Wind Tunnel Tests of How Plants Feedback on Dune Shape

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Along the US East and Gulf coast *Ammophila breviligulata, Carex kobomugi, Panicum amarum, Uniola paniculata,* and *Spartina patens* are the dominant plant species stabilizing foredunes.

Background: Beach-dune systems are natural buffers of inherently geologically unstable coastal areas; similarly, they protect the homes of 10% of the world population, as coastal areas are often densely populated and or highly developed. Dunes will form with sediment supply, wind, and an obstruction, i.e. plants or fences, with the former being ideal. Plants are ecosystem engineers; they create, modify, and maintain the dune habitat. Aboveground plant shoots capture windblown sand while belowground roots bind sand and stabilize dunes as the first line of defense during storms. Worldwide, very few plants can tolerate and thrive the harsh abiotic conditions close to the ocean. In both developed and natural mid-Atlantic areas, management efforts to build or recover a dune system generally include planting *Ammophila breviligulata* to trap sand and in doing so, both build and stabilize bedforms. Theoretical evolution of a dune system starts at the individual plant level with the formation of bedforms, nebkha and shadow dunes, around plants. These initial forms can evolve into complex systems capable of buffering upland areas against storms. Recent studies suggest that species may differ sand trapping efficiency and they may support different topographies, building dunes morphologically similar to their own stature. We believe that the bedforms created at the onset of dune evolution, i.e. after a storm or at the backbeach, may carry over through the life of the dune, such that understanding how plant morphology and density affects dune morphology is key to optimizing dune management, maintenance, and creation. Maintaining safe shorelines buffered by dunes must involve consideration of how plant species differ in their ability to build and stabilize dunes. However, species-specific data of this nature remains largely unknown despite its applied usefulness both in management with regards to planting efforts and dune modelling with regards to vegetation parameterization.

Scope of Work: With ERDC and USGS funding, we built a removable bed unilateral flow wind tunnel to test how the morphology among and within dominant US East coast fore dune plants feeds back on bedform accumulation. This accumulation is around the individual plants at a baseline of zero accumulation (i.e. flat back beach or post storm) as the initial stage of dune evolution. We tested different planting densities, 12" and 18", the two most commonly used in planting efforts working with *A. breviligulata, Carex kobomugi*, and *Panicum amarum* as the dominant mid-Atlantic dune building and stabilizing species. We sought to include local high school students and garner local support beyond our six initial partner organizations. Our findings are relevant for natural and manmade coastal dune systems across the US coastline, including the Great Lakes.

Methods & Wind Tunnel Specs: Our wind tunnel is located in Waretown NJ at the Ocean County Vocation Technical School. The wind tunnel is capable of reaching a max speed of 27 mph (12.1 m/s) and was designed for adaptability beyond the scope of this research. It has a 6m chamber with a 1m x 2m cross sectional area. Pre-fabricated boxes, 1m x 1m x 0.3m can be inserted and sealed into the wind tunnel 3.6m downwind such that a continuous sand bed can be created within the chamber. We had four box replicates per density per species as well as four null boxes with only sand and no plants (N=40). We measured various morphological parameters of the plants box^{-1} and

then subjected each to 30 minute trials at 18.5 mph (8.25 m/s). We used a 3D sensor built into the wind tunnel to scan the resulting topography, i.e. the bedform accumulation around the individual plants. By knowing the morphology of each plant in a box, we were able to attribute bedform morphology to plant morphology, as well as to biomass after harvesting all plants post-trial.

Results & Outcomes: Our plant species varied in morphology and biomass was most closely coupled with all of our morphology parameters. Bedforms did not form in the absence of plants in our null trials. Bedforms formed in all experimental trials and we are able to see differences in accumulation as a function of species and biomass as effects. Bedform height varied by plant biomass, which varied by species. Bedform volume and area varied by plant biomass and bedforms varied in shape as a function of species. Density did not affect bedform accumulation. This research is ongoing and we intent to field validate the results as well as further explore the relationships between the different morphological measures and the significant effects.

We began with a ≅$42K budget and grew our initial 6 partnerships into 20. We had over $16K donated in equipment, consulting, and engineering; this figure is not including the cost of the space donated by the NJ Ocean County School District, time and materials for electrical work, or the 20 tons of sand donated by Island Beach State Park, NJ. People also gave their time - we logged over 140 volunteer research hours donated over the course of nine days from eight institutions; we trained nine high school students from the Marine Academy of Technology and Environmental Science (MATES), to collect all the plant morphology data (400+ plants) and did so over the course of a day, logging 50 total hours of work. The wind tunnel will exist in perpetuity for local high school, MATES, and academic use. There are various measures in place to ensure its continued use beyond this research, such as a searchable website, the creation of ambassadors within MATES, the creation of lesson plans around the wind tunnel, and garnering media attention. There is interest in use from outside academic researchers and we currently have a proposal submitted in the BAA system to further enhance the adaptability of the wind tunnel as well as conduct more studies.

Information about how plants shape dunes will become more important with time as storms continue to grow more frequent, severe, and unpredictable with climate change. Coastal dunes are unique systems and information needed to inform management spans a variety of disciplines. Many studies and management strategies simplify the system and approach it from one dimension - this work and all future work will approach the topic with a multifaceted perspective spanning ecology, sedimentology, geology, and conservation management.

Partners:

-ERDC
-USGS
-ASBPA
-Ocean County, NJ
-NJ FWS
-Ocean County School Board – OCVTS
-MATES
-NJDEP
-Handy Man Pros NJ
-AJ's Jeeps
-One Ton Bag LLC
-Motion Industries
-Air Systems Engineering Inc.
-SICK
-Coastal Transplants
-Moxley Electronics
-Pineland's Nursery
-American Littoral Society
-Save Barnegat Bay
-EMCO Industrial Plastics Inc.