In 2007, police in a northeastern U.S. state received a tip about a cold case dating back to 1984. A woman had gone missing that year, and authorities learned that four cars had possibly been compacted, stacked together, and buried behind her house shortly after she disappeared.

Suspecting the woman’s remains might be buried with them, the police called on Jim Doolittle, a soil scientist with the USDA-Natural Resources Conservation Service (NRCS), to search for the cars with a technology called ground-penetrating radar (GPR). Unlike police radar, which transmits radar waves through the air, GPR sends radar energy into the ground. Some of that energy then bounces back to a receiving antenna when it hits something in the soil. And, sure enough, Doolittle did detect a large object more than 15 ft beneath the surface of the woman’s former backyard. The radar data also suggested it was metallic.

But “GPR detects, it doesn’t identify,” Doolittle says. That’s why he couldn’t be certain he’d located the crushed cars and was so alarmed to learn what the police planned next. The backyard was right out of Better Homes and Gardens magazine, he says, with lush plantings and elegant walkways and fountains. “And the next thing I hear, they’re going to dig it up.”

Anxiously awaiting news on the day of the excavation, Doolittle asked himself whether he might have misinterpreted the data. Then the police unearthed some wire fencing and a small appliance, and Doolittle was sure he had, that the backyard had been destroyed for nothing. But after almost calling off the search, the police dug deeper and found the cars (although not, unfortunately, the woman’s remains).

“So, that was a good story,” Doolittle says, with a hearty laugh. “It could have gone the other way, too.”

Few people know the truth of those words better than Doolittle. A pioneer in the use of GPR in soil, he started with the technology more than 30 years ago when it was still a novelty. He has since “lowered the radar antenna” in all 50 states and several foreign countries, he says, learning mostly through trial and error when GPR works well and when it doesn’t.

In Florida, where Doolittle first began using the technology, it performs wonderfully. But the first time he took his radar unit outside Florida, the outcome was completely different. In front of a large crowd, he tried to detect the bedrock beneath the soil near the town of Hondo, TX—and failed utterly. “I’ll never forget that day,” he says. “The radar had no penetration.”

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At the level of individual cases, too, GPR is never a sure bet. True, it was successfully used to help pinpoint the lost grave of 15th-century British king, Richard III, last year. But in the first forensic investigation ever conducted by a USDA soil scientist, it also failed to find the body of a murdered six-year-old boy, who police suspected was buried near Vero Beach, FL. (The boy’s grieving father, John Walsh, became an advocate for missing and exploited children and later hosted the television program America’s Most Wanted.)

**Soil Conditions Play Large Role in Success**

Why, for instance, did GPR work so poorly in Hondo, TX? Soil scientists now know that radar energy quickly “attenuates,” or weakens, under certain soil conditions. “The signal energy gets absorbed by the chemical properties of the soil, so that we don’t get a reflection back,” explains Mary Collins, a retired University of Florida professor and GPR expert who began working with Doolittle in the 1980s.

GPR can’t “see” anything, in other words, under high pH, high salt, or—as in Texas—high clay conditions. “But in Florida,” Collins adds, “the soils are very acidic and sandy, and, oh, it would work beautifully.”

Under other conditions, meanwhile, GPR spots too many things: tree roots, rocks, and other objects that can be mistaken for the true search item. Tree roots can cloud the picture nearly anywhere. But in the northeastern U.S. where Surabian works, there is another complication. The soil is “glacial till”—full of unsorted sediments varying widely in texture, size, and density.

“So, if you’re looking for what we call ‘anomalies’ and you’re not used to viewing this kind of material, it can be really confusing,” says Surabian, who is the state soil scientist for Connecticut and Rhode Island. “It takes a lot of passes with the radar to get comfortable with identifying something out of the ordinary.”

One time, for instance, Surabian used GPR to help the Connecticut state archaeologist search for the buried stone foundation of a historic meeting house. As she moved the radar unit across the soil surface, “there was so much rock in the soil that I kept saying, ‘Well, was that [the foundation]? Was that it?’” Surabian recalls with a laugh.

Finally, the pair decided to try the opposite approach. Instead of moving the GPR toward the suspected location of the foundation, they positioned the radar unit directly above it—or, where they thought it was—and surveyed out from there.

“Then I could definitely tell: Here’s the rock foundation and here’s where I’m stepping off,” Surabian says. “So, it takes some ingenuity sometimes.”
Debbie Surabian describes a radar record in the field as she and colleagues search for the buried stone foundation of a historic meeting house.

There are also many times when ingenuity, enthusiasm, and good soil conditions are all present, but things still don’t get found. Doolittle once hunted for unexploded bombs in the soil beneath a former bombing range on a tiny Hawaiian island—the only time he ever received hazardous duty pay. After surveying a stretch of ground with GPR and detecting nothing unusual, Doolittle and his colleagues were digging a soil pit when a metal ball rolled in from the side. It turned out to be a bomblet from a cluster bomb.

“So, that’s an error of omission,” Doolittle says with understatement. “The lesson here is that I can detect things with radar, but I can’t detect everything in every inch of ground.”

Searching for Buried Remains

In other cases, the existence of buried artifacts may not be true (see sidebar), while in still others, an object simply can’t be detected with GPR. It’s a common misconception that radar can pick up skulls or bones, for example, says Surabian, who holds GPR workshops for detectives and forensic scientists in the northeast. Instead, radar operators look for a break or disturbance in the soil’s natural structure of horizontal layers, indicating a possible grave shaft. Or they try to detect a coffin, blanket, or trunk that the body might have been placed in, Collins says.

Separating Tall Tales from Historical Events using GPR

Since she began working with ground-penetrating radar (GPR) in 2000, Debbie Surabian has used the instrument to search for all manner of things in the soil, including unmarked graves, buried time capsules, pipes, foundations, water raceways, and even the crash site of a fighter jet.

But finding the objects themselves isn’t what interests the Natural Resources Conservation Service (NRCS) soil scientist the most. It’s learning the truth behind the tales people tell about them.

“When I go to these sites, I’m always hearing stories, and they’re part of our history,” Surabian says. “So, is it just a story or is it real?”

One of her favorite examples comes from work she did for a historic cemetery in the Stonington borough of Connecticut. According to the Stonington Historical Society, an English mariner named Captain Thomas Robinson bought 11 acres of land on Long Point in the borough in 1771. He then built a house, sold house lots to others, and began using one lot as a burial place for his family and a few friends. This cemetery was eventually expanded and became known as the Robinson Burying Ground.

The cemetery was thought to contain several unmarked graves, but when Surabian was called in to search for them, she was told about something else that might be under the ground. According to local legend, a British bombshell landed in the cemetery during the Battle of Stonington in 1814 (part of the War of 1812), creating a large crater. When a local woman named Elisabeth Hall died shortly afterward from an illness, Surabian was told, her daughter hastily buried her and her bed in the cavity.

“So, I’m thinking, “that’s a great story!”” Surabian says with a laugh, and she decided to make a pass with the radar to look for the crater. During her first run with instrument, she called excitedly to her close collaborator and fellow NRCS soil scientist, Jim Doolittle: “Jim, I think I see it. Wow!”

Upon setting up a search grid to look more systematically for the crater, the pair was even more convinced they’d located it. GPR indicated that the soil used to fill the hole was different from what was there originally. Plus, the soil’s typical structure of horizontal layers, or “horizons,” had been disrupted in what the radar data indicated was a perfect V-shape.

Not surprisingly, the radar failed to detect Elisabeth Hall or her bed; GPR normally doesn’t pick up bones or other human remains, Surabian explains. Still, she’s thrilled to have helped confirm at least part of the story of the unusual burial and the “legend of the crater.” Sometimes tall tales are true.

A filled bomb crater can be visualized on this 2D radar record from the Robinson Burying Grounds.
One of the most unforgettable days in Collins’ career involved such a search. Several years ago, she got a call from the sheriff’s office in Brevard County, FL. A 12-year-old boy had been murdered 15 years earlier, and his body was never found. Now, though, police had a prisoner in custody who had confessed to the crime and described where the boy’s buried remains could be found. Did Collins think she could locate them with GPR?

Her years of experience told her the chances were low, especially since the body had been buried for so long. Still, Collins agreed to try. “So, my graduate student and I went to the field site, not knowing that the TV cameras from Orlando were going to be there,” she says. “And, then, this is why it really stands out, because the boy’s parents were also there.”

After speaking briefly with the couple, Collins began pulling her GPR unit across the site. She and the sheriff’s deputies worked all day, finding several anomalies that forensic archeologists at the scene then dug for. But none of them was the boy. “It was a real shame,” Collins says, “because I really did want to find something.”

No doubt everyone at the scene was as disappointed as Collins, although she did caution the police and the parents that the search likely wouldn’t succeed.

That’s the thing about GPR. As a sophisticated technology that’s employed to help solve archeological and criminal mysteries, it naturally catches people’s attention. “Everybody wants to know if you found anything,” Surabian says.

What people tend not to be so interested in, however, are GPR’s limitations, Doolittle says. By talking about them more, he thinks soil scientists could do a service both to the public and their own profession.

“There is a lot of glitter and Hollywood with the radar, but we have to temper that,” he says. “And the tempering comes from understanding how it behaves in different soils.”