Sand dunes offer clues to coastal erosion and how to prevent it

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European coastal regions have a long history of interacting with sand dunes. Credit: CC0 via Pixabay

The 200 million Europeans who live in coastal zones are already feeling the impact of global warming through extreme variations in sea level and

flooding.

Many parts of Europe could suffer 10 times more coastal flooding by 2100, depending on the trajectory of greenhouse-gas emissions that cause climate change, according to the European Environment Agency.

History lessons

For major cities close to the shore, this is going to be a big issue," said Dr. Joana Freitas, an environmental historian at the University of Lisbon in Portugal.

The predicted rise in sea levels has focused attention on the measures that can be taken to protect Europe's coastline. As the first natural line of defense against flooding and coastal erosion, sand dunes have an important role to play in sheltering these areas.

But today's sand dunes don't provide as much protection as they once did.

Looking at how people have interacted with nature can provide valuable insights into recent changes in the environment and humankind's role in causing them, according to Freitas.

She is the lead researcher of the DUNES project, which is putting together a complete history of human-environment interactions in coastal areas worldwide.

The project, which began in November 2018 and runs through April 2024, covers France, Portugal, the U.K., Brazil, Mozambique, North America and New Zealand.

"Humans have a long history of connecting with dunes," said Freitas.

That history is marked by ups and downs. In the 17th to 18th centuries, dunes in Denmark, France, the Netherlands and Portugal were considered dangerous because the sand blown inland by the wind silted rivers and harmed farms.

Tree traps

To prevent this, coastal inhabitants planted marram grass—Ammophila arenaria—to trap the sands.

Later, from the end of the 18th century, several countries in Europe supported the planting of trees on dunes to prevent the destruction of arable land and increase dunes' economic value by turning them into forested areas.

Trees can grow well on stabilized dunes and become part of their ecosystem. And, in general, vegetation such as grasses, shrubs and bushes can help stabilize dunes and prevent their erosion as well as provide a home for plants and wildlife.

But large-scale tree plantings carried out in the 19th century and early 20th century caused more damage than the inhabitants likely realized. For one, as these new forests often were monocultures of non-native species, they disrupted the existing ecosystems.

Second, extensive tree planting—along with the spread of urban areas, building of harbors and dams, dredging of navigation channels and construction of seawalls and low barriers known as groins—caused profound changes in coastal areas.

For example, they deeply affected the balance between sediment added to and removed from a coastal system's littoral zone, which is the part of a sea close to the shore. This activity reduced the amount of sand on

some beaches, limiting their ability to act as a buffer and protect structures and buildings on the coast.

Wave power

"Dunes are keepers of sand, they are reservoirs," said Freitas. "When there are bigger and stronger waves during storms, the sand is taken from the beach, which creates an underwater barrier, so the next waves will be blocked."

Eventually, over weeks or months, more gentle waves gradually return the eroded sand from offshore to the beach. This fluctuating of the shoreline backwards and forwards over time is a normal coastal process that is hardly noticeable in normal times but can be dramatic during storms.

Freitas is concerned that if the natural balance isn't maintained, beaches will eventually be destroyed and the coastal protection dunes provide will be lost.

Olivier Burvingt, a researcher at the University of Bordeaux in France, is well aware of the potential impact of storms and sea level rises on coastal sand dunes.

As part of the ERoDES project, Burvingt and colleagues are seeking to understand how dunes respond to and recover from extreme weather events along the Atlantic coast of Europe. The three-year project runs through August 2024.

By using light detection and ranging, or LiDAR, laser technology, the ERoDES team can collect precise data from the air along several kilometers of dunes.

"Regional coastal monitoring programs across Europe provide us with data that were collected using aircraft that fly over dunes," said Burvingt. "That way we can measure and study the topographical changes of the dune sediments with a vertical precision of up to 10 centimeters."

Like Freitas and her team, ERoDES is also looking back in time and drawing on physical and digital archives and models to understand more about dunes' behavior now and in the future.

Regional puzzles

The vast amount of data collected by the project can provide insights into the difference in resilience of some of the most exposed coastal dunes along the Atlantic coast.

For example, the team is studying the response and recovery rates of eight coastal dune areas ranging from north-western England to southwestern France in the 2011–2020 period.

All the areas under study have been exposed to and eroded by massive storms in the Atlantic, particularly extreme weather experienced in the winter of 2013–2014.

A puzzling element for the researchers is that, although exposed to the same storms, the dunes have responded differently and have all recovered at varying speeds. While some areas have returned to the same state they were in before the storms, others are still recovering or have lost even more sand.

"We're trying to understand why their response is different," said Burvingt.

All eight sites have different environmental characteristics, including

tides, climate, dune size, coastline shape and vegetation density.

One of the main findings from the project so far is that the dunes with the steepest slopes were the ones to lose the most sand.

Another is that the rate of recovery is mainly dependent on the amount of sediment available along the coastline. Being able accurately to assess these sediment budgets is key to anticipating the evolution of coastal dunes.

At the project's end, these results will be shared with coastal authorities across Europe. Based on the characteristics of each region, officials can tailor a strategy to protect the dunes, restore the coasts and guard against future storms and flooding.

New approach

Both ERoDES and DUNES advance a broad EU initiative to help cities and local authorities better understand the climate threat they face and how to react in time.

But in doing so, the two projects take a new approach to adapting to global warming by avoiding a traditional focus on new technologies and methods that can prevent, or at least reduce, the impact of future flooding, drought, wildfires and other consequences of rising temperatures.

Instead, ERoDES and DUNES move towards relying on steps that work with an ecosystem rather than introducing traditional human-made fixes such as seawalls, dams and dikes. Future dune restoration and protection are set to depend on planting native vegetation and re-introducing indigenous plant species—actions that are kinder on the environment and relatively inexpensive.

"This simple and effective nature-based solution has been done by coastal populations for centuries in some European countries," said Freitas.

As for the research itself, she stressed the benefits of its interdisciplinary nature.

"One of the most important contributions of DUNES is to show that transdisciplinary work between the humanities and the sciences is possible, rich and valuable and should be a path to follow more often in the future," Freitas said.

Adapting to climate change

According to the latest data from the World Meteorological Organization, Europe is warming twice as fast as the world average.

Adapting to climate change means taking action now to prepare for both the current effects of climate change and the future ones.

The EU Mission on Adaptation to Climate Change focuses on supporting EU regions, cities and local authorities in their efforts to build resilience to the inevitable effects of a changing climate.

With concrete targets for 2030, the EU Mission to Restore our Ocean and Waters will protect and restore aquatic ecosystems to support biodiversity and ensure native wildlife and plants have a home for years to come.

Nature-based solutions are inspired by and supported by nature. They use nature's own resources—clean air, water and soil—in a smart way, to tackle environmental challenges while supporting biodiversity and providing environmental, social and economic benefits.

Other projects that are implementing nature-based solutions to coastal erosion, including dune restoration, include REST-COAST and Interreg MANABAS.

More information:

- DUNES
- ERoDES

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