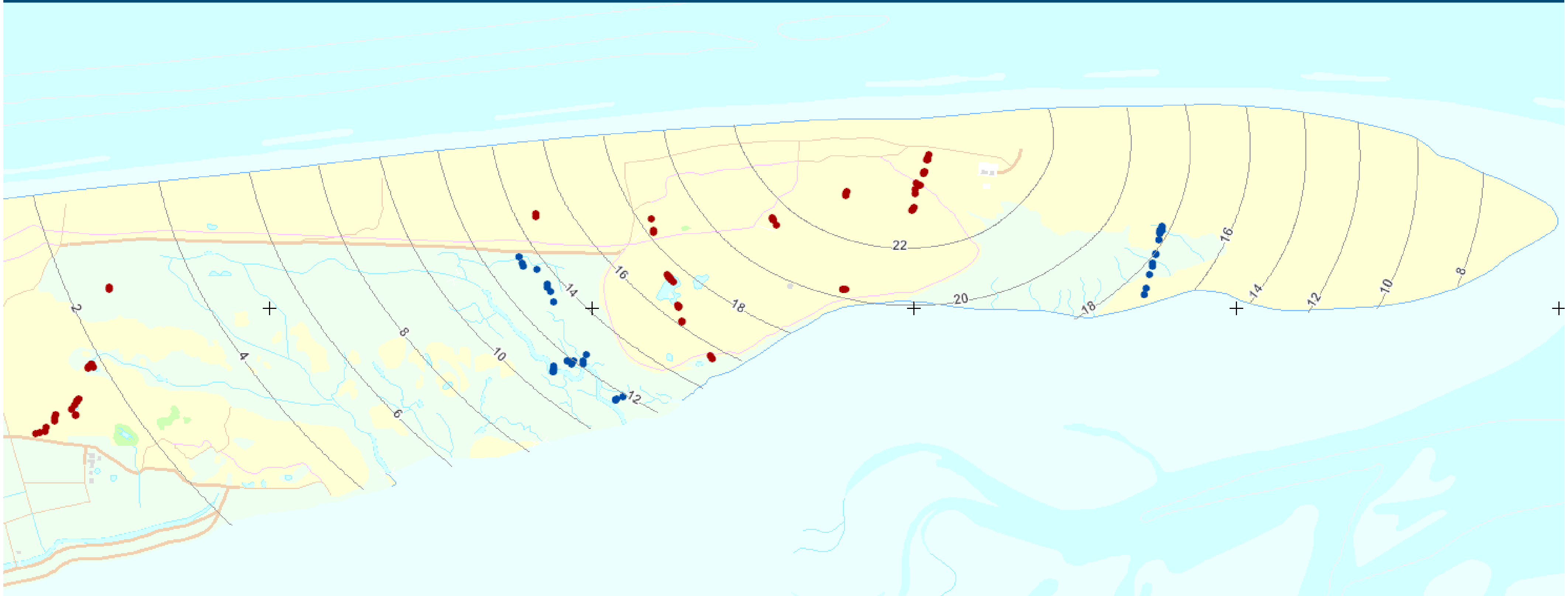
Soil subsidence is simulated sea level rise!

- Present soil subsidence at Ameland: ~38 cm
- IPCC: sea level rise ~44 cm in 2100
- Veerman: sea level rise ~100 cm in 2100
- Main concerns:
  - will natural areas be flooded, i.e. will their area decrease?
  - will there be a loss of biodiversity?

Monitoring at Ameland since 1986

- ~100 plots in 9 transects
- Vegetation relevés at various intervals (1 - 6 years)
- Elevation, groundwater level, soil chemistry, precipitation and evaporation, flooding, grazing intensity, ... included in monitoring
- Wealth of information, can be used to predict effects of future sea-level rise
- Our focus is on
  - vegetation change
  - change in elevation

Plots are arranged in transects

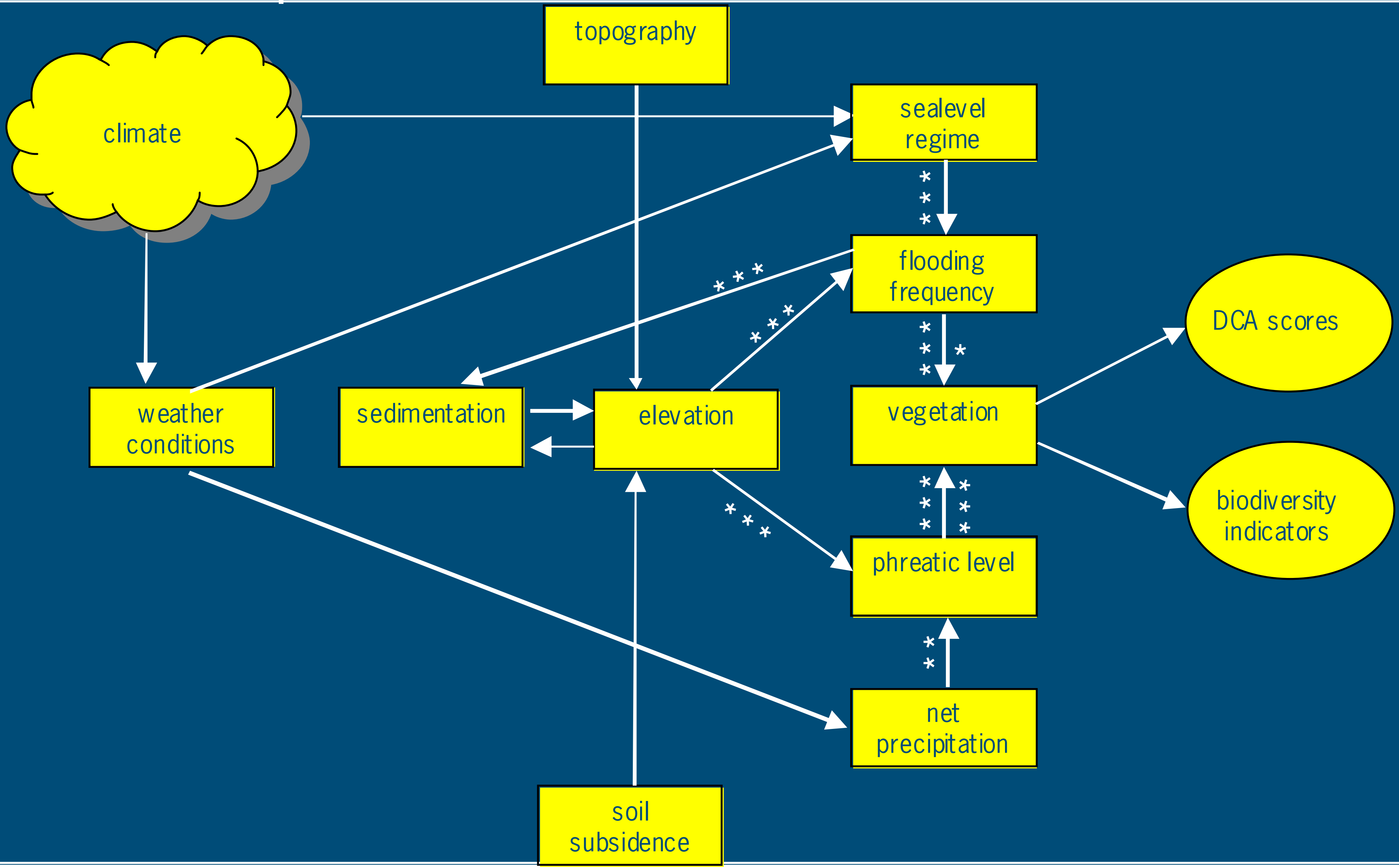


red = ‘dune’ , blue = ‘salt marsh’

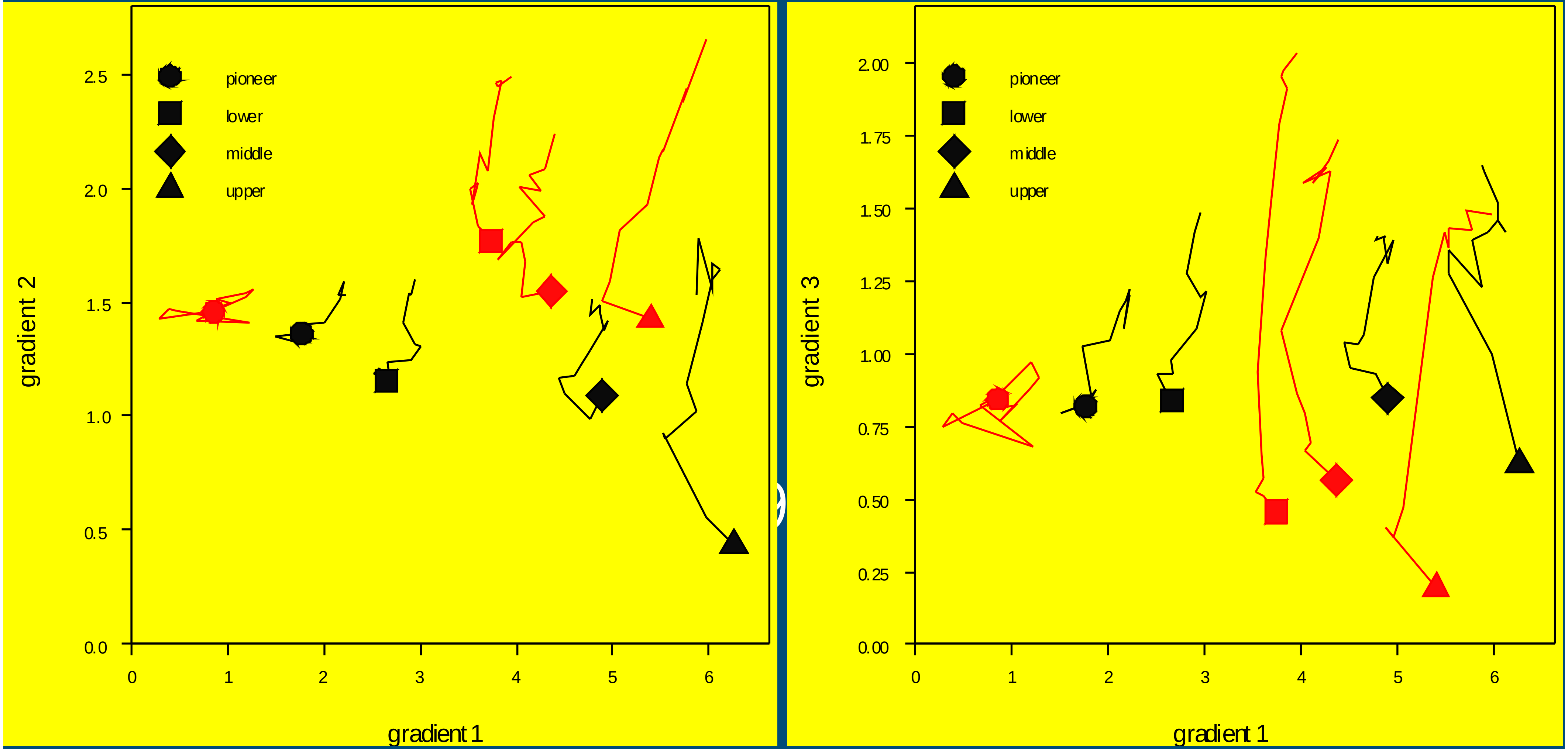
Data analysis

- Mainly by mulitivariate statistics (ordination)
- Ordination diagrams can be used to demonstrate temporal change in vegetation and its relation to environmental change

Our conceptual model...



And what happened over time



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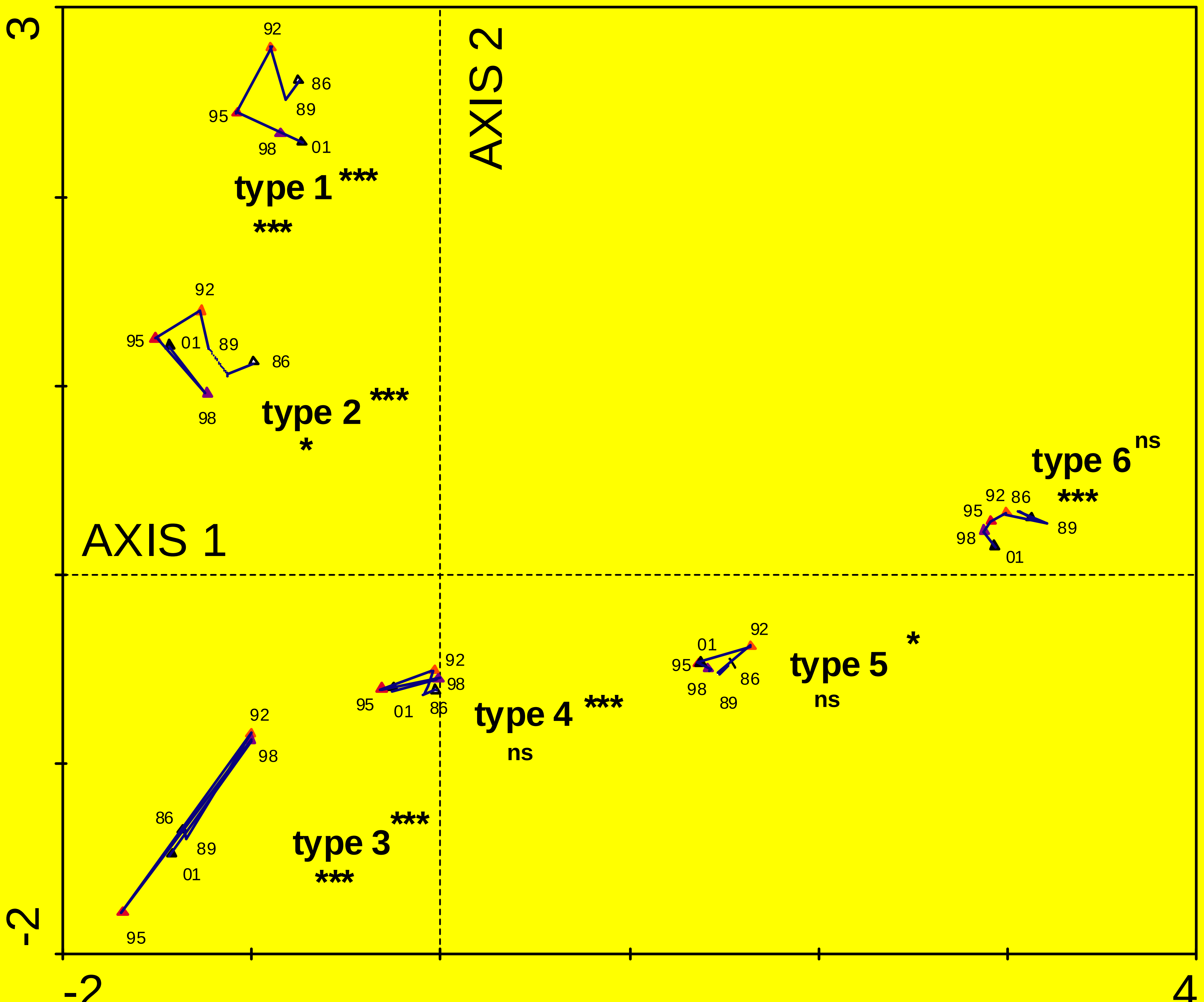

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Most important changes up to now

zone	vegetation	soil
pioneer	little change	strong sedimentation, or cliff erosion
lower salt marsh	little change	sedimentation
upper salt marsh	succession, increase of Elymus athericus	some sedimentation
dune slack, incidentally flooded	increase of salt marsh species after flooding	very little sedimentation
wet dune slack (incl. freshwater pools)	increase of annuals in dry spring	no sedimentation (accumulation of organic matter may occur)
dry dunes	succession, eutrophication	sedimentation of wind-blown sand may occur

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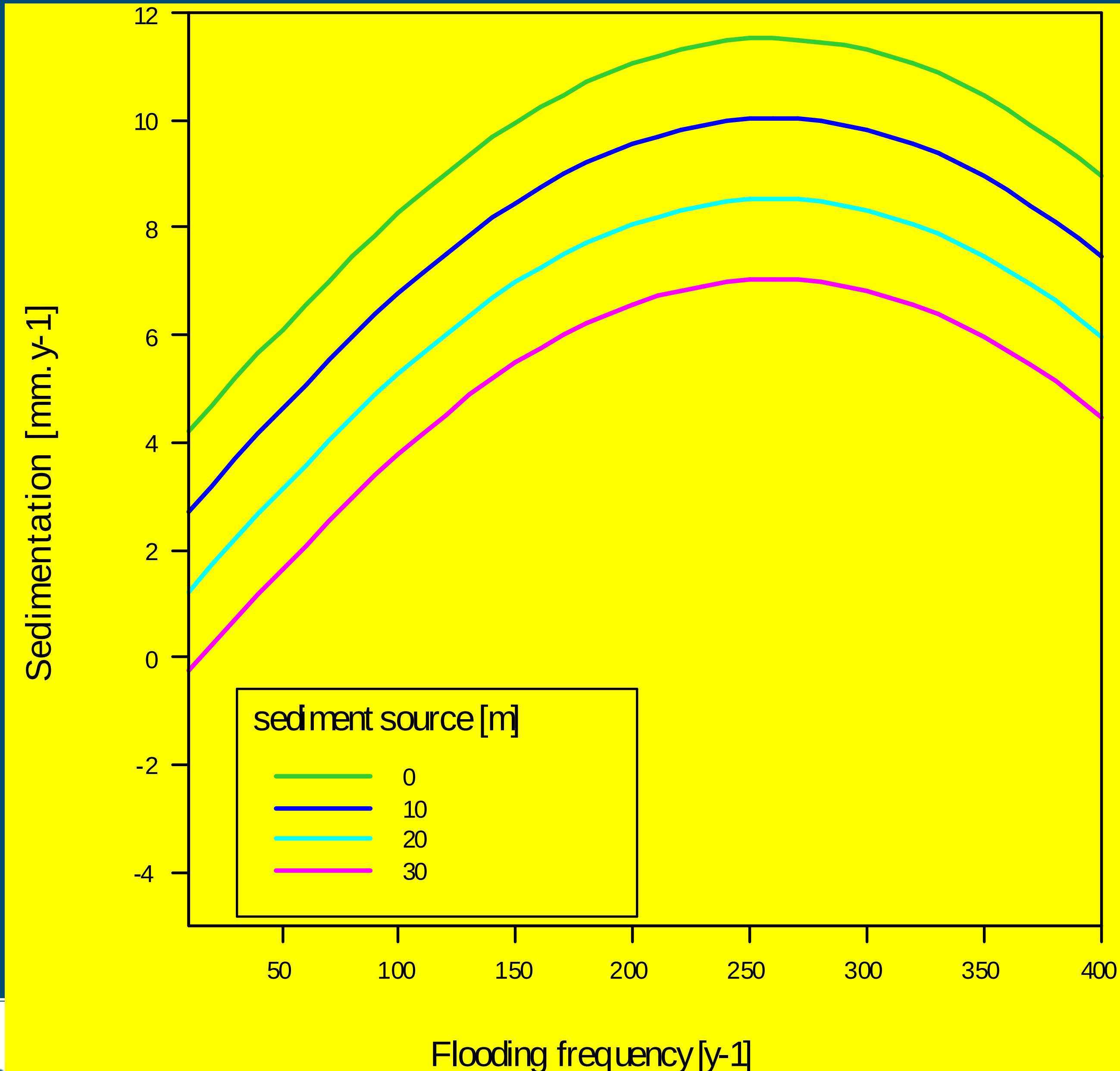
What will happen if sea level rises?

zone	with climate change…
pioneer zone	cliff erosion may increase
lower salt marsh	sedimentation increases, little change in vegetation
upper salt marsh	sedimentation increases, little change in vegetation
dune slack, incidentally flooded	vegatation changes into salt marsh
wet dune slack (incl. freshwater pools)	waterlevel increases, 'drowning' of shrub vegatation may occur
dry dunes	no change

Relation between flooding and sedimentation



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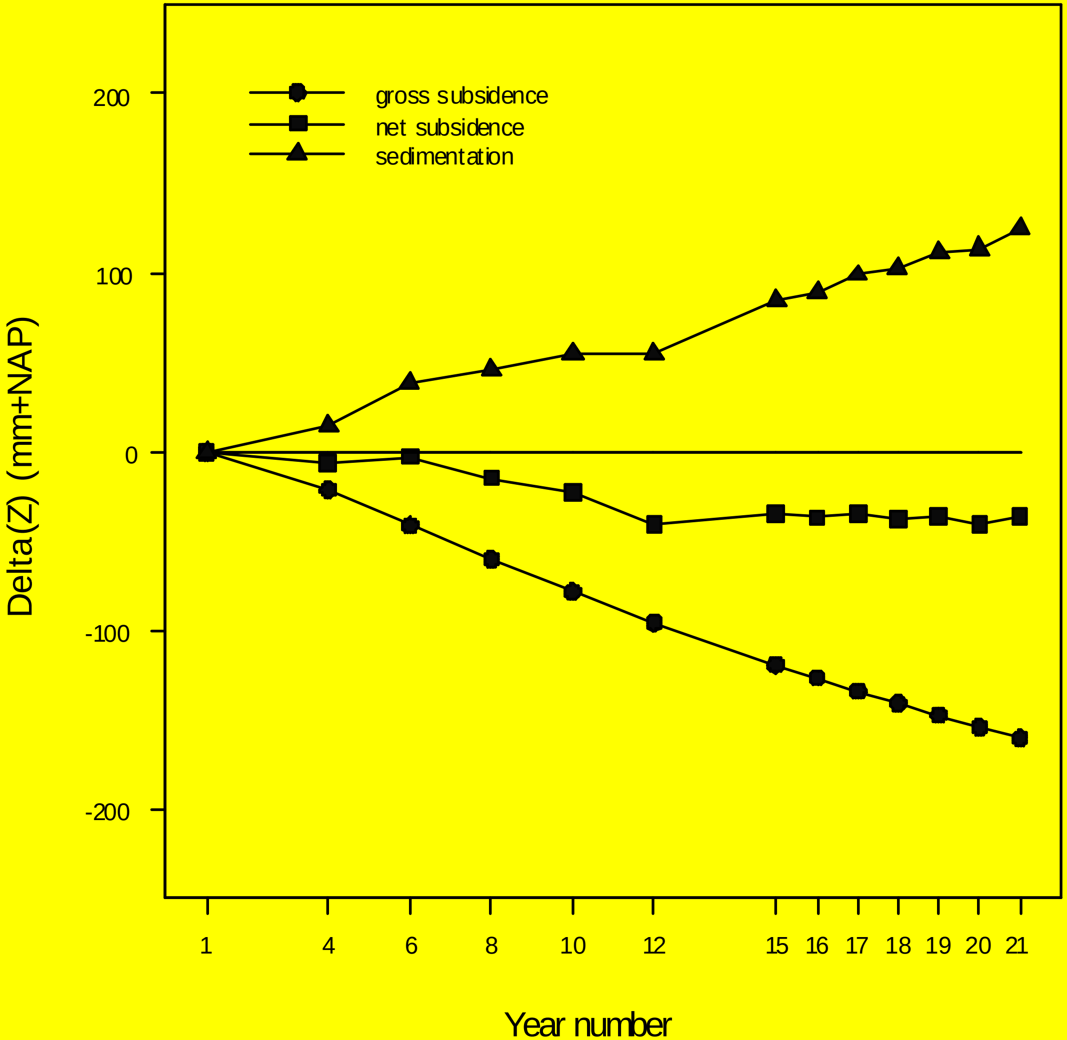
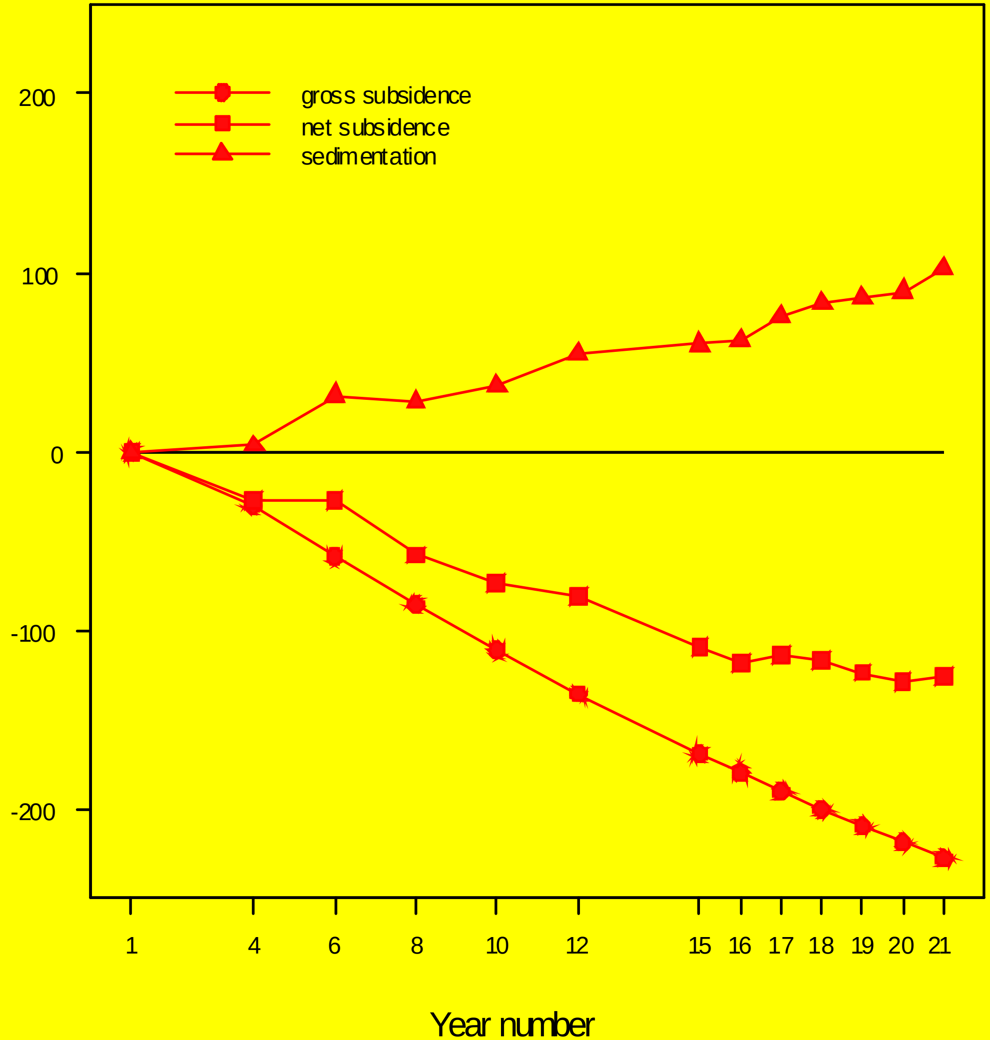
Subsidence is compensated by sedimentation





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Conclusions: sedimentation

- Total sedimentation over whole observation period:
  - Nieuwlandsreid 6.2 ± 9.0 $mm.y^{-1}$ (95% conf. interval)
  - Hon 5.1 ± 6.6 $mm.y^{-1}$ (95% conf. interval)
- Expected sea-level rise until 2100:
  - IPCC 4.4 ± 3.3 $mm.y^{-1}$ (range)
  - Veerman 8.8 ± 3.2 $mm.y^{-1}$ (range, excl. soil subsidence)

Conclusions: sea-level rise

- In pioneer zone and lower salt marsh sea-level rise will be largely compensated by sedimentation
- Present sedimentation rate is large enough to keep pace with sea-level rise according to IPCC, but not according to Veerman
- However, sedimentation increases as flooding frequency increases
- Strongest effect of sea level rise expected in wet dune slack, where sedimentation is low

Conclusions: vegetation

- Flooding-related vegetation gradient in salt marsh ('zonation') is extremely stable over time
  - this may partly explain the increase of sedimentation at higher flooding frequency
- But in dune slack, vegetation shifts along gradient as conditions change
  - with sea-level rise, this may lead to permanant changes
- Both in salt marsh, dune slack and dry dune, succession towards more eutrophic vegetation is the most prominent temporal trend

Conclusions: biodiversity

- Loss of species number, and conservancy value is mainly related to succession (both in salt marsh and dune slack)
- Succession is not related to soil subsidence, but is an autonomous process, accelerated by:
  - nitrogen deposition
  - lower cattle intensity
  - collapse of rabbit population
- Sea-level rise is expected to increase dynamics and thereby retard succession




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Monitoring will continue!

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