Is an Old Dune a More Resilient Dune? Assessing the Importance of Ecological History in Coastal Protection from Storms and Sea-Level Rise

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Coastal foredunes represent the first line of defense against ocean-side flooding and are increasingly built to enhance coastal protection and resilience. However, constructed dunes lack significant internal architecture relative to slowly developed, naturally built dunes. The internal biotic structure of dunes, including roots and vesicular-arbuscular mychorrhizal fungi, have been recognized as buffering storm-induced impacts through mechanical strengthening of the dune. The absence of internal biomass within constructed dunes potentially leaves them more vulnerable to the impacts of storms and longer-term coastal changes. However, the dynamics of a sandy, mostly unvegetated dune also allows for more active sediment transport which has the potential for milder slopes which reduce total water levels during future storm events and which may promote faster post-storm recovery. These complex eco-morphodynamic feedbacks therefore have implications well beyond the storm-time scale. Here, the role of these biotic processes of coastal dunes are explored along the Outer Banks, North Carolina.

To explore these feedbacks, this work involves collection and analysis of high-resolution mobile terrestrial lidar datasets to explore regional-scale spatio-temporal ecological characteristics and morphology change. Remote-sensing measurements will be complemented by internal biomass sampling and characterization through an intensive sediment coring program and *in-situ* monitoring through use of a minirhizotron camera. With these field observations this work aims to quantify (1) the role of internal biomass in reducing impacts during storms and (2) the mechanisms by which the mechanical strengthening from internal biomass alters the style and rate of scarp slumping.

This multi-disciplinary project will result in new parameterizations for the ecological role on dune dynamics, which will be incorporated into existing models of subaerial and subaqueous morphology change in coastal environments. These improved numerical models will allow for the exploration of specific, applied research and coastal management questions that bridge timescales associated with short-term dune dynamics to those associated with barrier-system response to sea-level rise. The updated numerical models will be tested against field data that spans times scales of days to decades from the U.S. Army Corps of Engineers Field Research Facility (Duck, NC) and from across the broader Outer Banks. Applied and exploratory numerical modeling simulations will explore how the internal biomass architecture of the dune alters coastal evolution on scales of days to centuries, with a primary goal of considering how modern management decisions have future implications. These exploratory works include assessing tradeoffs between natural dune dynamics (*e.g.*, promoting internal biomass) and the instant flood protection services provided by a constructed dune, which has direct application for our coastal management partners. This work will be completed in close coordination with local to federal management partners, including regular input from a management-transition advisory group.