Engineering Considerations for NNBF

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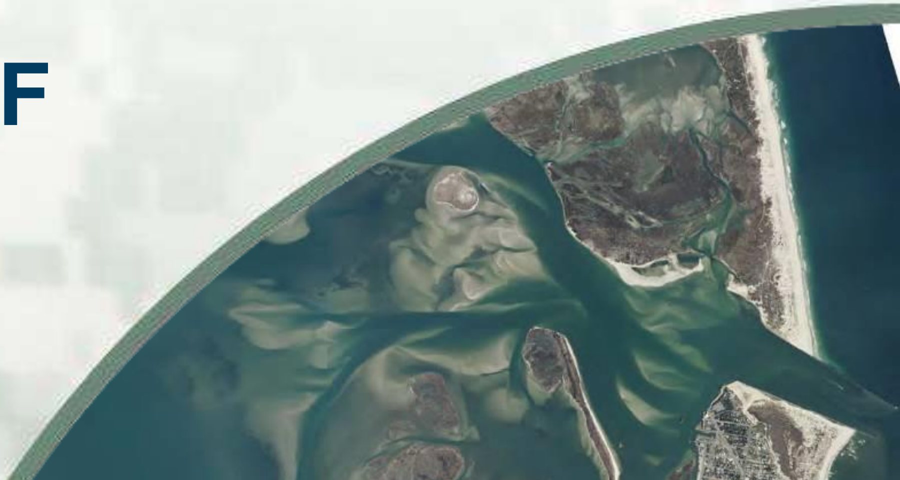
Engineer Research and Development Center



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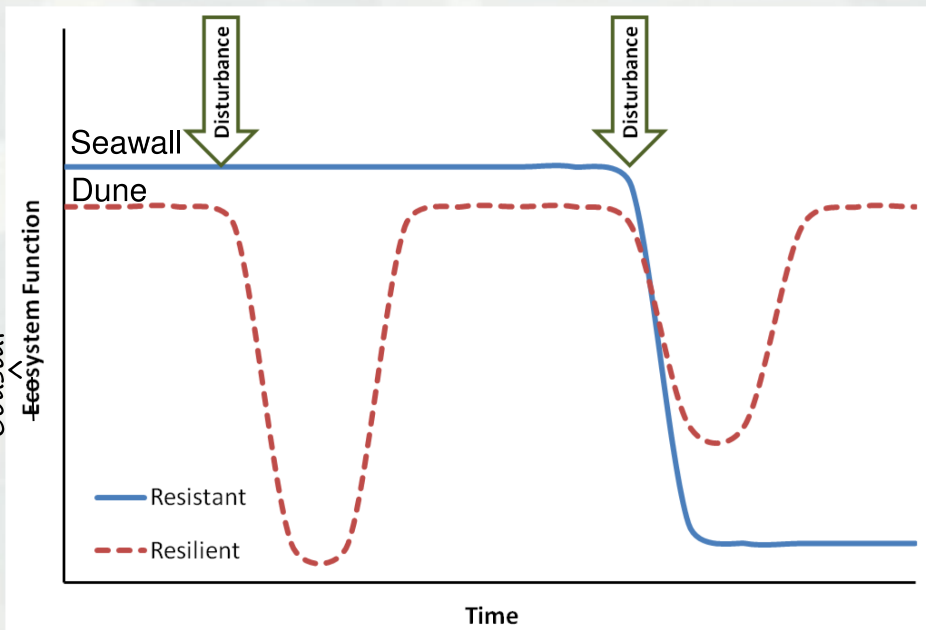
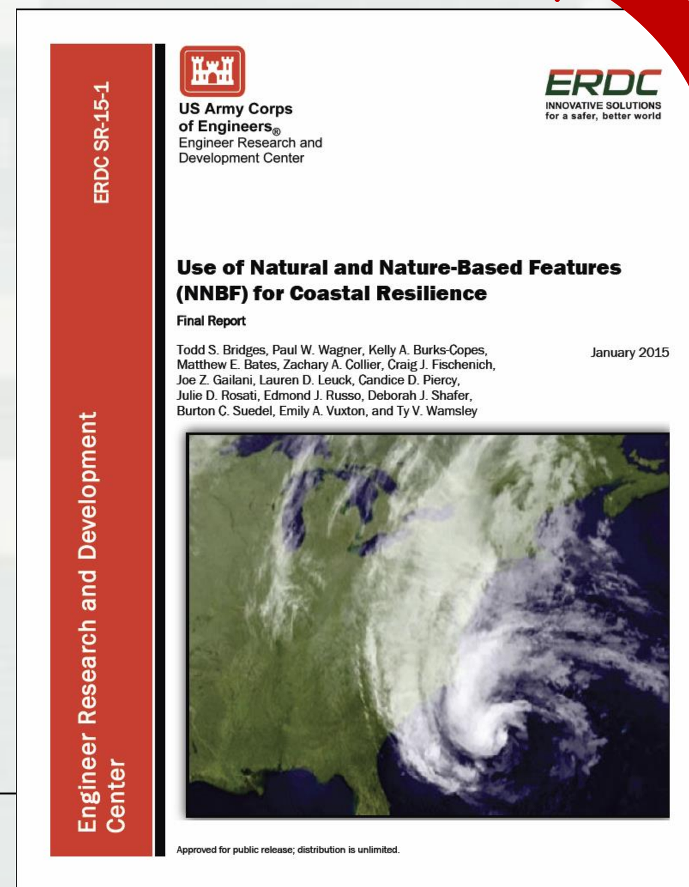
Designing for coastal resilience

<u>Resilience</u> is the ability of a system to prepare for, resist, recover, and adapt to achieve functional performance under the stress of both natural hazards and human-related disturbances through time





ERDC SR-15-1

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INNOVATIVE SOLUTIONS for a safer, better world

Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience

Final Report

Todd S. Bridges, Paul W. Wagner, Kelly A. Burks-Copes, Matthew E. Bates, Zachary A. Collier, Craig J. Fischenich, Joe Z. Gailani, Lauren D. Leuck, Candice D. Piercy, Julie D. Rosati, Edmond J. Russo, Deborah J. Shafer, Burton C. Suedel, Emily A. Vuxton, and Ty V. Wamsley

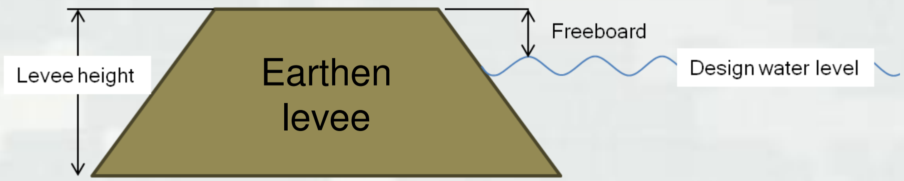
January 2015

Engineer Research and Development Center

Approved for public release; distribution is unlimited.

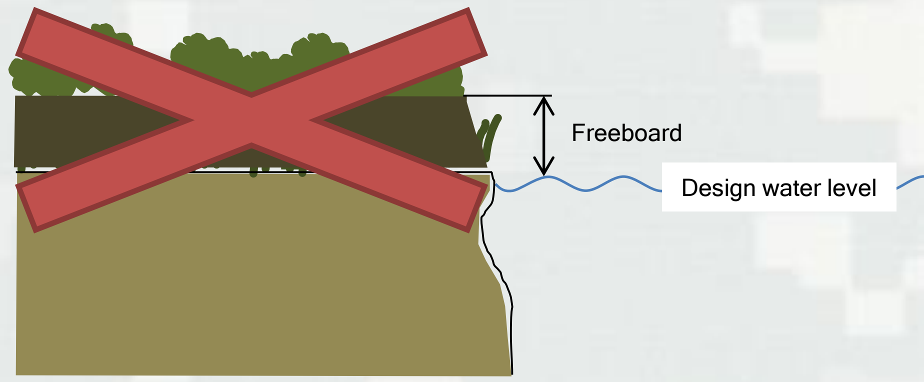
Engineering design must account for ecosystem function

Structural engineering approach



Traditional engineering deals with uncertainty by employing a margin of safety such as extra freeboard in levee design

Ecological engineering approach



Increasing the height of a constructed marsh to add freeboard will convert the site to an upland that will not function as a marsh

Cross-cutting project: developing NNBF engineering guidance

Dunes

Walkway construction


Sea Grant
NJ Sea Grant Consortium

Research Projects
2014-2016

Facilitating Natural Dune Building R/6410-0013

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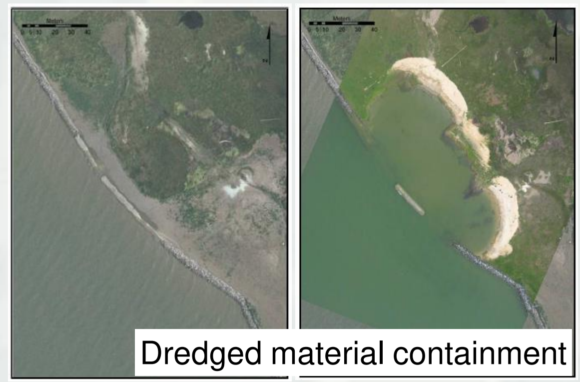
Bulldozed dune at Brick Township following Hurricane Sandy 2013

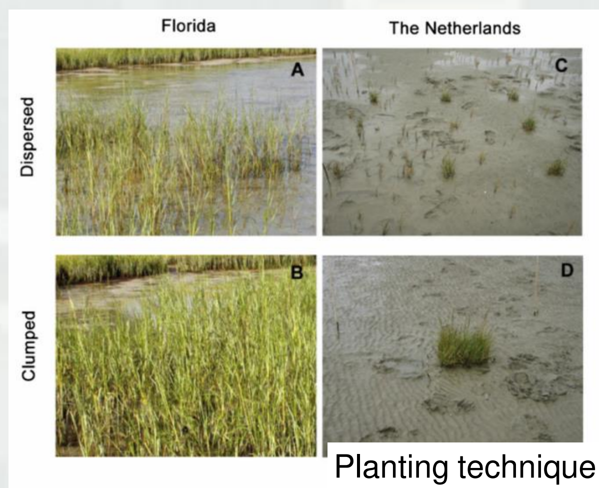
Assessments of damage along the New Jersey shore after Tropical Storm Sandy indicate that the condition of the dunes had a pronounced effect on susceptibility to flood and wave damage. Not all dunes were alike; some dunes evolved by natural processes; some were created by direct deposit of fill; some were

Naturally evolving dune at Avalon 2009


Reinforced dunes

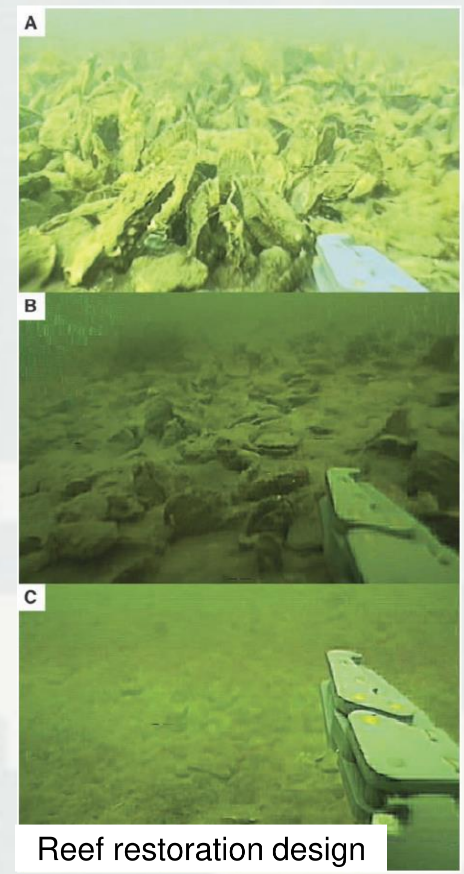
Wetlands


Dredged material containment



Planting technique

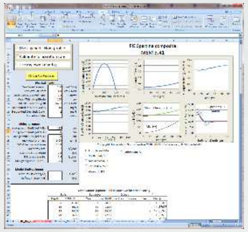
Oyster Reefs



Reef restoration design

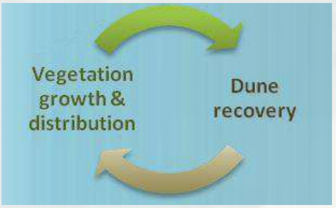
ERDC is trying to fill in the gaps with lab and field studies as well as modeling

Wetlands



- Wave attenuation flume study
- Field demo of thin layer marsh nourishment
- Short- and long-term modeling of marsh elevation after nourishment

Dunes



Field data from FRF

+

Flume study on vegetated dune response

→ Long-term dune morphology modeling

M. A. Bryant and J.M. Smith
Mary.Bryant@usace.army.mil

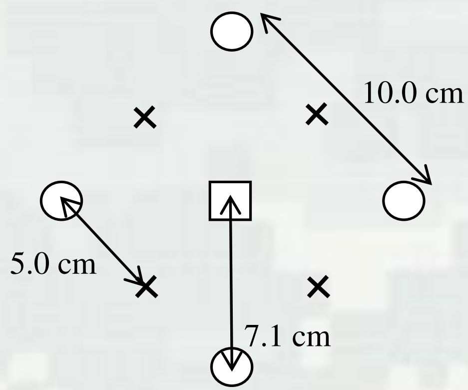
Wave Attenuation by Vegetation

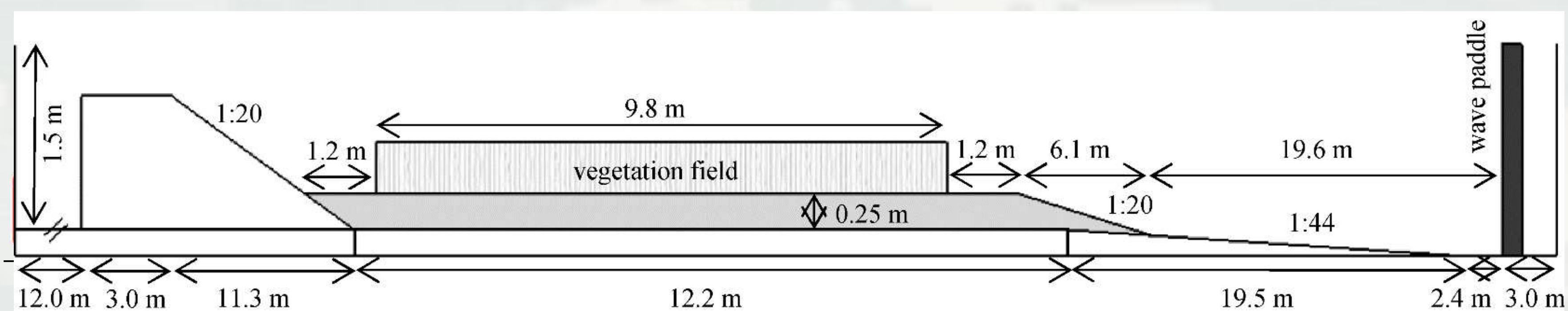
- investigate the interactions between water waves and wetland plants
- interested in smooth cordgrass (*Spartina alterniflora*)
  - dominant emergent grass species along Atlantic and Gulf of Mexico
- idealized *S. alterniflora* constructed of polyolefin “shrink” tubing
  - flexible under wave action
  - readily available
  - modulus of elasticity and and diameter close to values reported in literature

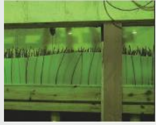
Source: http://plants.usda.gov

Laboratory Setup

- CHL wave flume
  - 64.1 m long, 1.5 m deep, 1.5m wide
- 9.8 m vegetation field
  - 100, 200, and 400 stems/m^2
- instrumentation
  - 13 wave gauges
  - 4 ADVs
- wave conditions
  - irregular waves

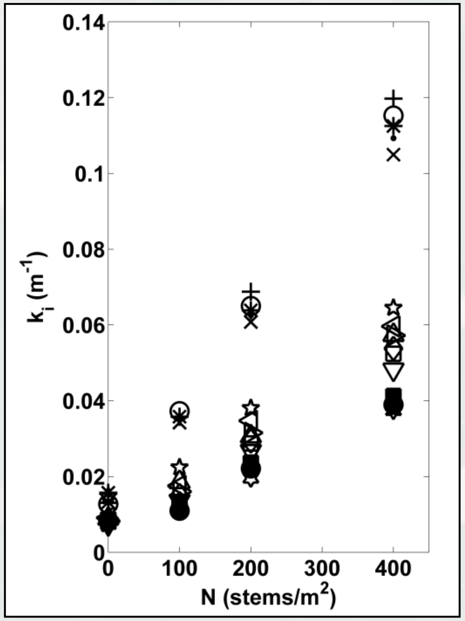


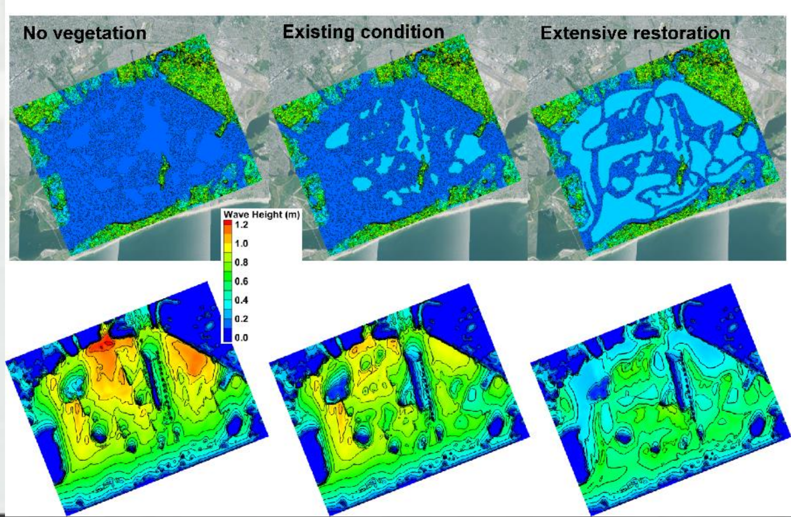




Results and Conclusions

- wave attenuation was found to:
  - increase with stem density
  - decrease with deeper water
  - slightly increase with incident wave height
  - trend with wave period unclear
- application of vegetation in spectral wave model STWAVE shows significant reductions in wave height on project scales
  - resiliency of vegetation?
  - does the benefit justify the cost compared to other shore protection measures?
  - permanence of constructed wetlands?





Marsh nourishment with thin-layer application of dredged material

M. Chasten, C. Piercy, T. Welp, D. Golden, M. Yepsen, J. Jahn

- Degraded salt marshes in NJ
  - Edge erosion and subsidence
  - Loss of vegetation
  - Increase in pannes and pools
- Partnered to improve our understanding of science and engineering of marsh restoration with DM
- Additional work with E.B. Forsythe National Wildlife Refuge

US Army Corps of Engineers® Philadelphia District

ERDC

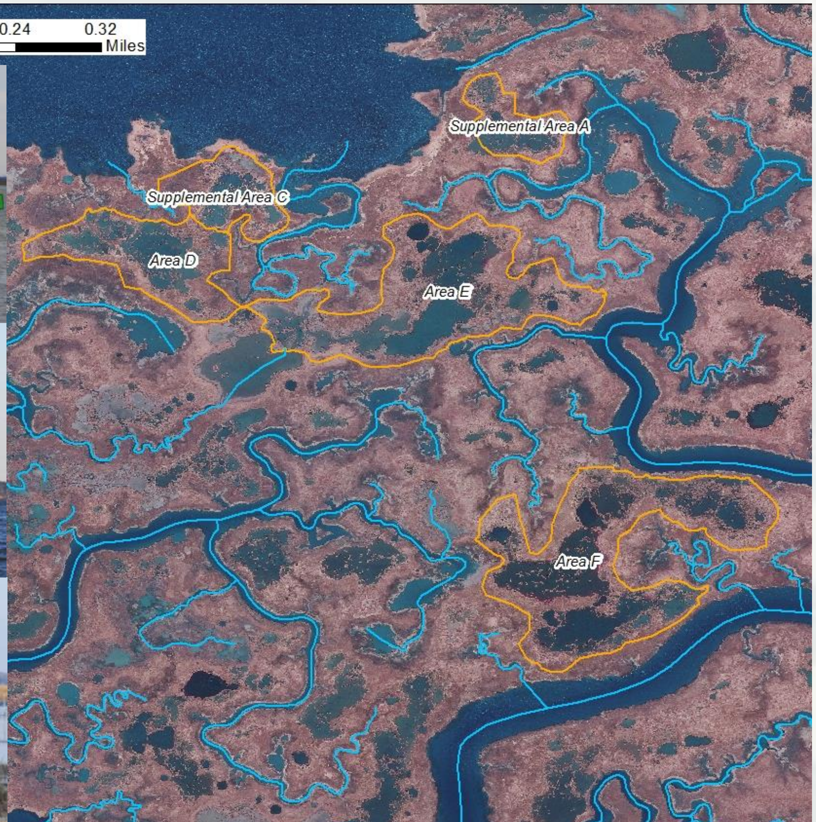
The Nature Conservancy
Protecting nature. Preserving life.

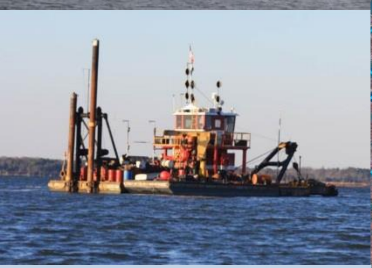
GreenVest
One Step Ahead.

New Jersey Department of Environmental Protection

Avalon, NJ: design and construction

M. Chasten, C. Piercy, T. Welp, D. Golden, M. Yepsen, J. Jahn





- NAP Post-Sandy emergency dredging of NJIWW federal channel
- ~6 acre pilot constructed Dec 2014
- ~ 35 acres of marsh received DM between Nov 2015 and Feb 2016
- Thicknesses ranged from just a few cm up to ~0.5 m in pools
- Defined target elevation based on vegetation community surveys
- Placed within hydrologically isolated areas on the marsh

Avalon, NJ: monitoring recovery

M. Chasten, C. Piercy, T. Welp, D. Golden, M. Yepsen, J. Jahn

- Before-after control-impact monitoring design
  - Water levels (NFWF partners/ERDC)
  - Soil physical and biogeochemical properties (ERDC)
  - Vegetation and infaunal communities (NFWF partners)
- Will implement similar monitoring scheme at Seal Beach NWR, CA and Narrow River, RI

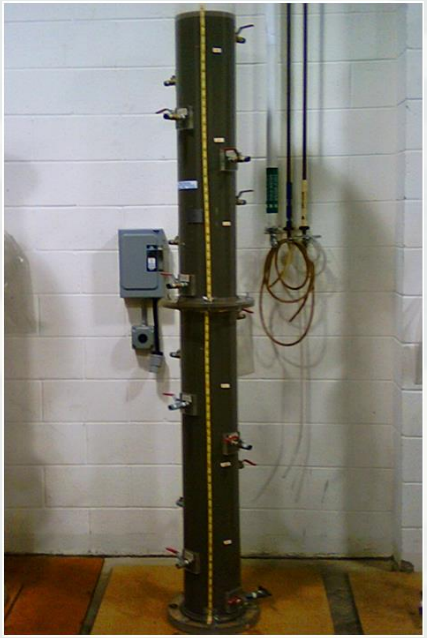
October 2014

May 2015

Thin-layer in wetlands: Bulking Factor & Consolidation

T. Welp, S. Bailey, P. Schroeder

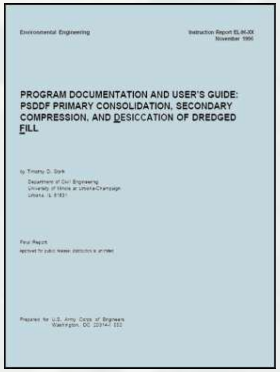
- Appropriate elevation is critical to a successful marsh.
- If material is hydraulically placed, elevation changes over time.
- Elevation change can be modeled.
  - Maximum volume: at end of placement
  - Elevation subsides during primary settling and drainage of ponded water (SETTLE)
  - Long term: consolidation of dredged material and underlying foundation (PSDDF).



Environmental Engineering

PROGRAM DOCUMENTATION AND USER'S GUIDE: PSDDF PRIMARY CONSOLIDATION, SECONDARY COMPRESSION, AND DESICCATION OF DREDGED FILL

Final Report

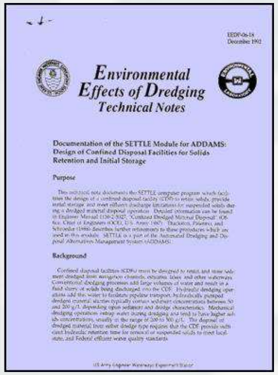


Environmental Effects of Dredging Technical Notes

Documentation of the SETTLE Module for ADDAMS: Design of Confined Disposal Facilities for Solids Retention and Initial Storage

Purpose

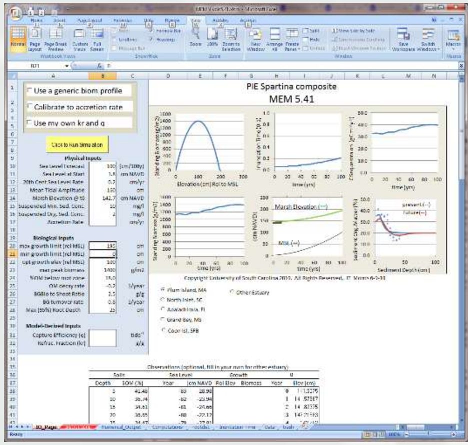
Background

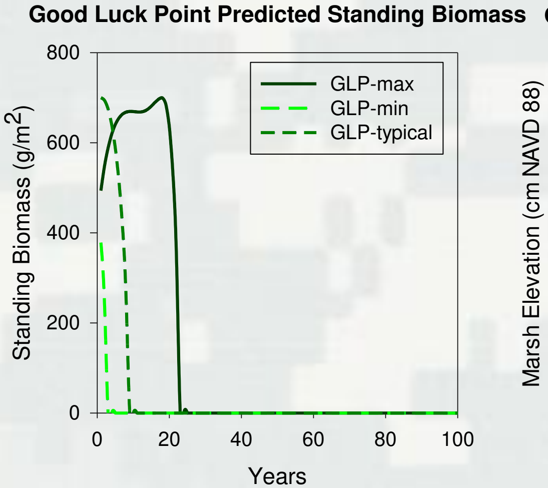


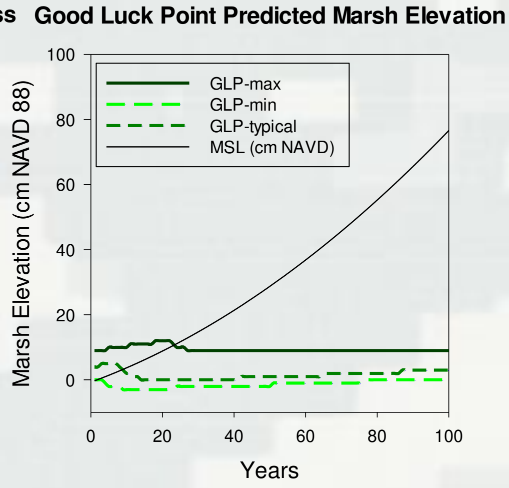
Predicting marsh response to DM application long term

C. Piercy, J. Morris, C. VanZomeren, T. Swannack, P. Schroeder

- Marsh Equilibrium Model projects future conditions based on known interactions between biomass and accretion
- Developed at University of South Carolina by Dr. James Morris
- Goal: use MEM to predict the response of marshes to thin-layer and other episodic sediment deposition events







Leveraging Field Research Facility data to improve model performance

Monthly evolution of an eroding & prograding dune system

K. Brodie, N. Spore

Above- and belowground biomass sampling

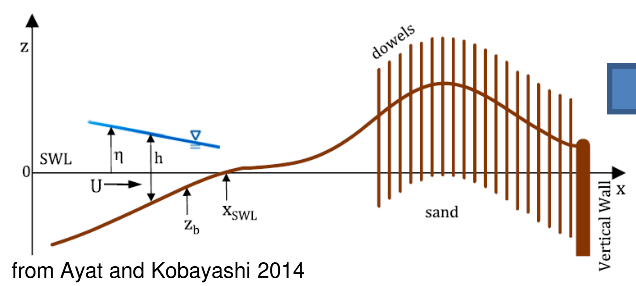
C. VanZomeren, D. Evans

Validation dataset for integrated dune morphology model

The effect of vegetation during storms: how important is it?

D. Bryant, M. Bryant, A. Priestas, C. Piercy

- Goal: quantify the effects of above- and below-ground biomass on dune erosion during collision and overwash
- Developing series of flume experiments with simulated vegetation
- Will inform how coastal morphology models handle erosion of vegetated dunes

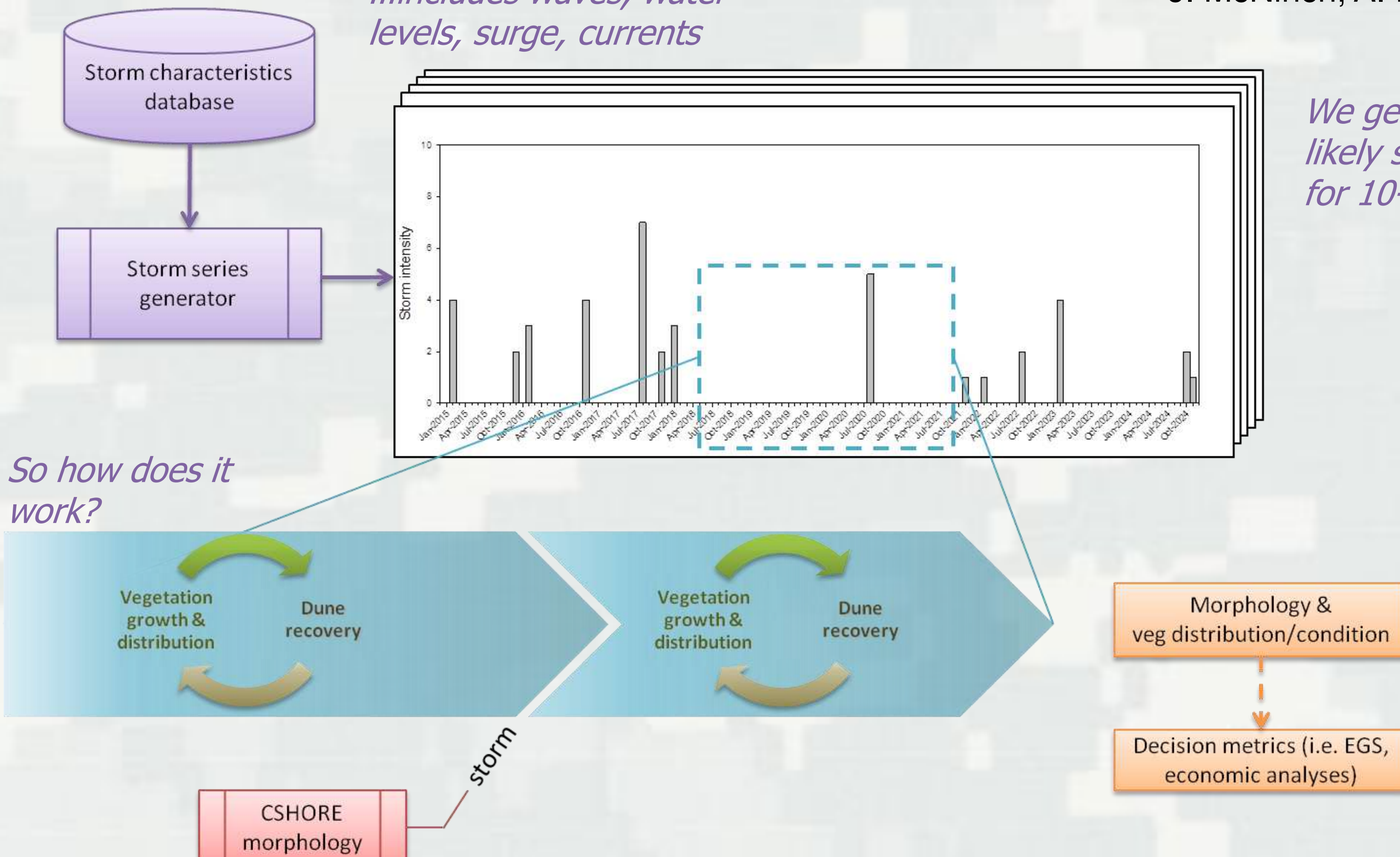


from Ayat and Kobayashi 2014

Integrating morphology and ecological modeling to better predict dune response and recovery

C. Piercy, B. Johnson, T. Swannack, J. McNinch, A. Duarte

...includes waves, water levels, surge, currents

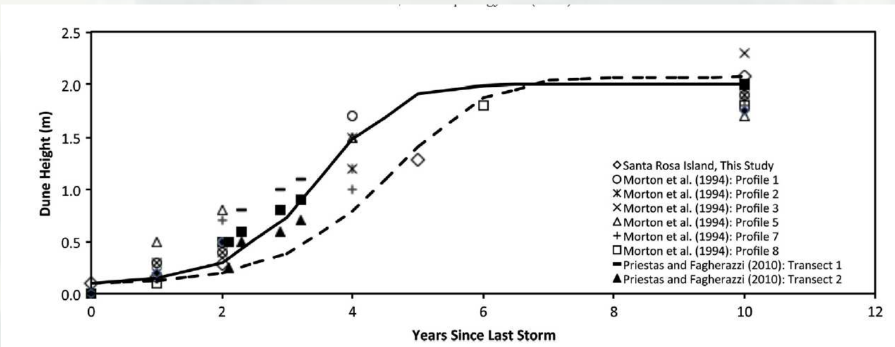


We get a distribution of likely storm scenarios for 10-50 year future

And what are the outputs and what are they used for?

Modeling the role of vegetation for dune recovery

Dune recovery response mimics vegetation growth patterns



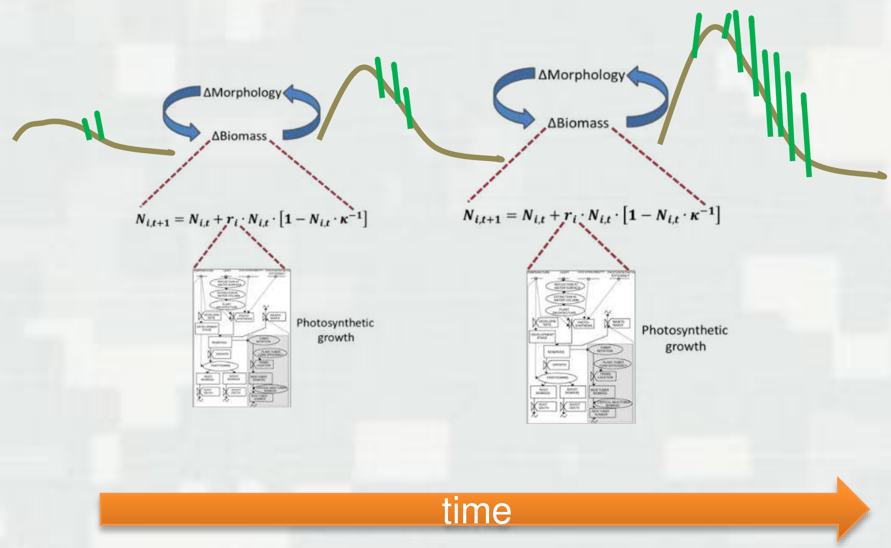
Beach recovery

Bare sand to early successional species

Establishment and growth of dune-building species

Transition to mature dune vegetation community

Vegetation biomass enhances dune growth



Engineering Challenges and Opportunities

1. Appropriate design criteria and performance metrics (beyond survivability)
2. Quantifying costs and benefits (engineering, ecosystem, and social)
3. Designing for constructability
4. Communication (successes, failures, and emerging opportunities)
5. Multidisciplinary collaboration
6. Scaling (lab to project to shoreline to coast)
7. Interaction of multiple features within a system
8. Standardized methodologies/metrics for measurement, analysis, and monitoring