

Can plants defend coasts against storms?

Rusty A. Feagin & M. Luisa Martínez

Salt-marsh plants can protect inland areas against huge waves – but seemingly only up to a point, and big storms cause progressive damage. **See p.1194**

Plants and other organisms can reduce the erosion of coasts by winds and waves. The physical structures of sand-dune and wetland plants, seagrasses, oysters and macroalgae can slow the flow of water and wind, capture sediment and modify soil. Over time, these organisms can also build land, store greenhouse gases, provide habitats for other species and beautify beaches and wetlands¹. In some cases, they can be used as a nature-based solution in place of engineered structures. But coastal engineers and planners are often hesitant to incorporate them into construction projects, because their ability to perform in extreme conditions is unknown. On page 1194, Willemsen *et al.*² determine the limits of coastal protection that salt-marsh plants can provide.

A long-standing problem for coastal scientists has been defining what the performance limits of coastal vegetation are for reducing wind and wave energy, and how they change over time. For salt marshes, Willemsen *et al.* found these limitations by carefully excavating 3–6 tonne blocks of plants and soil and transplanting them into a massive, 300-metre-long wave flume. They then hit the salt marsh with powerful waves up to 2 metres in height. This ‘big science’ experiment alone was an engineering challenge to construct and conduct. As a reward for their labour, the authors successfully delineated the performance limits of salt-marsh plants as a

nature-based solution during storms.

Willemsen and colleagues found that plants reduced wave heights effectively during small storms, but had less of an effect during large ones. For example, during a brief simulated storm (of less than one hour) with a water depth of 1.5 metres above the marsh and waves that were 0.75 metres tall, the wave heights were reduced by around 17%. However, after simulating for 25 hours a large storm with a water depth of 4 metres and 2-metre-high waves, heights were reduced by only about

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1%. Their findings are conceptually similar to those of previous experiments in salt-marsh³, sand-dune⁴ and seagrass⁵ environments.

But Willemsen *et al.* go a step further and extrapolated their experimental results to determine the global implications. To achieve this, they first produced a statistical regression model that showed how wave height and exposure duration can be used to predict the wave-reduction abilities of vegetation. The model’s prediction strength was high, as indicated by a standard R^2 value of 0.93.

Using this model, the authors then mapped the potential reduction in wave height in salt marshes worldwide. Their approach was similar to that of previous work⁶, although that study investigated the lateral erosion of marsh edges, as opposed to the plants’ wave-reduction abilities. Willemsen *et al.* also describe the global distribution of the wave-reduction benefits and find hotspots on all continents, and in areas as varied as India, Argentina, Australia, Canada and the Netherlands.

However, the model and map were created using only one plant species, the grass *Elymus athericus* (also known as *Thinopyrum acutum*), the distribution of which is limited to Europe. Some species will reduce wave heights, flooding and erosion more effectively than others will⁷. Plant height, stem diameter, flexibility, leaf density and canopy complexity vary for different species. Still, as the authors note, the plants in their experiment were relatively small and flexible compared with most other types of wetland vegetation. Therefore, the global extrapolation was appropriately conservative.

More broadly, the use of organisms as nature-based solutions for coastal protection (Fig. 1) has many other elements that still need to be explored. Although the authors focused mainly on wave reduction by the plants, their wave-flume experiment also showed that the marsh surface experienced a very low amount of sedimentary erosion. However, the marsh soil used was relatively fine and probably cohesive. As others have shown⁸, extreme shear can happen in other types of marsh soil, resulting in much higher rates of erosion. Sediment loss to waves is more likely to be a function of soil characteristics than of vegetative structures⁹. Moreover, work in both dune¹⁰ and marsh¹¹ environments has shown that, in a strange turn of events, the wave resistance of vegetation can also lead to uprooting and could enhance erosion. In addition to plant cover, local coastal elevation, land topography and shore width can determine the relative effectiveness of protection by nature-based solutions.

Finally, Willemsen *et al.* show that, at a

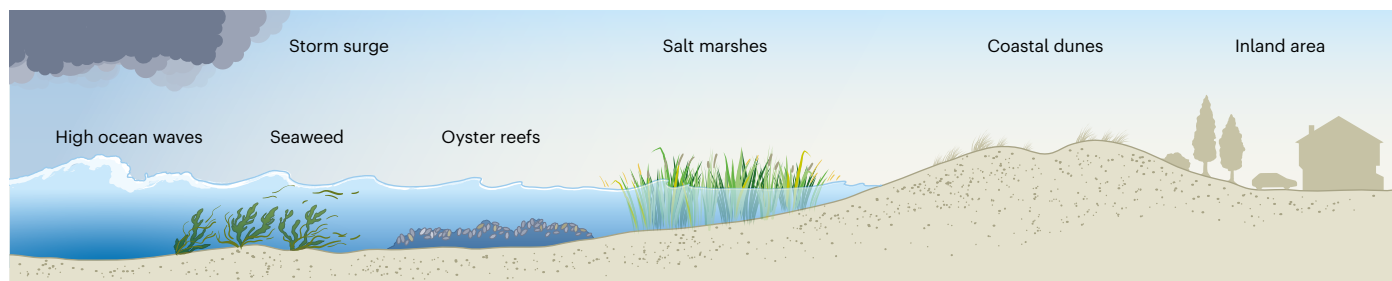


Figure 1 | Nature-based solutions for protecting coasts against extreme storms. As the climate changes, the occurrence of severe storms will probably increase. Nature-based solutions can help to protect coastal infrastructure. Depending on the location, such solutions could include seaweed, oyster reefs,

salt marshes and sand dunes. Willemsen *et al.*² now show that salt-marsh plants can reduce wave heights effectively during low-energy storms. However, during high-energy storms, wave attenuation is less effective and salt-marsh vegetation is damaged progressively.

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minimum, the use of salt-marsh plants as a nature-based solution can save policymakers large amounts of money. In an example given by the authors, building on the work of others, even a small wave reduction can decrease the height that an engineered levee needs to be to provide protection from even the most extreme storms. Moreover, a height difference of only a few dozen centimetres is worth at least US\$1 million in both avoided construction costs and storm damages. Unlike engineered structures, such as sea walls, vegetated ecosystems also provide habitats for both globally threatened species and ones that are specific to that area. Overall, the benefits of salt marshes and other nature-based solutions will only prove more valuable as Earth warms, the sea rises and storms become more extreme.

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Electronic engineering

Fabric user interface can be worn on your sleeve

Shanshan Yao

Touch-sensitive, light-emitting yarn can turn everyday clothing into washable, bendable user interfaces with dynamic graphics and versatile computing functions. **See p.1167**

On page 1167, Fu *et al.*¹ report a fabric sleeve that displays graphics, senses touch and environmental conditions, and conducts simple computational tasks, all while stretching and breathing like ordinary cloth. By seamlessly assembling electronic devices directly into fibres, the authors have turned everyday

clothing into a graphical user interface (GUI) – a visual display, similar to a smartphone screen, that allows people to interact with electronic devices.

Conventional GUIs rely on flat, rigid 2D screens, whereas fabrics are constructed by intertwining flexible 1D threads.

Previous attempts to build textile displays generally involved attaching 2D display panels or sparsely distributed light modules onto fabrics^{2,3}. However, these approaches often either compromise the fabric's softness and stretchability or offer limited pixel density. Specialized light-emitting threads have also been used as the basis of textile displays, but these are often dim, slow to react to user prompts, require high operating voltages or do not support individually coloured pixels that can be easily controlled^{4,5}. Fu *et al.* have solved the mismatch between 2D circuitry and 1D fibres by building the entire fabric-based GUI directly from flexible, touch-sensitive and light-emitting yarn.

The researchers developed a scalable process to make their millimetre-thick fibres. First, they used lasers to strip the protective insulation from specific spots on hair-thin copper wires that were aligned in parallel. Tiny light-emitting chips were then attached to the exposed sections using a solder that bonds exclusively to the stripped copper, creating electrical connections to the chips. This approach enabled thousands of chips to be connected along the wires with extreme precision. The resulting constructs were then incorporated into a transparent plastic tube – a precursor structure, which was 20 by 18 by 200 millimetres, that would eventually be turned into the final fibres. To achieve this, the wires were fed into a channel running along the long axis of the tube.

Next, Fu *et al.* added a pressure-sensitive structure made from two strips of a compressible, conductive polymer into a second longitudinal channel in the tube. To make the fibres, the whole assembly was passed through an apparatus that heats and stretches the structure, maintaining the arrangement of its components but greatly reducing the area of its cross-section. A custom funnel was used to prevent the chips on the wires from twisting out of alignment during this process.

The authors' method can produce fibres up to 10 metres long that are thin and flexible



Figure 1 | A textile that acts as a graphical user interface. Fu *et al.*¹ report a graphical user interface made from light-emitting, pressure-sensitive fibres. The device has the flexibility and breathability of conventional fabric and was integrated into the sleeve of a garment. It responds to touch and executes various functions, including acting as a calculator.

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