MADALGO
CENTER FOR MASSIVE DATA ALGORITHMICS

Jesper E. Moeslund
Aarhus University

AU Ecoinformatics & Biodiversity Group

Danmarks Grundforskningsfond
Danish National Research Foundation

The Impacts of Coastal Squeezing on Salt-Meadow Plant Communities in Denmark

Introduction

Salt meadows are dynamic terrestrial grasslands fringing low wave-energy coast lines. They are protected by law due to their unique flora and fauna. Predictions demonstrate a likely sea-level rise ranging from 0.18 to 1.6 m by year 2100 relative to the current sea level[1,2,3]. However, little work has been done to elucidate the effects of such future sea-level rises on salt-meadow plant communities in Denmark. Traditionally, salt meadows are divided into four contiguous community zones each reflecting the local soil salinity. In response to a future sea-level rise a landward migration of these communities is likely. Nevertheless, migration will be limited upwards as the upper boundaries of the meadows typically comprise dikes or farmlands, acting as artificial barriers. Consequently, the area between the barrier and the sea including the salt meadows will shrink, a phenomenon called coastal squeezing (Fig 1). The salt-meadow zones are known to span approximately 15 cm vertically[4] emphasizing the need for very fine resolution high accuracy topographic data covering all Denmark to reveal patterns within these zones and to evaluate general relationships between elevation and vegetation. The aim of this study was to recover the known relationships between elevation and vegetation and to evaluate the effect of spatial resolution on these relationships. Based on this we quantify possible consequences of coastal squeezing on Danish salt meadows.

Jesper Erenskjold Moeslund[1,2,3], Lars Arge[2], Peder Klith Bøcher[3], Bettina Nygaard[4], Jens-Christian Svenning[1].

[1] Ecoinformatics and Biodiversity Group, Department of Biological Sciences, Aarhus University.
[2] MADALGO - Center for Massive Data Algorithmics, Aarhus University.
[3] Faculty of Agricultural Science, Aarhus University .
[4] National Environmental Research Institute, Aarhus University.

References

[1] IPCC (2007). Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon *et al.* (eds)]. Cambridge University Press
[2] Horton *et al.* (2008). *Sea Level Rise Projections for Current Generation CGCMs based on the Semi-Empirical Method.* Geophysical Research Letters 35, L02715.
[3] Grinsted *et al.* (2009). *Reconstructing Sea Level from Paleo and Projected Temperatures 200 to 2100 AD.* Climate Dynamics 34, 461.
[4] Sadro *et al.* (2007). *Characterizing Patterns of Plant Distribution in a Southern California Salt Marsh Using Remotely Sensed Topographic and Hyperspectral Data and Local Tidal Fluctuations.* Remote Sensing of Environment 110, 226.

Methods

Plant data from 27 salt meadows throughout Denmark comprising 1118 sample sites were obtained from the NOVANA program. A measure quantifying the average influence of salt was calculated for every sample site. Topographic data was extracted from four Digital Elevation Models (DEM) in various spatial resolutions (Fig 2). Regression models relating dominance of salt-tolerant species to elevation above sea level were developed. Using current and five future sea-level-rise (SLR) scenarios these models were integrated using GIS to predict current and future salt-meadow plant community structure. We used five SLR scenarios based on the A2 and the A1FI climate change scenarios[1] (Fig 3).

Concept – Coastal Squeezing

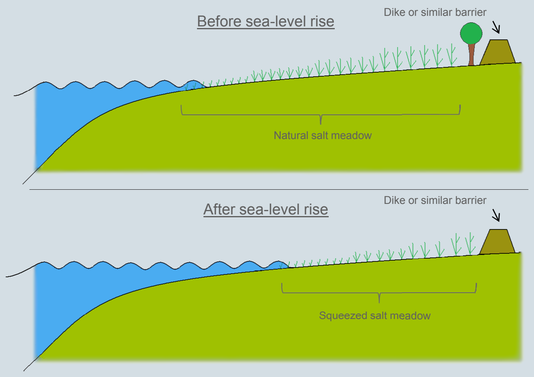

Figure 1. In presence of a dike or a similar barrier the coastal plant communities are unlikely to be able to migrate landwards in case of sea-level rise. This entails a squeezing of especially the uppermost vegetation zones.

Results

The regressions documented a locality-dependent decreasing dominance of salt-tolerant species with elevation ($R^2_{adj} \approx 67\%$). The strength of these relationships clearly depended on the spatial resolution and the type of the underlying DEM (Fig 2). When projected onto the five sea-level-rise scenarios, the regressions predicted:

- A pronounced loss of salt-meadow area (not shown).
- The middle and upper salt meadows will experience the most severe losses, while the lower salt meadows will expand (Fig. 3).

Results

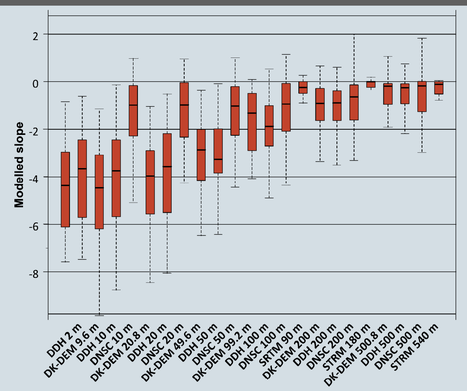

Figure 2. The relationship (slope) between elevation and vegetation weakened with decreasing spatial resolution, with the LIDAR-based DEMs yielding the strongest relationships.

Conclusion

To reveal and generalize salt-meadow elevation-vegetation relationships very fine spatial resolution DEMs are needed. Future sea-level rises constitute a threat to salt-meadow associated biodiversity in Denmark:

- Sea-level rise will cause a restructuring of the salt-meadow plant communities.
- The pronounced loss of total salt meadow area is likely to entail a drastic reduction or even the loss of species or species populations characteristic to salt meadows.
- As the zones primarily lost are the middle and upper salt meadows the species known to inhabit these areas are especially at risk from future sea-level rise.

The Salt Meadow

Photo credits: © J. E. Moeslund

Figure 3. A case study: The response of the four vegetation zones to five sea-level-rise scenarios in a salt meadow on the island Mandø in the Wadden Sea, Western Jutland. Especially the middle and upper salt meadow will shrink, while the lower salt meadow will gain area.