Travel the length and breadth of Pennsylvania and you’ll notice a divide that has defined the state from the start: The southeast is settled and wealthy farm country, while the less prosperous north and west have always depended on boom-and-bust cycles of resource extraction. Nearly all of Pennsylvania was clear-cut in the late 1800s and early 1900s, making it for a time the largest producer of lumber in the United States. Underground coal mining began even earlier, followed by surface strip-mining in the 20th century. Oil and gas production have also flourished here; since 1859, more than 325,000 wells have been drilled.

Now the latest boom is on. Thousands of feet below the surface are the Marcellus and Utica shales and their largely untapped reserves of natural gas.

For decades, geologists have known about the fuel stored in deep rock formations such as the Marcellus, which runs beneath Pennsylvania, New York, West Virginia, and other Appalachian states. But extracting it wasn’t economical until the advent of horizontal drilling and the controversial technique known as hydraulic fracturing (view video here: http://marcellus.psu.edu/resources/drilling/index.php), or fracking. In the latter process, millions of gallons of pressurized water, sand, and chemicals are injected deep into the earth to fracture the shale and release the trapped gas.

Since 2004, nearly 3,000 shale gas wells have been drilled in Pennsylvania, which is still just a tiny fraction of the state’s conventional oil and gas wells. But because shale gas is so deep and extracting it means handling massive amounts of water, much more infrastructure is involved than in conventional drilling—creating a much bigger footprint as a result, says Pennsylvania State University assistant soil science professor Patrick Drohan.

“I could see right away when I saw my first Marcellus gas pad,” he says, “that this would be something that would change Pennsylvania’s landscape unlike anything the state has seen in well over 50 years.”

To support the drilling of a 5,000-foot-deep well and the fracking process that follows, engineers must build a raised, gravel pad of three to five acres in size and a stormwater system to handle the resulting runoff. New roads to the drill pad are needed, as are compressor stations for pumping the gas and pipelines to carry it away. And because most of the pressurized water comes back up once hydraulic fracturing is finished, flowback water storage ponds and treatment facilities must be constructed, as well.

But the vast landscape changes produced by shale gas development are poorly understood, which is why Drohan, Penn State wildlife ecologist Margaret Brittingham, and others are now working to shed some much-needed scientific light on the process. Their first goal has been to char...