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Soil-vegetation interactions in coastal landscapes - erosion reduction as ecosystem service in the context of integrated coastal zone management

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The joint-research project "Gute Küste Niedersachsen" is a multidisciplinary approach across spatial and temporal scales investigating ecosystem services for coastal protection. Current national coastal protection concepts predominantly target flood protection and rarely consider additional benefits to coastal ecosystems or vice versa. How maritime landscapes, such as salt marshes, coastal white dunes or a diversification of dike vegetation, can be integrated into approaches of coastal protection without compromising protection levels is the driving question in "Gute Küste Niedersachsen" and heeds recent European Framework directives calls for the restoration of a good ecological status. An in-depth understanding of dynamics within coastal ecosystems, covering eco-hydrodynamics and eco-geomorphodynamics is developed in real world laboratories at the German North Sea coast, as part of the project.
Systematic field observations in collaboration between biologists, geo-ecologists and coastal engineers are conducted to identify seasonal changes of vegetation regarding zonation, height, root length density and bio-mechanical parameters like bending stiffness or tensile strength. The differences of bio-mechanical vegetation traits from specific plant species, e.g. the European beach grass *Ammophila arenaria*, will indicate differences in bio-stabilization states.
Complementary field data of topography and soil parameters, e.g. shear and pull-out resistance, among other parameters, are acquired, employing specifically developed instrumentation like the DiCoastar for automatic and digital measurements of shear resistance over rotation angle. Additionally, values such as water and biomass content obtained from soil samples help to elucidate erosion stability of coastal ecosystems.
Field campaigns are focused on two real world laboratories, the tidal barrier island of Spiekeroog, Germany, and a coastal mainland section. Spiekeroog offers a variety of dune systems exposed to divergent environmental conditions such as established and recently developing natural dunes at the north-eastern coast, dunes that are used for coastal protection at the north-western coast, dunes in combination with a sea wall that are already supported by sand nourishment at the western coast or established dunes along the south-western tip of the island. Furthermore, the island holds a unique setting with an engineered dune, which was created to integrate a dike

system into the landscape. This offers a one-of-a-kind opportunity to investigate differences between six different dune system types within close proximity regarding their vegetation bound bio-mechanical properties and linked soil-bound erosion resistance.
In addition, Spiekeroog offers an abandoned dike line, for which a sectional re-planting is rolled out with alternative seed combinations for ecologically upgrading grass dikes and boost plant diversity while coastal protection is maintained. A direct comparison against a sea dike is made at the second real world laboratory situated at the adjacent mainland coast. This setting facilitates the comparison between different biological revetment types and their respective performance in coastal protection regarding wave-soil-vegetation interactions.
In a subsequent step, the extensive data set will be used to develop surrogate plant models and mimic nature in hydraulic laboratories and numerical simulations to project system performance under climate change scenarios. Finally, technical guidance as well as policy recommendations will be derived for enhancing ecosystem services of artificial structures for coastal protection.