

US Army Corps of Engineers®



Beaches and Dune Systems: EWN Applied Research, Outcomes, and Case Studies

Measuring the Impacts of Vegetation on Dune Erosion

Short Course: Use of Natural and Nature-Based Features in Estuarine Systems December 8, 2022

Overview of the Beaches and Dunes

 Physical, biological, geological, and chemical processes create *natural* beach and dune systems. These natural systems evolve and commonly provide multiple benefits to human settlements and infrastructure.





Distribution of the sandy shorelines. Luijendijk et al. 2018 "The State of the World's Beaches," Scientific Reports. DOI:10.1038/s41598-018-24630-6



Benefits of Coastal Dune – Storm Damage Reduction

- Observed to provide coastal protection during storm events
- Vulnerable coastal populations due to increasing threats sea level rise, increased storm activity, erosion
- Beach nourishment has been found to be the most cost-effective, socially and environmentally suitable way to reduce storm damages and coastal flooding (ASCE 2016)



City of New York. 2013. *planNYC: a stronger, more resilient New York*. New York, NY: The City of New York. http://www.nyc.gov/html/sirr/html/report/report.shtml.



Benefits of Coastal Dune - Ecosystem Services







Beaches and Dunes Systems – Why?

- What is the percentage of US population that lives in a coastal county?
 - 25%
 - 30%
 - 35%
 - 40%

Continue growth in the coastal zone!



Beaches and Dunes Systems – Why?

- Coastal counties make up less than what percentage of the contiguous US?
 - 30%
 - -20%
 - -10%
 - -5%

Continued coastal squeeze! (Coastal Squeeze is the "loss of natural habitats or deterioration of their quality arising from anthropogenic structures or actions, preventing the landward transgression of those habitats that would otherwise naturally occur in response to sea level rise in conjunction with other coastal processes - UK Gov)"



What Options Do We Have?

- Retreat, rollback, or managed realignment would allow the beach system to migrate landward. Nourishments, as part of this strategy, often aim to slow the landward migration of the beach and dune system.
- Hold the line would nourish the beach system to maintain the location of the beach and shoreline.
- Advance the line would nourish the beach with enough sediment volume to move the beach system and shoreline seaward.





What Options Do We Have?

- Retreat, rollback, or managed often requires property buyouts (becoming more common)
- Hold the line requires sediment to be brought in and placed (most common approach)
- Advance the line requires even greater sediment supply (least common)





Possible Solutions

 Range of solutions but we are focused today on those that are soft and dynamic but have the greatest ecosystem function





Dunes and Beach Nourishments

- Dunes are often built as part of a beach nourishment or grow following nourishment
- Dunes serve as sediment storage (engineering service) increasing coastal resilience







Investments in Nourishments and Dunes



• How much federal funding was spent between 2007 and 2017 on beach nourishments?

\$262 Million \$560 Million \$1.25 Billion \$1.40 Billion

- Numbers don't include local or state funded nourishments that do have an impact on coastal storm risk reduction
- Clear recreation benefits from nourishments



Basics of Natural Dune Growth





Vegetation and nearshore/dune morphology control the natural resilience of sandy coastlines



- Vegetation affects dune storm response and recovery
- Better managing our dune vegetation and wrack can improve overall coastal resilience
- Improving our dune modeling capabilities can help identify problem areas and better target beach nourishment and vegetation restoration



Recent Research Efforts

- Test the degree of protection and reduction in erosion afforded by biomass during events
- Provide a quantitative dataset that can be used to inform models and identify dune building strategies that can decrease dune erosion



- Most pioneering dune building vegetation belongs to the Family *Poacea (flowering grasses)*
- Growth stimulated due to sand burial
- Drought and salt tolerant
- Abundant belowground biomass
- Symbiotic relationship with arbuscular mycorrhizal (AM) fungi
- Poor growth from seed require plantings





Lamphere (2006

Bitter Panicu



Laboratory Model of Dune Erosion





Observed Differences In Erosion





Results – Dune Profile Changes



- Without biomass dunes suffered more erosion
- Biomass regardless of form decreased erosion
- Sediment eroded from the dunes deposited in the surf zone or deposited in the overwash



Results – Dune Volume Changes



Used mimics or single species. How does more natural ecosystems with a diversity of flora improve the performance of the dune? Result indicate that increasing dune biomass as quickly as possible to a natural level will increase dune storm performance and resiliency

Ayat and Kobayashi. 2015. Vertical cylinder density and topping effects on dune erosion 451 and overwash. Journal of Waterway, Port, Coastal, and Ocean Engineering 141(1).

Bryant et al. 2019. The response of vegetated dunes to wave attack. Coastal Engineering, 152, 103506.

Feagin et al. 2019. The role of beach and sand dune vegetation in mediating wave run up erosion. Estuarine, Coastal and Shelf Science, 219, 97-106

Kobayashi et al. 2013. Effects of woody plants on dune erosion and 482 overwash. *Journal of Waterway*, *Port, Coastal, and Ocean Engineering* 139(6):466– 472.

Silva et al. 2016. Response of vegetated 504 dunebeach systems to storm conditions. Coastal Engineering 109:53–62.



How much biomass to add? How do we increase the amount of biomass?



- Increasing levels of belowground biomass decreased the loss of dune material during overwash events
- What are the practical and economical implications and limits?
- Are there other processes that increase biomass?



Building Better?





Allowing for Natural Processes

- Results show that dunes with fully integrated biomass throughout the depth will be more resistance to erosion
- These results fit well with field observations that showed:
 - Artificial dunes may not respond as natural dunes to storm processes despite being planted with native species, resulting in more rapid erosion. (Morton et al., 1994)





Wrack Management : Pass Christian, MS

- County currently practicing beach grooming, raking of wrack-line to keep beach clear
- Approach: Place groomed wrack at toe of dune to encourage dune growth via Aeolian transport

Zone	Name	Description
1	Control	Typical beach grooming activities will occur (raking the beach and around dunes)
2	No Rake	Beach will be raked, but around dunes will be left un-raked for duration of study
3	No Rake & Treatment	Same raking practices as Zone 2. Wrack removed from the beach within Zone 3 will be placed on the dune.
8 8 600 ft. ZONE 1 600 ft. ZONE 2 600 ft. ZONE 3		
😫 Periodic su	rvey tripod placement 🛛 🚫 No-rake zone	Placed wrack





Findings of Interest: Volume Changes



Improving Dune Projects

- 1. Track the cost of your dune construction and maintenance Improves future decision making
- 2. Guarantee that plant vegetation has AM fungi present
 - Some growers use sterile growing medium
 - Consider inoculation/consider microbiology
- 3. Dredge material will not have the same microbiology or chemistry
 - May initially be too high in salinity and pH
 - Consider testing sediment before planting





Improving Dune Projects

- 5. Where possible build dunes to a lower height to allow for natural growth
 - Natural dunes have better biomass distribution – use natural processes
- 6. Careful and thoughtful contracting
 - Take control of the planting by guaranteeing plant survivability
 - Ask for the planting contractor to show experience/training/education/past performance
- 7. Biomass additions through additions or natural wrack placement/processes can simulate roots, increasing erosion resistance and resulting in earlier resilience.





Dunes "Triple Win"



Dunes and Beach Nourishments provide one of the most sustainable methods to

- 1. Increase Coastal Resiliency
- 2. Increase Environmental Habitat
- 3. Provide Recreational Areas that have measurable economic impacts
- Vegetation is critical in trapping and maintaining sand during wind transport events
- Vegetation provides added benefits in reducing storm erosion
- Vegetation is key is post-storm recovery and dune re-growth

