In Rhode Island, it was a day of 60 mile-per-hour northeasterly winds. The south shore of the state was battered, beaches were eroded, and coastal ponds were breached. It was Oct. 29, 2012, and Hurricane Sandy had arrived on the East Coast.

“What we got was nothing compared to what New Jersey and New York experienced, but Sandy did cause a lot of damage to towns in southern Rhode Island,” says Jim Turenne, Rhode Island assistant state soil scientist.

While the hurricane brought destruction to the East Coast, it also created something else. For Turenne and other soil scientists in the area, Sandy gave them the opportunity to study coastal soils that were exposed after the storm. With information and experiences taken from the storm, researchers built on their efforts to map and classify soils along the coasts. Scientists hope all of that data will help coastal residents better plan development and more easily recover from—or even avoid—damage from storms.

**Mapping Coastal Soils**

According to the National Oceanic and Atmospheric Administration (NOAA), more than half of the U.S. population lives within 50 miles of the coast. With people using the coastal areas for businesses, homebuilding, and recreation, understanding the soil on which that development is happening is crucial. How vulnerable are those areas to erosion and storm damage? What soils are best for building a home and where are those soils located?

A major step forward in helping to answer some of these questions took place in 2004 when Turenne and his colleagues started a coastal zone soil survey of Rhode Island. In addition to mapping soils on coastal land, the scientists also mapped “subaqueous soils”—soils that are underwater at depths up to 2.5 m (just over 8 ft). These soils had not been mapped with any detail; in fact, it was not until the early 1990s that these submerged areas were even considered soil.

The idea to define and map subaqueous soils was a bit of an accident, according to Debbie Surabian, a Natural Resources Conservation Service (NRCS) state soil scientist in Connecticut. To map soils efficiently, scientists typically take a circular route that covers a large work area and leads back to the starting point. George Demas, the pioneer of subaqueous soils, was following this practice in the 1980s when he dropped his auger in and said, “Hey, this looks like soil I can map.” Lots of research was done, and we expanded the definition of soils in the 11th edition of *Keys to Soil Taxonomy* to include subaqueous soils.

A big push in the mapping of subaqueous soils in the Northeast came from a project to restore coastal habitats. Scientists were working to bring back natural areas, such as eelgrass beds, that had been degraded. Biologists began to look for the best locations for re-establishing these habitats. But with all of the data they had, they realized they were missing one piece of information—the kind of soil in which eelgrass likes to grow.

These developments and the questions they posed led the way for the coastal
zone soil survey. In addition to the basic knowledge that comes from more fully mapping and interpreting coastal soils, these efforts help with restoration and recovery projects that often carry a large price tag. Millions of dollars are spent helping to restore coastal zones after storms such as Sandy, and any additional knowledge of the coastal areas aids in the recovery.

**Rare Opportunities after Hurricane Sandy**

While much work had been done to map coastal soils in Rhode Island by the time Hurricane Sandy arrived in 2012, the storm provided some additional information and opportunities. After the hurricane had passed, Turenne and some colleagues went out to look at the damaged areas. In several places along the coast, the storm had eroded and cut into the soil leaving behind outcrops—areas where multiple layers of the soil were exposed. Seeing these layers, which are usually buried, allowed scientists to better understand, map, and classify the types of soils beneath their feet.

In addition to being able to see soil layers that are normally hidden, Hurricane Sandy also gave the scientists an idea of what areas of the coast were most vulnerable to damage.

“The storm actually helped us see which areas eroded more and which areas were protected,” Turenne explains. “Previously, all of the beach had been mapped out as one beach unit. We developed different map units for the beaches separating them based on whether they were mostly sand, stones, or boulders. And we saw differences in erosion.”

The beaches made up mostly of boulders were resistant to erosion and made it through Hurricane Sandy largely intact. The sandy beaches, however, were easily and quickly eroded. In some areas, the dunes lost 50 to 60 ft of material. By determining which types of beaches were more or less prone to erosion, soil scientists offer helpful information for future uses of beach areas.

The storm also provided unexpected opportunities to better see and map other locations, such as ponds. In many coastal ponds in Rhode Island, inlets have been dredged, allowing salt water in and subjecting the ponds to tidal flooding. Trustom Pond is a freshwater pond that does not have such an inlet. But during the hurricane, it did breach. The storm overwashed the barrier and created an opening through which the pond water could escape. Water levels dropped about 5 ft.

With the pond water levels very low, Turenne and a colleague from NOAA were able to walk around the pond and photograph soils that were usually under water. They were also able to dig holes and collect soil samples much more easily than when the soils are under water.
An area of Napatree (extremely bouldery) soils exposed following the breach of Trustom Pond by Sandy. Dark lines on the rocks indicate the water level before the breach.

“I came across the pond, and it was almost like someone had pulled the plug out and just drained the whole thing,” Turenne says. “I had mapped the pond in 2007, and this gave me a chance to check my mapping by looking at these areas that were now exposed.”

In Connecticut, restoration efforts were also underway after Hurricane Sandy. Much of Surabian’s effort was focused on sediment removal. The storm had pushed sediment up into salt marsh channels, restricting flow in the channels and causing flooding.

“We went out and helped determine what fresh sediment was there,” Surabian says. “These areas have been mapped but very coarsely. That’s one of the things we want to map more fully—our marsh areas. But what we could do [immediately] was walk the streams and find the depth of looser, fresher sediment deposited by the storm.”

Among the sediment, one thing that Surabian was looking out for was sulfidic material—soil materials that contain sulfur compounds that are oxidized to sulfuric acid when the soil is exposed to air. The materials accumulate in coastal marshes near the mouths of rivers and streams. If kept underwater, the sulfuric acid isn’t released. But these materials are easily mobilized during flooding and storm events.

“If it comes up, most of the time it smells like rotten eggs, and you’ll know it’s there,” Surabian explains. “When the sulfides do oxidize, oxygen in the water is consumed, and metals and ions are released into the water. It causes habitat degradation and kills plants and animals.”

With the many problems that sulfidic materials can cause, it’s important that soil scientists know where they are, especially in areas prone to storms. These materials are now tested for and identified as part of subaqueous soil mapping. Identification of materials such as these is another reason that the coastal zone soil survey can help with planning projects along the coast and recovery efforts after storms.

Ongoing Mapping and Outreach

Hurricane Sandy and other storms have provided soil scientists with rare glimpses into coastal soils as well as reasons to better understand them. And soil scientists have made great strides in coastal zone soil survey mapping in the last decade. As of this year, all of the dunes, marshes, and beaches in Rhode Island have been re-mapped and interpreted. Turenne hopes to finish mapping the small coastal ponds this year also.

In addition to the mapping, outreach has been an important part of the coastal zone soil survey project. With the large amount of data now available, Turenne and his colleagues want to make sure that people are aware of and are using the information. The data are available via the SoilWeb app, making them extremely easy to access and use. (The app, developed in partnership between University of California–Davis California and NRCS, is available for iPhone and Android devices.)

“We’re trying to spread the word that the coastal community can now use a tool that they weren’t familiar with using before,” Turenne says. “With smartphones, you can just be sitting on your boat or the beach, hit the SoilWeb app, and you’ll get the information you want.” Adds Surabian, “Anyone from a town planner to a shellfish management planner can use the data.”

Turenne is often asked about the dynamic nature of coastal areas and what that means for mapping. But he says that the coasts are actually more stable than some might think. Mike Bradley, at the University of Rhode Island, did a study in which he looked at bathymetry—a type of underwater topographical map. Using data from a coastal lagoon, he compared bathymetry from the 1960s to new bathymetry that was collected as part
of a subaqueous soil survey. He found few differences. Maggie Payne, with the Rhode Island NRCS, also found few changes in a similar study of Little Narragansett Bay.

“The studies basically show that there’s really not that much change that occurs. If you think of the life of a soil survey being 20 to 30 years or so, there’s little change that occurs in that time,” Turenne explains.

To address the few changes that they might find, Turenne and his colleagues are making yearly updates to the data in Rhode Island. If they see that something has changed, if a storm comes along that shifts things around, or if another pond is mapped, they add that information into the yearly updates of survey data. These additions will keep the coastal maps and information reliable.

While much progress has been made in Rhode Island and other select places in the northeast, the efforts need to continue. Turenne recently gave a presentation about mapping coastal soils at the National Cooperative Soil Survey Conference in Maryland. He pulled up the SoilWeb app and looked at coastal areas that were hit by Nemo, a storm that came through after Hurricane Sandy. He found very little information.

“For the Plum Island area in Massachusetts hit hard by Nemo and other storms, there was basically no data and no interpretations,” he explains. “There was nothing to say you may not want to put a house in this area because it’s going to be washed into the sea during the next storm. This troubles me. There is no data telling people to stay away from these areas.”

But through the many efforts of soil scientists like Turenne and Surabian, the knowledge to map and understand coastal soils across the country – and even around the world – is now available. “There needs to be a push to map these areas,” says Turenne. “We have the capabilities and the right protocols and procedures to map coastal areas quite effectively and efficiently.”