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[Home](#) / [Training](#) / [Catalog](#) / Using Novel Approaches...

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# Using Novel Approaches to Create Resilient Dune Systems Following Hurricane Maria

## TRAINING TYPE

Peer-to-Peer Case Studies

## CONTACT

Dr. Robert J. Mayer

## SCALE

Site, Shoreline

## LOCATION

North Coast of Puerto Rico

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**We'd love to hear from you.**

***The Takeaway:*** Using Biomimicry, Planting, and Wooden Boardwalks for Creating Storm Resilient Dune Systems in Puerto Rico.

## Overview

Learn from Dr. Robert J. Mayer, Director of Vida Marina, about innovative restoration techniques used to create resilient dune systems that provide protection from coastal storms.

“Coastal dunes play a significant role in hazard mitigation.”



### Dr. Robert J. Mayer

Director – Vida Marina

Center for Conservation and Ecological Restoration, University of Puerto Rico at Aguadilla

## Lessons Learned

- **Know the permitting process.** To accomplish the work, Vida Marina had to obtain a permit from the Puerto Rico Department of Natural and Environmental Resources.
- **Find volunteers.** Engaging K through 12 students as volunteers was a great opportunity to help them meet graduation requirements while getting the community involved.
- **Biomimicry is more effective than using intact wooden pallets or snow fencing.** Biomimicry is a technique that uses matrices created with pieces of wood to generate turbulence and reduce wind velocity, resulting in the uniform accumulation of sand that is resistant to storm surge and strong wave action.
- **Biomimicry protects newly planted vegetation.** The matrices used in biomimicry are less likely to be disturbed by people, easily re-adjusted as needed, lighter, and protect recently planted vegetation from sand blasting, while also resisting storms better.

- Dr. Robert J. Mayer, Director – Vida Marina, Center for Conservation and Ecological Restoration, University of Puerto Rico at Aguadilla

## The Process

### Issues Affecting Coastal Dunes in Puerto Rico

Dunes provide protection to communities and habitats throughout Puerto Rico's municipalities, with approximately 48 percent of the island's dunes found on the north coast in Isabela, Dorado, and Loiza. The once expansive dune systems are now extremely fragile due to the destruction of vegetation and sand compaction by all-terrain vehicles, illegal sand extraction by the construction industry, and heavy foot traffic. With the loss of vegetation, the dunes are more susceptible to erosion and to the displacement of sand during storm events. These changes have also altered habitats, making way for invasive species such as the green iguana, which feeds on sand-stabilizing vegetation.

In addition to the dunes being affected by human activities and invasive species, Puerto Rico was hit in September 2017 by Hurricanes Irma and Maria. In March 2018, winter storm Riley brought additional impacts. The storms resulted in near record-breaking high tides and coastal flooding that caused severe erosion, breaching, and flattening of many dunes on the north coast. The combined effects of rain runoff and wave action destroyed and breached some primary dunes.

## Addressing the Impacts through Dune Restoration

Historically, hard structures such as “rip-rap” have been used to protect shorelines along the Puerto Rico coast, but have now been found to disrupt the flow of sand and exacerbate erosion on adjacent shorelines. Dr. Robert J. Mayer, founding director of Vida Marina, the Center for Conservation and Ecological Restoration at the University of Puerto Rico at Aguadilla, notes that “investments in infrastructure should not jeopardize the ecosystems and natural resources that underlie economic wealth and human well-being. Built infrastructure is strongest the day it is built, but often grows weaker with time and requires more maintenance than natural and nature-based infrastructure.”

Robert and his team are testing restoration approaches to help address the issues affecting Puerto Rico’s dune systems. His work focuses on ecological restoration projects that not only provide storm damage protection, but also reduce foot traffic and other erosion issues, creating resilient dune systems. This work is done through Vida Marina, where Robert and his team are currently prioritizing sites affected by extreme weather.

Their restoration projects have five steps

1. Select the coastal dune sites to be restored.
2. Capture aerial imagery with an unmanned aerial system (UAS) to assess the condition of the sites pre and post storms.
3. Process and analyze the aerial imagery using photogrammetry software to estimate the value of the dune systems in terms of reducing storm damage.
4. Plan “on-the-ground” ecological restoration courses of action for sites identified as “high priority” to provide valuable storm damage protection.
5. Implement restoration actions.

To get started, they selected

23 sites along the north coast of Puerto Rico (<https://coast.noaa.gov/data/digitalcoast/img/trainings/puerto-rico1.jpg>)

, focusing on highly populated areas that are located behind coastal dunes impacted by extreme weather. They began working through their restoration steps by collecting aerial imagery, analyzing each site from the ground and air, monitoring vegetation cover, analyzing conservation threats on each site, and identifying nature-based infrastructure to increase resilience and provide critical services to communities in a cost-effective manner.

Robert and his team then made recommendations for ecological restoration courses of action at each site. These included the following:

- Installing wooden boardwalks to redirect foot traffic away from sensitive areas of coastal dunes;
- Adding signage to educate beach users about the importance of dunes and the restoration projects taking place;
- Planting dune vegetation propagated in the Vida Marina greenhouse; and
- Installing sand-trapping devices that take advantage of Aeolian sand transport to increase dune height and keep sand from accumulating on personal property during storms.

“One day we came across a great idea for trapping sand, and we immediately gave it a try,” Robert says.

This method became known as “biomimicry”—a technique that uses matrices created with pieces of wood to generate turbulence and reduce wind velocity, resulting in the uniform accumulation of sand that is resistant to storm surge and strong wave action.

“Biomimicry,” Robert says, “does a great job at protecting recently planted vegetation from sand blasting, allowing it to flourish.”

The technique is now attracting interest among graduate students at the University of Puerto Rico, thus expanding Vida Marina’s capacity to employ biomimicry around the island. Kindergarten through twelfth grade students are also using this technique in science fair projects. Student volunteers of all ages also helped with restoration, which gave them the “green contact hours” required for graduation.

## Outcome

Many of the biomimicry matrices installed by Robert and his team have been rebuilding dunes that were affected by Hurricanes Irma and Maria and winter storm Riley. Robert’s team is continuing to spread the word about the importance of dune restoration by working with the University of Wisconsin – Madison Arboretum’s Earth Partnership Program on environmental education efforts. They also offer talks in schools all over the island, year round.

Vida Marina will be continuing this work with the restoration of additional dune sites as a collaboration with the University of Wisconsin – Madison. This work will be funded by the National Fish and Wildlife Foundation’s 2019 Coastal Resilience Grant.

## Contributing Partners

Caribbean Coastal Ocean Observing System

Corona

Federal Emergency Management Agency

U.S. Department of Interior

NOAA

National Fish and Wildlife Foundation

Puerto Rico Sea Grant

Rip Curl Planet

SEE Turtles

Toyota Foundation

University of Wisconsin

## More Details

### Tools Used



- RTK GPS Unmanned Aerial Imagery (UAS) platform to collect aerial imagery (i.e., drone)
- Pix4D – a suite of software products that use photogrammetry and computer vision algorithms to transform both RGB and multispectral images into 3D maps and models; used to assess current condition and value of dunes for storm protection
- Waypoint-mission engine to perform repetitive aerial imagery for the calculation of vegetation cover on each site to monitor the progress of re-vegetation of restoration areas
- Law enforcement using hidden wildlife cameras to prevent illegal sand extraction

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### Funding



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- JetBlue for Good
- U.S. Forest Service through Puerto Rico Department of Natural and Environmental Resources
- Diversified and Special Services, Inc.

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### To Learn More



- Vida Marina at University of Puerto Rico Aguadilla (<https://www.facebook.com/vida.aguadilla/>)
- University of Puerto Rico Aguadilla (<https://www.uprag.edu>)