Universität Rostock Traditio et Innovatio

Aus der Professur für Landschaftsökologie und Standortkunde
der Agrar- und Umweltwissenschaftlichen Fakultät

Thesen der Dissertation

Ecosystem services in coastal Phragmites wetlands at the southern Baltic Sea: Nutrient regulation, water purification and erosion control

zur Erlangung des akademischen Grades
Doktor der Agrarwissenschaften (Dr. agr.)
an der Agrar- und Umweltwissenschaftlichen Fakultät
der Universität Rostock

vorgelegt von
Diplom Geographin Svenja Karstens
wohnhaft in Rostock

Verteidigung am 05. Mai 2017

Rationale and objectives

- Coastal wetlands can provide a variety of ecosystem services. In order to understand how ecosystem services are supplied and might change under human influences the biological, physical and chemical processes need to be studied.

- The Baltic Sea region has become an important economic driver and anthropogenic stresses on the coasts continue to rise. Eutrophication and hypoxia remain major environmental challenges. Coastal wetlands with their ability to buffer nutrients have the potential to counteract eutrophication.

- Coastal wetlands are still under-studied. The research of this thesis took therefore place directly within coastal wetlands at the Darss-Zingst Bodden Chain, a lagoon system at the southern Baltic Sea.

- The objectives were to analyze (1) how regulating ecosystem services in coastal wetlands are supplied, (2) how they are interrelated, and (3) how physical, biological and chemical processes govern them. The focus was on following regulating services: erosion control, water purification and nutrient regulation.

Materials and Methods

- In order to investigate the role of wetlands as 'pollutant buffers' sediment samples in different wetland zones at two contrasting study sites were analyzed for their heavy metal (Mn, Fe, Cu, Zn, Al, Co, Cr, Ni) and macronutrient (C, N, P, K, Mg, Ca, S) concentrations.

- To gain insights into the processes of phosphorus (im)mobilization, laboratory experiments and field work were combined. Soluble reactive phosphorus concentrations, oxygen saturation, pH, redox potential, sulfate concentrations, conductivity and temperature were measured monthly in the wetland waters. Equilibrium sorption isotherms were assessed by batch incubation experiments to evaluate the phosphorus sorption capacity of sediments under oxic conditions. Additionally, turbulent kinetic energy was measured in the wetland waters because hydrodynamics influence the oxygen uptake by sediments.

- Changes of surface elevation and microtopography were measured bimonthly at five different locations within a dyked coastal wetland using a Surface-Elevation Table (SET). The SET consists of benchmark pipes permanently installed in the ground and a portable leveling device that can be attached to each benchmark pipe. Additionally, wetland expansion between 1953 and 2013 was analyzed.

Results

- Land use activities adjacent to coastal wetlands have a large impact on the sediment composition:
  - Heavy metal concentrations were significantly elevated in the wetland zone that borders directly an arable field where crop production with fertilizer application took place at least since the 1950ies.
  - In contrast to this, heavy metal concentrations were low in the coastal wetland that is confined by a dyke with sheep grazing in the hinterland.
  - Influences from the sea on sediment compositions were minor compared to the influences from land.

- The relationships between oxygen saturation, water level and soluble reactive phosphorus in the wetland waters showed a threshold-type behavior. Oxygen shortages may not be caused by external nutrient input, but by hydrodynamic calm conditions with stagnant waters.

- Sorption experiments under aerobic conditions confirmed that the sediments are capable of immobilizing large amounts of phosphorus within short timeframes if oxygen supply is sufficient. Once the oxidized sediment surface layer vanished, phosphorus was released into the water column.

- None of the SET-measuring locations in the dyked wetland could currently keep up with the local sea level rise. At the wetland fringe erosion prevailed and in the wetland interior the high sediment organic matter content enhanced compaction processes.

Conclusions

- In order to know how regulating services are supplied, it is important to identify the specific site conditions of a coastal wetland. It has to be clear whether storage capacities have been reached, how the wetland and the adjacent hinterland have been used in the past, how freely water exchange can take place or if the wetland is expanding or retreating.

- *Phragmites* wetlands at the Darss-Zingst Bodden Chain can be 'water purification systems' retaining excess macronutrients and heavy metals in the sediments. However, it is possible that redox-sensitive elements are released from the sediments in the temporarily anoxic basin zone. Future developments should be monitored closely to avoid breakthroughs due to exceeded carrying capacities.

- Wetland evolution in dyked environments could be threatened due to the suppression of sediment supply from land.

- Regulating services can sustain and support each other. A wetland that traps particles and suppresses erosion serves well as an active 'pollutant buffer' storing excess nutrients or heavy metals in retained sediments.

- Sustainable reed harvest that aims to remove pollutants or flooding corridors that enhance the aeration of wetland waters do not have to be in conflict with erosion regulation as long as a 'greenbelt' of reed with no harvest is maintained between the adjacent hinterland and the wetland.