US Coastal Research Program (USCRP) DUNE R&D

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 protecting inland habitats & infrastructure. Dunes grow over time with pants as ecosystem engineers that both build the habitat & stabilize it to combat erosive forces during high tides & storm events. Management efforts to build or recover dunes generally include planting dune stabilizing plants like Ammophila breviligulata to trap sand & build dunes over time. Recent studies suggest that species may differ in their efficiency at trapping sand & may build dunes of varying morphologies, potentially similar to their own stature (i.e. a taller plant builds a taller dune). This has direct implications for storm recovery time, accretion efficiency, & how we approach planting efforts. Maintaining safe shorelines buffered by dunes must involve consideration of how plant species differ in their ability to capture sand & stabilize dunes. However, species-specific data of this nature remains largely unknown. To examine this, we built a unilateral flow wind tunnel to discover how A. breviligulata, Carex kobomugi, & Panicum amarum affect initial sand accumulation at the baseline of zero accumulation around the plant base.

Approach

The wind tunnel is capable of reaching a max speed of 27 mph (12.1 m/s) & was designed for adaptability beyond the scope of this research. We pre-established plants in monocultures at one of three non-staggered planting densities, 18”, 12”, & 6” on center, in boxes designed to be inserted into the wind tunnel maintaining a continuous chamber length (n=4 replicated per species per density). We subject the plants 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 & biomass.

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Findings

Our plant species varied in morphology & biomass was most closely coupled with all of our 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) & we are able to see differences in accumulation as a function of species & biomass as effects. Bedform height varied by plant biomass, which varied by species. Bedform volume & area varied by plant biomass & bedforms varied in shape as a function of species. Density, 18" or 12" spacing, did not affect bedform accumulation. We are still analyzing the 6" density trials, this spacing mimics field density whereas 12" & 18 are spacing distances are those commonly used in planting efforts. This research is ongoing & we intent to field validate the results as well as further explore the relationships between the different morphological measures & the significant effects.

Benefits

Information about how plants shape dunes will become more important with time as storms continue to grow more frequent, severe, & unpredictable with climate change. Coastal dunes are unique systems & 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. We have involved local high school students every step of the way in the research & have logged over 150 volunteer research hrs over 10 days from volunteers from eight institutions. The science findings have direct applications for management planting efforts & we hope that by involving local high school students, we are inspiring the future scientists of tomorrow.

Status/Steps Moving Forward

We are currently in the process of repeating the experiments carried out in 2017 with the same wind speed, plants, spacing, & 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, & teaching. We have an upcoming collaboration to examine the effects of lift & drag on plants experiencing wind stress & 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 & colleges.

More Information

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, & or getting involved, such as by helping with lesson plans or using the wind tunnel. For more information on the additional coastal dune research & outreach being carried out by Bianca, please visit https://thedunegoon.weebly.com.