Population dynamics of *Hippophae rhamnoides* shrub in response of sea-level rise and insect outbreaks

Mathieu Decuyper
Robbert van den Dool , Pieter Slim, Loek Kuiters, Jeroen Jansen, Ute Sass-Klaassen

WAGENINGEN UNIVERSITY & RESEARCH
World Agroforestry

Background

- Land subsidence caused by gas extraction
- Extraction on Ameland since 1986 -> 35 cm subsidence
- Simulation of sea level rise IPCC scenario’s

Background

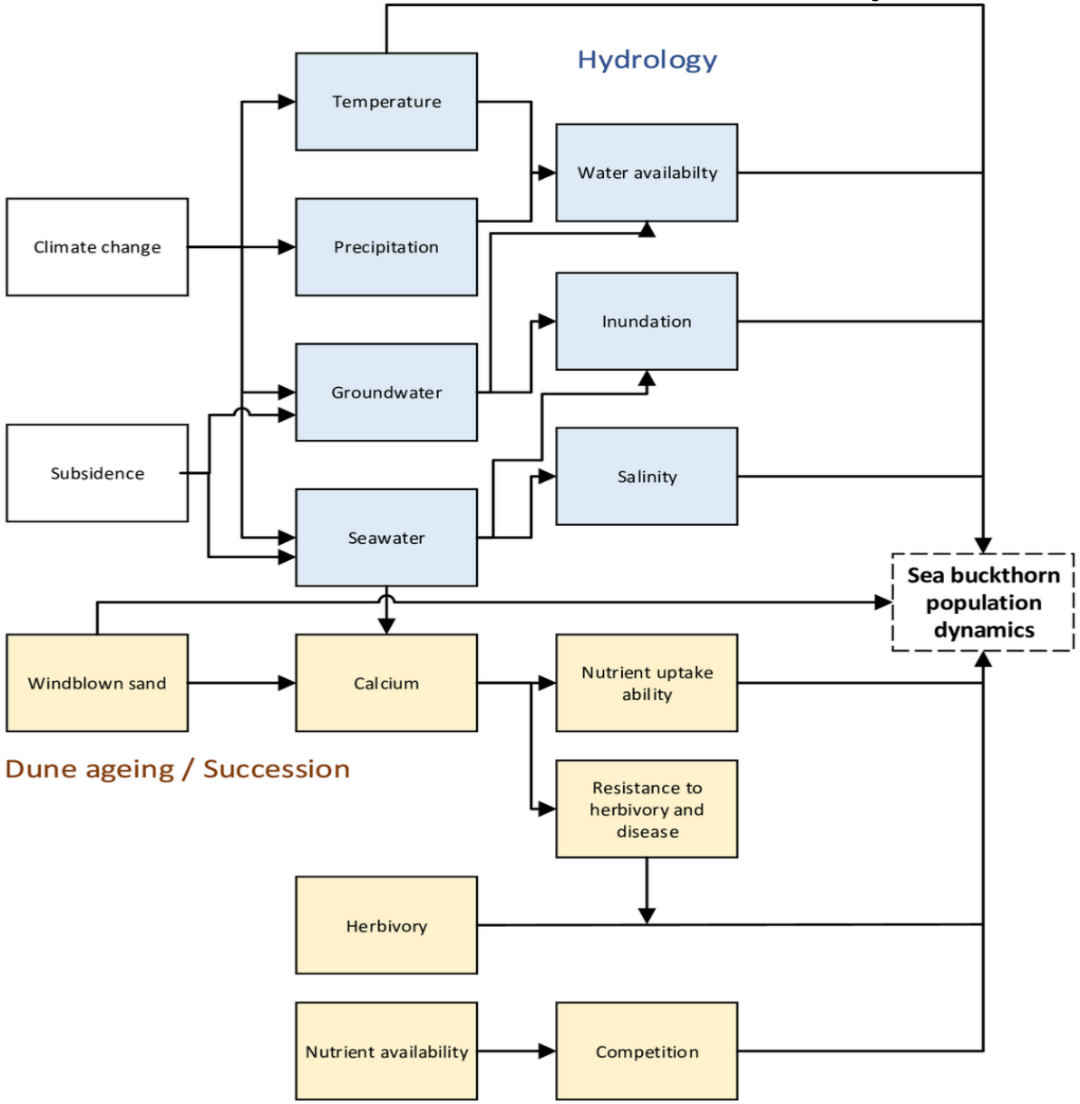
- In this study we assess the population dynamics of sea-buckthorn (*Hippophae rhamnoides* L.) in Ameland
- In Natura 2000 habitat type ‘Dunes with *Hippophae rhamnoides* (H2160)’ are protected
- Expansion of this habitat type will be at the cost of more vulnerable habitat types such as ‘Humid dune slacks (H2190)’

  and ‘Grey dunes (H2130)’

Introduction - research questions

- How did the population of sea-buckthorn on Ameland develop during decades of soil subsidence/relative sea-level rise?
- What are the main drivers of its development? What are the main factors influencing sea-buckthorn growth, and what could be the effect of soil subsidence on growth?

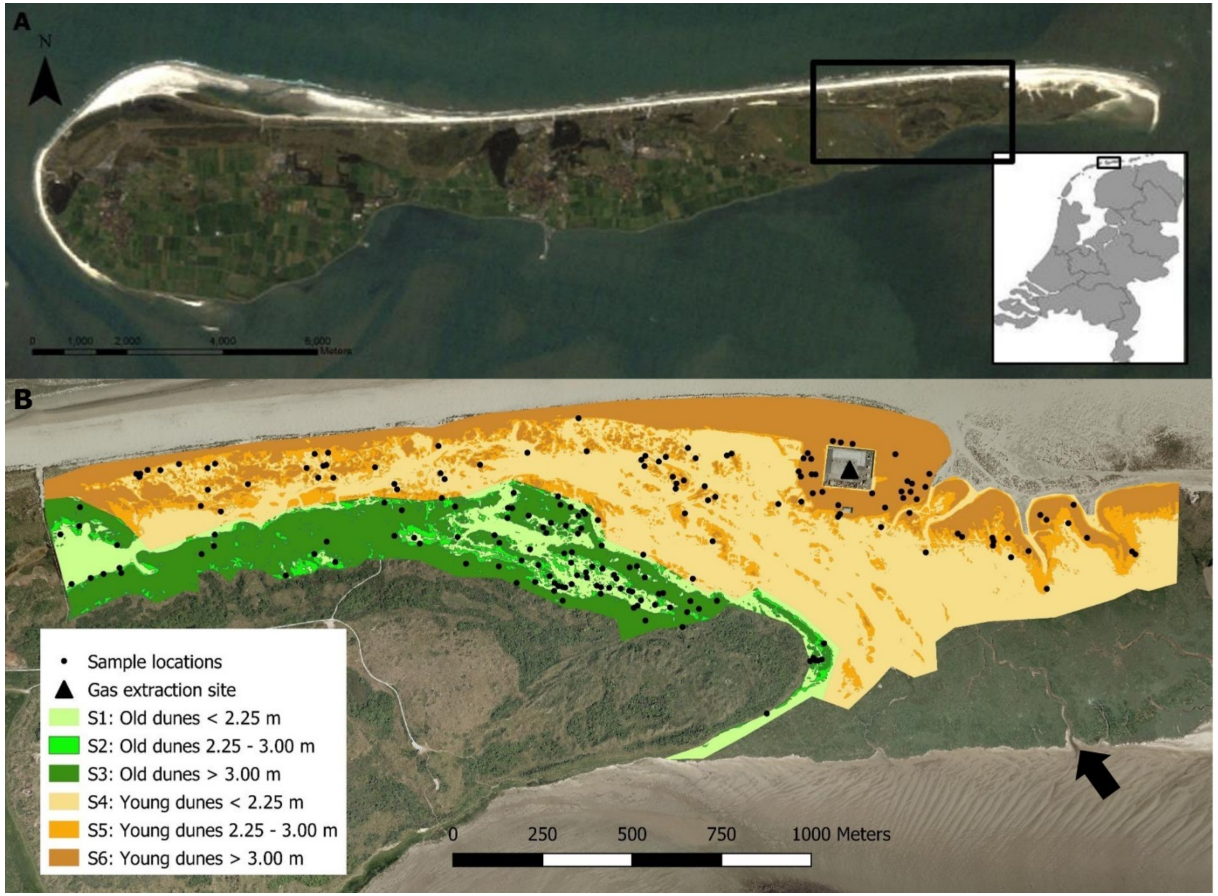
Introduction - main factors influencing sea-buckthorn development and growth



- medium tolerance to flooding and salinity
- affected by root-feeding nematodes
- succession (accumulation of soil organic matter)
- shade intolerant
- insect outbreaks (brown tail moths)

Methods

- East side of Ameland
- 6 strata covering dune height and age
- Combination of dendrochronogy & aerial photographs



Aerial photographs

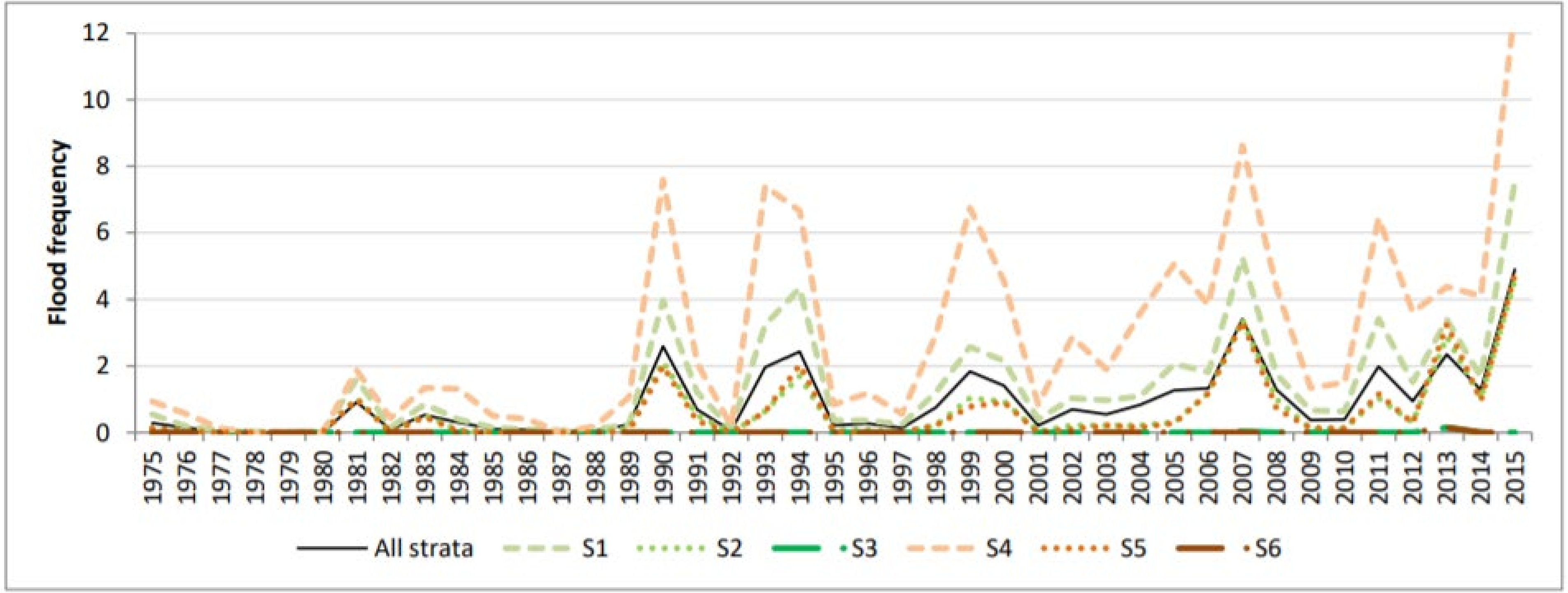
- Dutch Topographic service Cadastre
- 1959, 1986, 2000, 2009 and 2014
- Mosaicked, geo-rectified and geo-referenced (ArcGIS)
- Supervised, pixel-based image classification (ArcGIS)
- Maps and experts were consulted to determine classification training areas and visually verify the classification accuracy

Methods - sampling

- Stem segment at the base of the shrub (196 samples)
- Due to the vegetative reproduction 7m distance (pseudoreplication)
- Up to three radii were measured due to irregular eccentric tree-ring patterns
- Detrended to correct for age related growth trends using Regional Curve Standardization

Other variables

- **Sea level data:** obtained from two tide stations: Nes (1975–1981, 10 km from the study site centre) and Wierumergronden (1981–2015, 3 km from the study site centre)

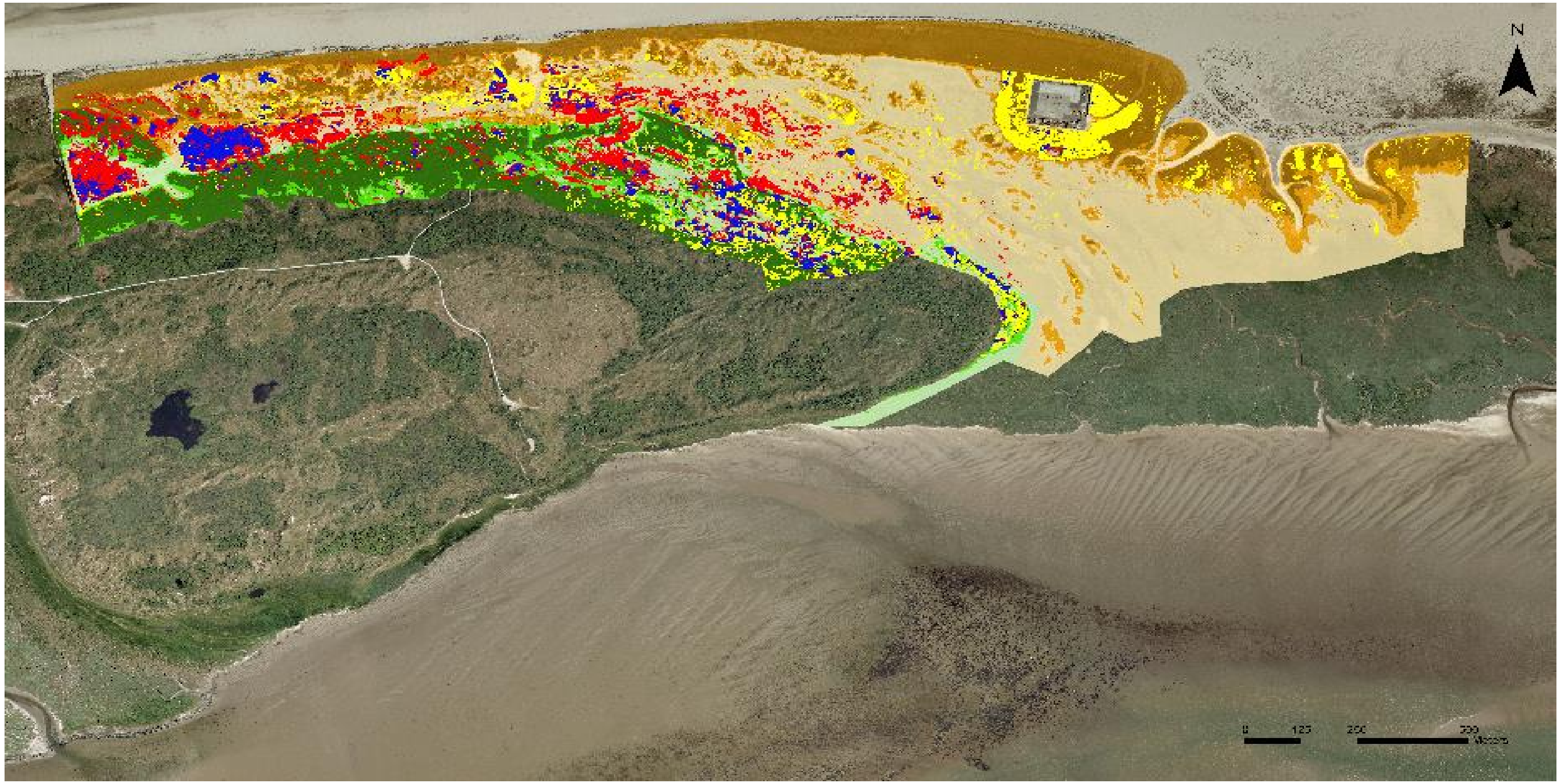


Other variables

- **Sea level data:** obtained from two tide stations: Nes (1975–1981, 10 km from the study site centre) and Wierumergronden (1981–2015, 3 km from the study site centre)
- **Groundwater.** Data on groundwater depths were gathered from six piezometers (1989–2015) within the study area and a piezometer situated just outside the study area (1975–1988).
- **Precipitation and temperature.** Monthly precipitation data was collected from the weather station on the island (KNMI—Royal Netherlands Meteorological Institute; stationNes, 1975–1995) and from the gas extraction site in the study area (1996–2015)
- **Brown-tail moth (*Euproctis chrysorrhoea* L.) outbreaks**: network of volunteer green sector professionals and the Dutch 'National Database Flora and Fauna' (NDFF) -> Leen Moraal

Years with outbreaks are: 1978–1979, 1984–1985, 1993, 1996, 2007, 2010–2011, 2014–2015

Results: vegetation cover

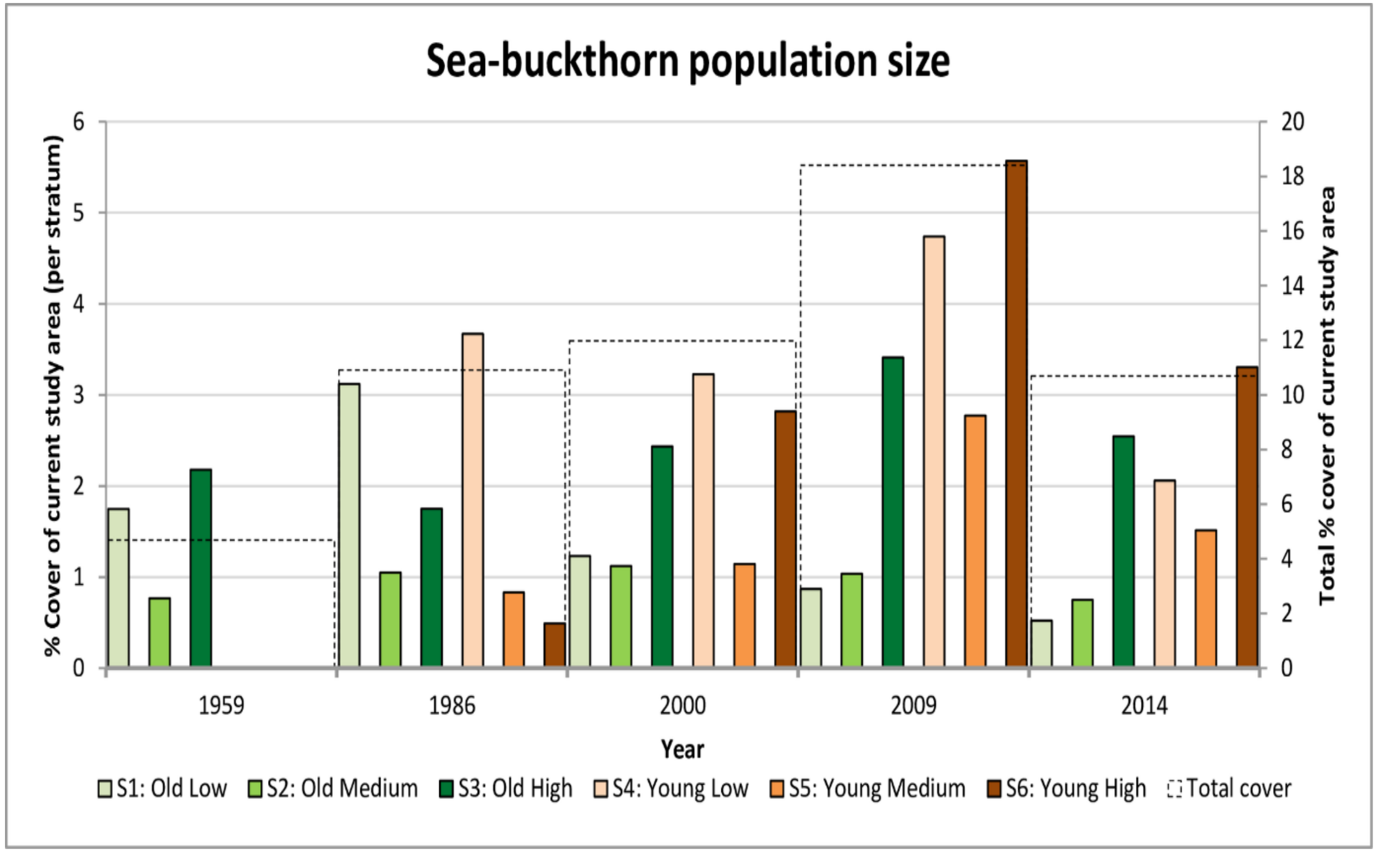


Sea-buckthorn cover changes between 1986 and 2000 (red=disappeared, yellow=appeared, blue=remained).

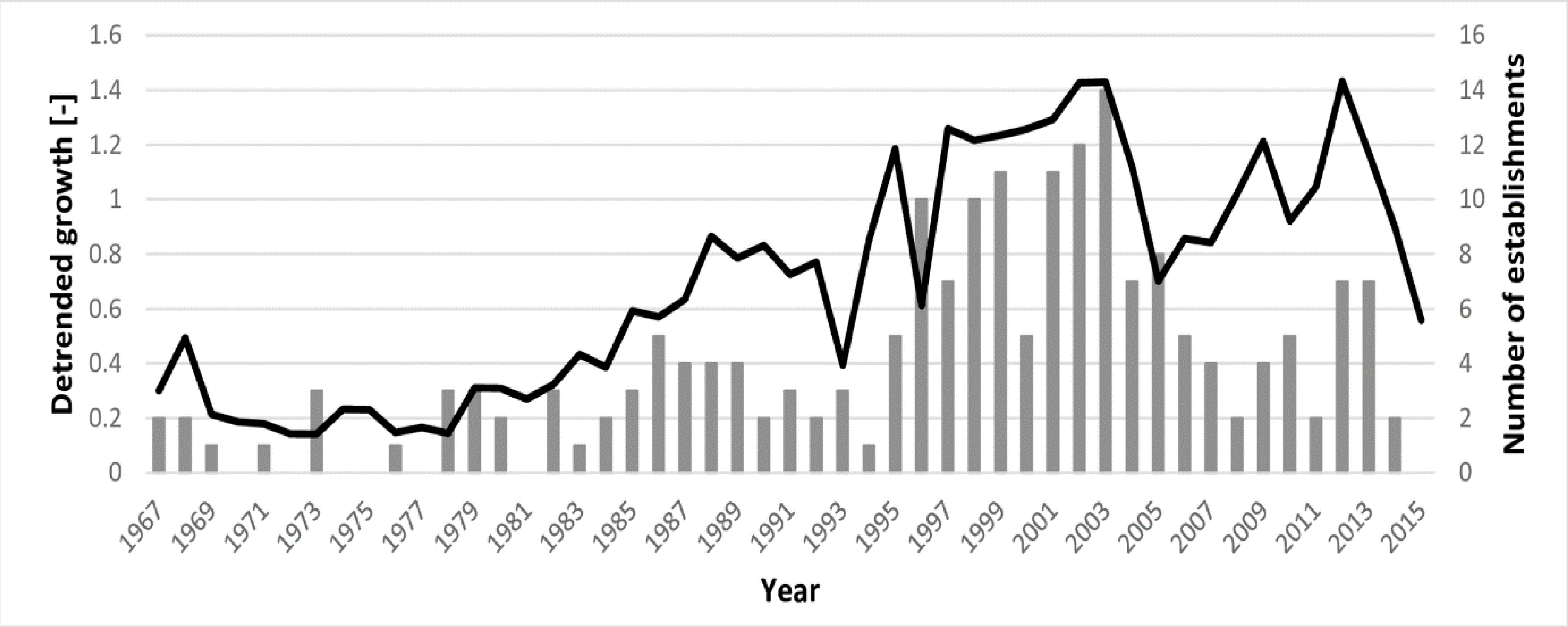
In this timeframe extensive mortality in dunes at lower elevation

Results: vegetation cover

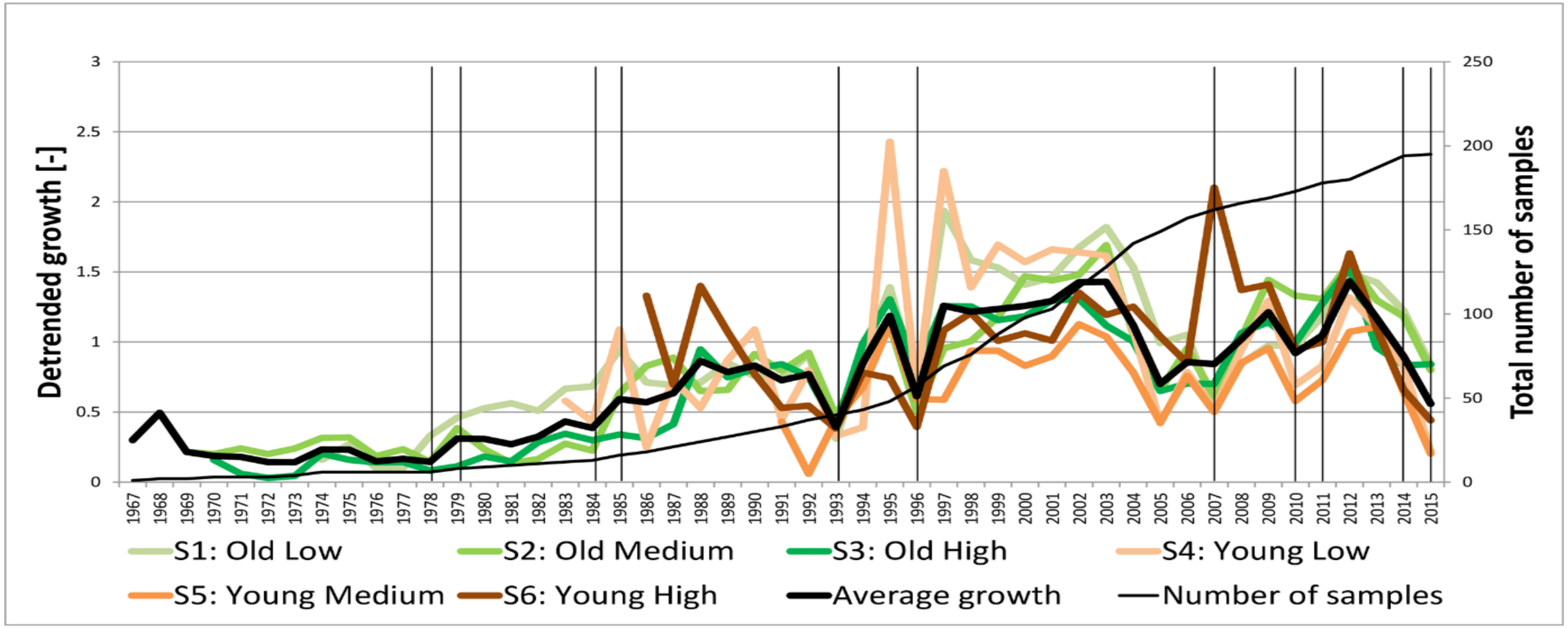
- 1959-1986: The newly formed growing foredunes reduced sand dynamics and seawater influence in the areas behind the dunes, which favored the establishment of sea-buckthorn in these low areas.
- 1986 and 2000: majority of the sea-buckthorn population was found in the younger dunes and was strongly reduced in most of the older dunes
- 2000–2009: strong increase in the younger dunes
- 2009-2014: strong overall decrease



Results: establishment and growth



Results: establishment and growth



Results: effect environmental variables on growth (mixed models)

- Insect outbreaks: negative effect in all strata
- Precipitation and temperature: no effect
- Groundwater: stronger (negative) effect in the strata at higher elevation(S3 and S6), where a lower groundwater table can lead to drought stress and a negative effect in the lower dunes due to water stress
- Sea water flooding: did not have a significant effect

Conclusions

- The population size over time (based on areal photograph classifications) indicates that succession is the main driver
  - Sea-buckthorn is a nitrogen-fixing pioneer species it has the ability to colonize marginal soils, as is the case for the newly formed dunes
  - In the older dunes the competition for light, or unfavorable conditions created by nematodes (*Longidorus* sp.)
  - In 2014 the dunes categorized as ‘young dunes’ are not that young anymore (approx. 28 years)
  - However, the drop in cover between 2009-2014 is quite steep -> other factors at play?

Conclusions

- Although increased flooding frequency over time, no significant effect found
  - related to the timing and duration of flooding events (dormancy plant)
  - only in 2015, seawater flooding occurred during the growing season, but its effect on growth is hard to disentangle from the insect outbreak
  - subsidence and subsequent higher flooding frequencies also indirectly impact the seabuckthorn vitality due to alterations in soil characteristics -> increased salinity and soil saturation
- Groundwater levels (which could be influenced by flooding – e.g. 2007) indicated water stress in the lower dunes.
- Precipitation and Temperature: no effect
- Frequency of the insect outbreaks has increased in the last decade and showed in most cases a drop in growth.

Thank you for your attention!

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RESEARCH ARTICLE

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Mathieu Decuyper[1,2,3]*, Robbert van den Dool[1,4], Pieter A. Slim[1], A. T. (Loek) Kuiters[1], Jeroen M. Jansen[5], Ute Sass-Klaassen[6]

1 Wageningen Environmental Research, Wageningen University & Research, Wageningen, The Netherlands, **2** Laboratory of Geo-Information Science and Remote Sensing, Wageningen University and Research, Wageningen, The Netherlands, **3** World Agroforestry (ICRAF), Nairobi, Kenya, **4** Centre for Crop Systems Analysis, Wageningen University and Research, Wageningen, The Netherlands, **5** Nederlandse Aardolie Maatschappij BV, Assen, The Netherlands, **6** Forest Ecology and Forest Management Group, Wageningen University and Research, Wageningen, The Netherlands

* mathieu.decuyper@wur.nl

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