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Environmental Operating Principle #2

Proactively considering environmental consequences and acting accordingly.

The vegetation growing on top of the dune is visible and so are the exposed roots, demonstrating that natural dunes are not just sand with vegetation on top, but a system with vegetation, or biomass, distributed throughout. *(Photo by Dr. Jeff King)*

Corps researchers investigate how to create resilient beach dunes

By Holly Kuzmitski
Engineer Research & Development Center

Reducing flood risk: it's one of the U.S. Army Corps of Engineers' primary missions. When we consider coastal flooding, dunes are a primary line of defense for coastal communities.

Dr. Duncan Bryant and Mary Bryant, a husband-and-wife team of researchers at the Engineer Research and Development Center's Coastal and Hydraulics Laboratory in Vicksburg, Mississippi, asked the question: Would stakeholders be more inclined to plant dunes if it was shown that vegetation, or biomass, stabilizes dunes, making them more resilient to extreme weather events?

"The Corps has had over 250 beach nourishment projects in the past 10 years — dunes are certainly part of that, but we don't know how big a part," Dr. Bryant said. "If we can find a better way to anchor dunes, we could build them smarter, so that they better protect both people and shoreline infrastructure and cause no environmental harm.

"Dunes are also sediment storage. During an erosion event — such as a hurricane or nor'easter — they release sediment; if they weren't there, the beach would be further degraded after powerful storms," he added. "When we're talking about making dunes out of dredged material, we don't want the dredged material to go back to the area we dredged it from. So from that standpoint as well, dune resilience is important."

Dr. Jeff King, deputy national lead for the Engineering With Nature® initiative, said that from an EWN perspective, dunes should be regarded as a valuable type of natural and nature-based feature. "Created dunes are nature-based landscape features that provide an engineering function. They help to mitigate flood risk and storm damage," he said. "They also provide environmental benefits to wildlife and social benefits for those that recreate on beaches.

"We are always trying to improve coastal protection. The research engineering team sought to quantify how to add value to that success," he added. "This is just the beginning of the investigation into what can be done, but they did reach some conclusions that will likely influence the composition of dunes in the future."

The Bryants first considered how they would simulate a natural dune system in the laboratory. "A laboratory experiment allowed us to control all the variables," she said.

"When we started investigating the role that vegetation plays regarding dunes, we saw that a lot of research had been done on how biomass helps build dunes, but not as much on how biomass stabilizes dunes during erosive events," she said. "The data that did exist were largely anecdotal and from post-storm observations. We wanted to be able to quantify the erosion of vegetated dunes with actual measurements."

The team reached out to Dr. Rusty Feagin at Texas A&M University for information on vegetation parameters to use for the study.

"Another thing we noticed was that no one had really looked into root structure — we expected roots would play a critical role in dune stabilization," she said. "We looked at above-ground vegetation and used dowels to represent the stems of plant material, and we used coconut fibers, or coir, to represent below-ground material, or the root matrix."

See **BEACH DUNES**, page 26

 continued from page 25

The entire study took about a year, from planning to conclusion. The team used the laboratory's wave flume, which is 1.5 meters wide and 63 meters long.

"We built a 1:15 scaled sand transport model to evaluate the beach and dune evolution," Dr. Bryant said. "We generated waves and recorded what happened to each dune, and we measured the change in each dune over time.

"We had a total of five hydrodynamic conditions—different water levels and waves to simulate different storm conditions experienced by natural dunes," he said. "We also tested five different vegetation covers.

"Some dunes had sand only, others had sand with below-ground material; some had sand with above-ground material, and then some had both. We focused the second part of the investigation on seven different amounts of below-ground material to see at what point below-ground biomass influences dune erosion and to what degree," he said.

"We found that the control dunes that were just piled sand eroded much more quickly than the dunes with the above-ground dowels. When we incorporated the coconut fibers, the dunes were significantly sturdier and persisted longer, and we had a pretty impressive dune elevation left behind, as compared to the control dune that was nearly completely flattened," she added. "We found out there was a clear service provided by the vegetation in terms of reducing erosion. The use of dowels and coir created a path forward for future laboratory and pilot studies."

Ultimately, the outcomes of the Bryants' continued research will help inform practitioners charged with designing and constructing future dune systems.

"Pursuing EWN-based research that yields more information about the dynamic interactions between vegetation and sand is incredibly important. Such knowledge supports the optimization of vegetation and sand composition, which will likely translate into reduced required maintenance and enhanced performance," said King. "Down the road, such optimization efforts could also equate to cost savings for future beach nourishment projects."

(Photo by Caitlin Hoch)

As part of the dune resilience study, Dr. Duncan Bryant, Mary Bryant and their team utilized the Coastal and Hydraulics Laboratory's wave flume. Waves are visible propagating over the model beach before impacting the dune.