Wind Tunnel Analyses of Vegetation Species: Differences in Sand Capture Efficiency for Natural & Nature-Based Dune Accretion & Management

Motivation & Community Need

Coastal dunes buffer inherently geologically unstable coastal areas, thereby reducing the risk of storm damage to inland habitats and infrastructure. Dunes grow over time with plants as ecosystem engineers that both build the habitat and stabilize it to combat erosive forces during high tides and storm events. Management efforts to build or recover dunes generally include planting dune stabilizing plants like Ammophila breviligulata to trap sand and build dunes over time. Recent studies suggest that species may differ in their efficiency at trapping sand and may build dunes of varying morphologies, potentially similar to their own stature (i.e. a taller plant builds a taller dune). The plant trapping characteristics have direct implications for storm recovery time, accretion efficiency, and how we approach planting efforts. Maintaining shorelines buffered by dunes must involve consideration of how plants differ in their ability to capture sand and stabilize dunes. However, species-specific data of this nature remains largely unknown. To examine this, a unilateral flow wind tunnel was constructed to examine sand accumulation morphology around the base of A. breviligulata, Carex kobomugi, and Panicum amarum, using at the baseline of zero accumulation as a function of the morphology of these plant species.

Approach

The wind tunnel can achieve a maximum speed of 27 mph (12.1 m/s) and was designed for adaptability beyond the scope of this research. Plants were pre-established in monocultures at one of three non-staggered planting densities, 18-, 12-, and 6-inches on center, in boxes designed to be inserted into the wind tunnel maintaining a continuous chamber length (n=4 replicated per species per density). The plants were subjected to 30 minute trials at 18.5 mph (8.25 m/s). Prior to trials, we measured the morphology of each plant. Post-trial we used a 3D sensor with sub-mm accuracy to scan the resulting topography, i.e. the bedforms around the individual plants. By knowing the morphology of each plant in a box, we were able to attribute bedform morphology to plant morphology and biomass.

Left: The wind tunnel which has a 1m x 1m moveable bed test area where boxes established with plants can be inserted. **Right**: *A. breviligulata* plants at 6-inch spacing and the resulting bedforms built around their base post-experimental trial.

Findings

The plant species varied in morphology, and biomass was most closely coupled with all of the morphology parameters. Bedforms did not form in the absence of plants in our null trials that contained only sand filled boxes. Bedforms formed in all of our experimental trials (trials with plants at one of three densities) and accumulation differed as a function of species and biomass. 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 between 18- or 12-in spacing did not affect bedform accumulation. The 6-in density trials, in which the spacing mimics natural density, are still being analyzed. The 12- and 18-in spacing densities are commonly used in plantings. This research is ongoing and the researchers intend to field validate the results as well as further explore the relationships between the different morphological measures and the significant effects.

Benefits

Information about how plants shape dunes will become more important with time as storms continue to grow more frequent, severe, and unpredictable, while the use of coastal regions continues to also increase. 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 approaches the topic with a multifaceted perspective spanning ecology, sedimentology, geology, and conservation management. Local high school students and students from 8 institutions were involved throughout the research and logged over 150 volunteer research hours across 10 days. The findings have direct applications for management planting efforts and involving high schoolers may inspire future scientists.

Status/Steps Moving Forward

We are currently in the process of repeating the experiments carried out in 2017 with the potential changes in wind speed, plants, and duration, but will alter the planting design to be staggered, as is more traditional in management. We have been approved for a second round of funding to further expand the capabilities of the wind tunnel for future research use, as well as to carry out this aforementioned research. The wind tunnel is available for outside use for research, outreach, and teaching. We have an upcoming collaboration to examine the effects of lift and drag on plants experiencing wind stress, and expect more collaborations. We will continue to involve high school students in all research. We hope to have students use the wind tunnel for science fair projects as well as to have classes visit as a hands-on learning lab resource. We hope to design lesson plans around using the wind tunnel for local high schools and colleges.

More Information

This project was funded through a USCRP challenge grant. For more information please contact the point of contact, Bianca Reo Charbonneau at Binoink@gmail.com. Please visit https://thewindtunnel.weebly.com for more specific information on the wind tunnel's specifications, those involved in this research, and or getting involved, such as by helping with lesson plans or using the wind tunnel. For more information on the additional coastal dune research and outreach being carried out by Bianca, please visit https://thedunegoon.weebly.com.