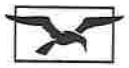
MICHAEL LEWIS

THE FIFTH RISK



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generation you're able to see how the rungs of the ladder of opportunity are laid out in front of you, and you can see the hands that pull you up. You see people pull you up and you say, 'Okay, I've got to do the same thing for other people.' I came up that ladder of opportunity, but even I didn't know the names of the government programs that made up the ladder itself. Growing up, what was obvious to me was the kindness of community members. But government was less visible. You need to work really hard to appreciate it."

And who wants to do that?

III

ALL THE PRESIDENT'S DATA

AS SHE WALKED the path that the tornado had torn through the American town, she was struck by how hard it would have been to imagine what she was now seeing. Two days earlier, on May 22, 2011, the wind had cleaved Joplin, Missouri, in two, leaving behind a lot of you-have-to-see-it-to-believe-it stuff: a rubber hose run entirely through a tree trunk; a chair sideways, all four legs piercing a wall; a giant Walmart tractor trailer thrown two hundred yards onto the top of what had been the Pepsi building; a full-size SUV folded in half around a tree. The metal had been flayed from the car, and the tree was no longer a tree but a tree trunk, as all the branches had snapped and blown away. "I felt like some giant had taken an egg beater and run it through a town," said Kathy Sullivan. "It was toothpicks."

Then she realized that the egg beater metaphor was not

exactly right, as the edges of the destruction were eerily undisturbed. What the tornado had narrowly missed was as perfectly preserved as what it had hit was perfectly eliminated. "It was like when you run your finger through the icing on top of a cake," she said. "A clean line of total destruction." Doctors in the local emergency rooms were seeing trauma they'd never seen. Body parts strewn on the ground outside the hospital. A small child, back stripped of flesh right down to the bone: they could count his vertebrae. People impaled by street signs. People with wounds that looked as if they were caused by automatic rifles—except that the objects deep inside them were not bullets. Seriously injured people had driven themselves to the hospital with dead loved ones in their cars and apologized to the hospital staff. They didn't know what else to do with the bodies.

Tornado outbreaks in the middle of the United States that spring had killed more than five hundred people. In Joplin alone 158 people had died, and thousands had been injured, many critically. That was more than had been killed by a single tornado since the U.S. government had taken on the job of warning people about them. In and of itself this was shocking, but to Kathy Sullivan it was especially so. These people had been informed; the warnings from the National Weather Service, which would soon be reporting to her, had been even better this time than they usually were. The initial tornado watch had come four hours before the event—but then a tornado watch is different from a tornado warning. The average National Weather Service tornado warning comes thirteen minutes

before a tornado strikes: Joplin's sirens had sounded the warning seventeen minutes before the tornado touched down and nineteen minutes before it entered Joplin. But the citizens of Joplin had ignored it. "*The majority of surveyed Joplin residents did not immediately go to shelter upon hearing the initial warning. . . ,*" as the report Sullivan would soon oversee noted.

One day someone will write the history of the strange relationship between the United States government and its citizens. It would need at least a chapter on the government's attempts to save the citizens from the things that might kill them. The first successful tornado prediction was made on an air force base in Norman, Oklahoma, in 1948. The men who made it had been lucky: they wouldn't be able to do it again. Knowing this, the government had taken the view that people were better off not being warned. The Weather Bureau, as it was then called, was banned from using the word "tornado." It just frightened people, the bureau believed. But word got out: the government meteorologists had this mysterious new skill. And people *demanded* to hear what they had to say, even if what they had to say was of little value.

Since then, the government meteorologists had gotten better at their jobs. The billions of dollars they'd spent on satellites, radar, computing power, and better forecast models had led to, among other things, truly useful tornado warnings. And yet people didn't seem to realize that

the government's weather information was more and more reliable—or even that it was their government giving it to them. It no longer shocked Kathy Sullivan to hear otherwise educated citizens say that they got their weather from the Weather Channel. Or some app on their phone. A United States congressman had asked her why the taxpayer needed to fund the National Weather Service when he could get his weather from AccuWeather. *Where on earth did he think AccuWeather—or the apps or the Weather Channel—got their weather?* Where was AccuWeather when winds of two hundred and something miles per hour were churning through an American town, killing people?

Clearly, citizens didn't understand their government. But that had been true for some time. Now Kathy saw that the government didn't really understand its citizens, either. Why had they not saved themselves? If anyone should know the answer to that question, it was Kathy herself—and she had no clue. In some curious way, the United States government had a better handle on the weather than on its own people. It had spent billions of dollars to collect data about the weather, and none about how people responded to it.

She could not help but admire the people of Joplin. Walking through the ruins, she saw all over again what she had seen so many times: how much better Americans were at responding to a disaster than preventing it. Everybody who could was pitching in to help. The border of the devastated area looked like a tailgater at a college football game. The people who had been spared were cooking food for the people who had not. "No one asked questions," said

Kathy. "No one asked if your home had been destroyed. If you walked up and said you were hungry, you got food."

No one could say she hadn't done her job. She was not by nature or upbringing a political person, but her ambition had led her to become one. She had made all the little compromises—done all the little deals with others and with herself—required to survive in the upper reaches of American government. She was now second-in-command—and soon to be first—at the National Oceanic and Atmospheric Administration, or NOAA. NOAA oversaw the National Weather Service, among other things. The National Weather Service had seen the tornado and had issued a warning. Her people had given these people what they needed to survive. And yet on May 22, 2011, more Americans had been killed by a single tornado than on any day in the past sixty-four years.

She might have said nothing. Just thrown up her hands in the privacy of her office and told herself that it wasn't her job to save people from their own stupidity. Instead she asked herself: *What don't we understand about our own citizens?* She flew back to Washington and gathered the relevant parties—all of whom might have claimed credit for a job well done—and asked them, "Is anyone here happy about the outcome?"

To their credit and hers, no one was.

Before she had been given her first paying job by the United States government, Kathy Sullivan had been put

through a battery of tests. Some were physical, some were psychological, and others—well, she didn't know quite what they were. At no point during them had she figured out what her testers were looking for. She survived two virtually identical interviews with the National Aeronautics and Space Administration, one with a good NASA cop, the other with a bad NASA cop. "The bad cop made you feel uncomfortable," she said. "The room was ill-lit. He sat behind the desk, and you sat in an exposed chair. You weren't facing each other. He was mumbling and not friendly. Then they did it all over again with a warm, sunny guy who was your best friend." Only much later did she learn that they wanted to see if she answered questions the same way whether she was at ease or not. "I didn't have anything to compare it to," she said. "You might try to manipulate the system, but you need to know the system, and I didn't."

Later she decided that they weren't even really trying to figure out who she was. All they had wanted was the answer to a question: Will she be that same person that she appears to be now when she is traveling at 17,500 miles per hour 140 miles above Earth and something goes bang?

This was her first job interview, and she was applying to be an astronaut. It was 1977, but the work was still risky. "Every flight was still proving that you can get up there and come back alive," she said. "It's like riding bombs." Still, 8,078 other Americans had applied for the job. Five thousand six hundred eight of these had satisfied the basic job requirements. Of those, NASA invited 208

people to the Johnson Space Center, outside Houston, for a week of interviews. "They interviewed us in groups of twenty," Kathy said. "I got there and saw this cluster of other people. It was all guys. That was okay. I'd been the only woman in a field camp and the only woman on a ship." The difference was that this wasn't just guys but a club. "My sense was a lot of these guys knew each other. They're fighter pilots or whatever. I'm twenty-five. I'm a grad student. I'm broke. They seem to be settled in and knew what they're doing—and I didn't. I thought, *Well, Kathryn, enjoy the week.*"

The main event was a ninety-minute interview at a long table filled with strangers. One was the famously inscrutable head of the astronaut program, George Abbey. At the start he leaned back in his chair, eyes half-closed, and did not so much ask as mutter, "Tell us about yourself. Start with high school." That was it. Nothing more. "It was deliberately underspecified," Kathy said.

Telling people about herself wasn't her strong suit. "I've never been a self-revealing person," she said. She went ahead and told them about herself anyway. How by the age of thirteen she'd learned from her father, an aerospace engineer, to fly a plane. How, as a girl growing up in the fifties and sixties, she assumed that her ticket to adventure was not a pilot's license but her gift for languages. Before she graduated from high school, without setting foot in France or Germany, she became fluent in both French and German. She planned to learn a bunch more languages. "My simple theory was: learn lots of languages and use

them to see the world," she recalled, in an oral history for the Johnson Space Center. She entered UC Santa Cruz in 1969 as a language major. But there was a science requirement, and to fulfill it she took two classes in ocean science. There she learned that human beings were now descending fourteen thousand feet in tiny submarines and *mapping* the ocean floor. "It was endlessly fascinating. This mix of things I'd always seen on the pages of *National Geographic*."

The travel she'd imagined until then had been horizontal: east or west, north or south. She now began to imagine it as vertical, too: up and down. She wanted to study the plates beneath the bottom of the sea.

She was accepted into graduate geology programs everywhere she applied, including Princeton, with full research fellowships. She accepted the free ride at Dalhousie University, in Halifax, Nova Scotia, because what interested her was the mountain range at the bottom of the Atlantic Ocean known as the mid-ocean ridge, and for several reasons Nova Scotia seemed to her the best place to study it. From just about the moment she arrived, she started looking for access to a submarine that could take her down, so that she might inspect the mid-ocean ridge up close. "I'm pursuing an academic career and asking, 'How do I get into one of those submarines?' I wanted to go see the stuff myself."

It was her brother who had first told her about NASA's new need for astronauts. He'd seen an ad in the newspaper announcing that the space agency was opening its rocket ships to all Americans between the ages of twenty-five and forty, under six feet tall, weighing less than 180 pounds,

and in possession of just about any sort of college science degree. He'd already applied and thought she also should. Women were specifically encouraged for the first time. Minorities, too. All that was required were some character traits: "a willingness to accept hazards comparable to those encountered in modern research airplane flights, a capacity to tolerate rigorous and severe environmental conditions, and an ability to react adequately under conditions of stress or emergency." Up to that moment NASA had been looking mainly for test pilots who could at least feign indifference to their mortality. Now they were looking for scientists—or at any rate scientifically minded people—but with a twist: they needed the temperament of fighter jocks. Kathy hadn't taken her brother seriously. *You really think they're going to hire an oceanographer? A girl????*

A few weeks later she ran across the call for astronauts again, this time in a science journal. They really did seem to want women scientists. And she sensed that she might be the sort of woman they were looking for. "I never brought normal girl books home from the library," she recalled. "I was fascinated by maps and the stories they told." She was handy, too, and quick to figure out how things worked. "I kind of always flunked the dolls test," she told an interviewer for the Johnson Space Center's oral history project. "I never found the dolls interesting. The doll*house* stuff I found interesting, but from an architectural point of view: *building* them. And I'd want to lay them out differently. I didn't want to just move the furniture around, and I sure didn't want to just sit there and imagine conversa-

tions [between dolls] that never happened. Let me go build another house; that was more interesting."

The head of NASA's astronaut program had asked her to tell the group about herself—but she sensed that they were after something else, too. They listened without saying a word, until she got to a point in her story where she was on a ship in the ocean, in a storm, conducting research. It was the aspect of research oceanography she loved best: "Figuring out how to adapt to everything that happens while you're at sea and still come back with the data that you needed, and the accuracy that you needed. I loved that challenge," she said. "Then you've got to work up the data and write the papers as sort of penance to be able to go out to sea again the next year."

George Abbey interrupted her just as she was describing how, in the middle of the storm, in the middle of the night, a critical piece of research equipment had busted. She'd had to haul it into the boat in the darkness and inspect each segment. The oceanographer in charge of the expedition had watched her labor for the first few hours but finally turned grumpy. "Just fix the damn thing," he had said, and gone to bed.

"So what did you do?" Abbey asked her.

"What do you mean what did I do?" she said. "We fixed it."

"And then you went to bed?" he asked.

"I felt like saying, *No, you idiot, I did not go to bed.*" Instead she explained that she had stayed up for two more hours, to make sure her fix held in the storm. Later NASA had her

take a Myers-Briggs–type personality test. Like virtually all the astronauts—but unlike roughly 85 percent of the American population—she profiled as a "mission-driven" person. "The mission-driven type was overrepresented in the astronaut population," she said. "Whereas more dreamer- or salesman-type folks are very underrepresented."

From the original eight thousand or so applicants, NASA selected thirty-five to become astronauts. Six were women, all scientists. A lot of the men were indeed former fighter pilots. They tended to see themselves as the main event and, at least at first, looked upon the women scientists assigned to accompany them as a sideshow. Kathy wasn't shy about expressing her thoughts on this subject. *You know you're just my taxi driver,* she told one of the pilots. *My job is the interesting part of this mission.* He didn't like it, but the space program was changing. "By the time I got to it," she said, "it had gone from just proving you could get there and come home alive to: what are we doing here?"

What they were doing in space was what she sensed she'd been put on earth to do: explore, gather data, and make sense of it. "The science was three big things," she said. "Bullet point one: using space as a platform to look back at Earth and out into the cosmos. Getting a different point of view. There is a kind of understanding of this planet that space alone makes possible. Bullet point two: What do we need to know that we don't know about living in space? Bullet point three: How does the human body respond to being sprung from the force of gravity? How do fluids flow? How does the body behave?"

What had grabbed her attention from the start was the earth science. The snapshot that might be taken of Earth from above, of the current conditions on Earth that were going to be crucial to mankind's understanding of its environment. "I was all about bullet point one," said Kathy.

She couldn't just skip the other bullet points, however. She might see her job as gathering data about the planet; but a lot of other people saw their jobs as gathering data about *her.* They now had another kind of human body to study, though it was reluctant. ("I was moderately disinterested in being a lab rat.") It didn't help that the engineers at the heart of the space program had some strange notions about women—for instance, that they were more vulnerable to rapid decreases in pressure. "The air force worked with this aerospace medical unit," she said. "They'd concluded that the women were more likely to experience the bends when the pressure went from high to low. They think they've detected a higher instance of damage to the central nervous system. They tell them I'm going to die." She thought: *You guys don't have enough data, and the data you have you've handled badly.* She pointed out that female deep-sea divers didn't experience any special problems at lower depths.

It was an open question as to which was more mysterious to a male NASA engineer: outer space or the American female. They appeared to have better data on outer space. They had prepared makeup kits for their space shuttles, for instance, even though Kathy and a couple of the other women didn't wear makeup. They set out to design flame-retardant one-size-fits-all bras and underpants, until the

women explained that the one-size-fits-all approach used for men's underwear wasn't going to work with women's underwear. In the end, the women won the right to buy their own flame-retardant underwear. And how would a woman urinate in space? The engineers worried about that one for a while. The male astronauts had been fitted with condom catheters, but these were always threatening to leak or even burst and obviously wouldn't work for women. To everyone's relief, a NASA engineer created an extra-absorbent polymer and worked it into a diaper that could be worn by all. (In the bargain he'd anticipated the baby diapers of the future.)

And of course, the male engineers were seriously worried about what might ensue if a woman had her period in space. "The idea that women might menstruate in orbit drove the whole place up a wall," said Kathy. "The male world's response was, *Oh, that's ok. We'll just suppress their periods.* We all looked at each other and said, 'You and what other army, buddy?' " The engineers finally agreed to pack tampons in the supply kits. The first time Kathy opened her kit she saw that each tampon had been removed from its paper wrapper and sealed in a plastic fireproof case. Heat-sealed tampons. Each plastic case was connected to another. She pulled on the top one and out pops this great long chain of little red plastic cases, like a string of firecrackers. Hundreds of tampons, for one woman to survive for a few days in space. "It was like a bad stage act," she said. "There just seemed this endless unfurling of Lord only knows how many tampons."

The engineers eventually sat down with the female astronauts to discuss the matter.

"Would one hundred be the right number?" they asked.

Kathy Sullivan worried that NASA might use the differences between their bodies as an excuse "to write different rules for males and females." The male astronauts, on the other hand, adapted pretty quickly to the presence of women. The guy she'd been assigned to walk with in space was named Dave Leestma. They'd had a moment together that captured the spirit of their interaction. They had started training in their space suits. Step 1 was to remove their clothes and put on the first layer of the 225-pound suit—the Liquid Cooling and Ventilation Garment. The test chamber was full of male engineers. "I have this fleeting sense that everyone has just realized that we're about to go boldly where no man has gone before—there's a woman in this mix," said Kathy, in the NASA oral history. "So I looked over at Dave and said, 'Dave, let me tell you my philosophy about modesty in circumstances like this.' He shifts a bit and says, 'Okay.' I said, 'I have none.' He said, 'Fine.' We start peeling off clothes."

Kathy couldn't have been less interested in the gender drama. She just wanted to go to space and "see it for myself, not in a magazine picture." She wanted to get on with the mission. Which was why she never complained about her space suit. "It was a small, medium, large kind of thing—not a custom fit kind of thing," she said. "My knee was never in the knee of the suit. The suits were stiff and took real muscle to move. Whenever I had to

bend my legs I had to overcome this extra leverage." By the time she realized that her suit was never going to fit, NASA had asked her to wear it. "I was not going to turn this into 'See, we told you she'd be all this extra trouble.' I decided, 'We're just sucking this up.'" But really, her space suit should have come with a warning label. In a test chamber, a NASA engineer had flipped the switch that enabled the space suit's emergency oxygen tank, and the suit had exploded in a giant fireball. "If you're doing some weird test that's unlike anything that you normally do, it would still get your full attention," Kathy said later, "but this was like saying that when you step on the gas of your car, it's going to explode. Highly discomfiting."

It was now October 11, 1984. The *Challenger* was in orbit, with her inside it, waiting to walk in space. The air was gone from the airlock. When they simulated this moment back on Earth they put a baking pan with water on the floor, to illustrate what might happen to your body's fluids if something went wrong with your suit. As the pressure dropped, the water would bubble violently, as if it were boiling. But then a couple of seconds later it would flash-freeze into ice crystals. Poof. "Don't open your visor!" they said.

On a mission this complicated, it was actually impossible to imagine everything that might kill you. The O-rings of the very spacecraft in whose airlock she now floated would soon become the most famous illustration of the point. Just fifteen months later, the failure of NASA to heed engineers' warnings about how brittle the rings that sealed the

solid rocket boosters could become in the cold would lead the boosters to leak and the *Challenger* to blow up, killing all the astronauts on board.

Later, when someone asked her why it never seemed to occur to her to be afraid, Kathy had an answer. In college she'd gone bushwhacking with a boyfriend around the Grand Canyon. They'd hacked a trail in a bad place, and they now had to jump onto a narrow ledge or go tumbling down a steep slope. The slightest misstep and she would fall to her death. "I mean, my knees are wobbling and shaking and I remember thinking: not now." Then she was fine. She'd discovered an emotional talent: she had the ability to decide not to be afraid. All the astronauts had it, she noticed. "If you are scared, I don't want you to be there," she said. "Be *here. Now.* Here. Now. This is the game. Be scared before. Be scared later. Not during."

Inside her space suit, with the pressure gone from the *Challenger*'s airlock, she felt no change at all, and that struck her here as strange, just as it had on Earth. "I always thought, Isn't this room supposed to look different when it has no air in it? But there's no difference!" She moved along a handrail to open the hatch. She poked her head out into space. Then she reached out and tethered herself to the hook on the outside of the capsule, before untethering herself from the hook inside the airlock. "Mountaineering 101." With her body traveling at 17,500 miles per hour she set out, hand over hand, to demonstrate that it was indeed possible to refuel a satellite in orbit. With that, she became the first American woman to walk in space.

That first step would shadow her for the rest of her life. President Reagan would invite her to a dinner at the White House and sit her beside him. Corporations would offer her high-paying jobs. Civic organizations across the country would offer her awards and ask her to come and tell her story. Seemingly all of Long Island would soon be in touch, because at some point in space she had looked down—how could she not—and shouted, "Hey, there's Long Island!" She had a choice of how to play her experience. "You can dine out on this stuff forever," she said, "but that was feeling shallow to me. I wanted to make the experience *matter.*"

The same internal process that had led her to decline the role of "girl" made it possible for her to pass on the role of "lady astronaut." She flew twice more into space, orbited Earth a few hundred more times, and then, in the early 1990s, went looking for something else to do. She now had a measure of celebrity and needed to make a decision about how best to use it. She wanted another mission that felt as important as the one she'd just completed. She wanted to do earth science, and she wanted the stakes of the science to be high: that wasn't surprising. What was surprising was where she finally found her mission: the United States Department of Commerce.

Around the same time, DJ Patil also wandered into the Commerce Department, though in truth he didn't know it. Physically, he was sitting at a desk on the campus of the

University of Maryland, pursuing his PhD in mathematics. He'd found a security hole in the U.S. government's computers, and he reached through it to grab what he needed. What he needed was a very specific pile of data. That it, like much of the rest of the government's data, resided in the Department of Commerce he hadn't bothered to figure out.

DJ had come to Maryland from California to study with James Yorke, a professor who had coined the term "chaos theory." The idea was simple: some small, barely noticed event can cascade into huge consequences down the road. (The day your parents met, for instance: what if that hadn't happened?) A lot of the drama in his life DJ traced back to a small, little-noticed event in his early childhood: a tendency to reverse the order of numbers. When you see "16" as "61," you have problems in school. Struggling with his assigned tasks, he diverted himself with unassigned ones. Watching spy movies, he became intrigued with picking locks. He'd pick his way into other kids' lockers, move the stuff around inside, then lock them back up—just to freak them out. Then he learned how to pick people's pockets for fun. He'd take the car keys off some unsuspecting grown-up, move his car, then return the keys to the guy's jacket pocket. In the eighth grade he hacked the English teacher's computer and changed the grades—and never got caught. In ninth grade, a prank gone wrong set an entire hillside in a well-to-do Silicon Valley neighborhood on fire. DJ ended up listening to a cop read him his rights. The landowner agreed not to prosecute if DJ agreed to spend the next few months at hard labor, restoring the

hillside. While he was doing that he got himself suspended from his English class for exploding a stink bomb, and a few months after that from math class for . . . at that point it hardly mattered. By the time he graduated from high school—after a merciful school administrator changed an F on his transcript to a C—he wasn't the only one who might look at "DJ" and see "JD."

At De Anza Community College he stumbled into a calculus class and liked it. More than liked it. He realized he had a gift for it. The calculus class was another small life event that wound up having big effects. By the time he arrived in Maryland to pursue his PhD, he was still interested in math, but not so much as he was in what might be done with it, to study a lot of otherwise inexplicable things that happened in life and nature. "I was always in love with the patterns in nature," he said, "and what I needed were the tools to understand them. And for me, math was the most sensible."

All sorts of natural phenomena might be modeled and understood with chaos theory. The collapse of the sardine population off the California coast, for example. Or the bizarre long landslides that occurred in the Mojave Desert, where the rocks ended up inexplicably far from where they'd started, given the slope of their journey. "These long run-out landslides are crazy. The question is: how did the rocks end up so far away?" In theory, the new math might explain it. In practice, there wasn't enough data on the movement of the rocks, or the sardine holocaust, for him or anyone else to study them effectively. The same went

for traffic jams, the boom-bust cycles in the wolf and deer populations in the American West, and countless other big events triggered by surprisingly small ones.

Then he happened upon the weather. He'd always been interested in it, but never thought of it as something he might study until he discovered that the U.S. government was sitting on a huge trove of weather data. It resided inside something called the National Oceanic and Atmospheric Administration, which was in turn inside the Department of Commerce—but he didn't have any idea of that yet. He was just roaming around servers within the U.S. government, the sole supplier of the data he needed if he was going to get his PhD. "The only place I could get the data was the weather."

Since the end of the Second World War, weather data collection has become one of the greatest illustrations of the possibilities of global collaboration and public-spiritedness. Every day thousands of amateur weather observers report data to their governments, as do a lot of experts aboard commercial planes in the sky and on ships at sea. Every day, twice a day, almost nine hundred weather balloons are released from nine hundred different spots on the globe, ninety-two of them by the U.S. government. A half-dozen countries, including the United States, deploy thousands of buoys to collect weather from the ocean surface. Then there's the data collected by billion-dollar satellites and fancy radar stations—in the United States alone, the

National Weather Service maintains 159 high-resolution Doppler radar sites.

The United States shares its weather data with other countries—just as other countries share their weather data with the United States. But back in 1996, when DJ was hacking the Department of Commerce computer servers, weather data was not generally available to even the most enterprising hacker. "It wasn't open to the public," said DJ, "but it turned out there was a hole." What came through that hole was such a vast trove of information that it overwhelmed the capacity of the computers in the University of Maryland's math department, so DJ hunted for other computers at the university he might use. "You can get historical data and play with it," he said "It was the original idea of the internet. I was *that* guy. I didn't have a supercomputer. So I just had to steal that, too."

He'd start work at eight every night, when no one else was using the computers, and go until seven the next morning. He cobbled together enough storage to hold his borrowed treasure. "That was my academic claim to fame," he said. "That I downloaded the Weather Service's data."

As he looked at the data, a couple of things became apparent. First, that the weather forecasts were improving more dramatically than he'd imagined. No one else was paying much attention to this, but for the first time in history the weatherman was becoming useful. Before the Second World War meteorology had been a bit like medicine in the nineteenth century: the demand for expertise was so relentless that the supply had no choice but to

make fraudulent appearances. Right through the 1970s, the weather forecaster would look at the available weather information and, relying heavily on his judgment and personal experience, offer a prediction. His vision typically extended no more than thirty-six hours into the future, and even then it was blurry: *snow will fall somewhere over these three states.* For a very long time the weather had been only theoretically predictable—that is, people had some pretty good ideas about how it might be predicted, without being able actually to predict it.

Around the time DJ began downloading it, the weather data had led to practical progress that shocked even the theoreticians. On March 12, 1993, what became known as the Storm of the Century hit the eastern United States. Its force was incredible: waves in the Gulf of Mexico sank a two-hundred-foot ship. Roofs across southern states collapsed under the weight of the snow. Tornadoes killed dozens of people. Travel ceased along the entire Eastern Seaboard.

But the biggest difference between this storm and those that had come before it was that it had been predicted by a model. Following a segment on *CBS Evening News* about the siege of the Branch Davidian compound in Waco, Texas, Louis Uccellini, a meteorologist with the National Weather Service, had warned of the coming massive threat.

The TV hosts had treated the nation's weatherman with amusement—they ended the story by saying, "The weatherman is usually wrong." But this time he wasn't. The National Weather Service had relied on its forecasting

model, with no human laying hands on the results, and it had predicted the location and severity of the storm five *days* before it hit. "It was unheard-of," said Uccellini. "When I started in the 1970s, the idea of predicting extreme events was almost forbidden. How can you see a storm before the storm can be seen? This time, states declared an emergency before the first flake of snow. It was just amazing for us to watch. We sat there wrapping our heads around what we'd done." Six years after the storm, Uccellini described the advances in weather prediction from about the end of World War II as "one of the major intellectual achievements of the twentieth century."

The achievements received surprisingly little attention, perhaps because they were, at least at first, difficult to see. It was not as if one day the weather could not be predicted and the next it could be predicted with perfect accuracy. What was happening was a shift in the odds that the weather forecast was right. It was the difference between an ordinary blackjack player and a blackjack player who was counting the cards. Over time the skill means beating, rather than losing to, the house. But at any given moment it is impossible to detect.

DJ could see that this progress was a big deal. A world-historic event. Here you could see chaos theory dramatized, but in reverse. You could rewind history and consider how things might have come out differently if our ability to predict the weather had been even a tiny bit better, or worse. "The failed hostage rescue in Iran was caused by a sandstorm we didn't see coming," said

DJ. "The Kosovo offensive was so effective because we knew we wouldn't have cloud cover." You could pick almost any extreme weather event and imagine a different outcome for it, if only people had known it was coming. The hurricane that struck Galveston, Texas, back in 1900, before anyone thought to name such storms, had struck without warning and killed so many people that no one ever figured out exactly how many had died. Maybe six thousand or maybe twelve thousand. What their grandchildren would know about the weather might have saved them all.

Here was yet another illustration of chaos in life: even slight changes in our ability to predict the weather might have fantastic ripple effects. The weather itself was chaotic. Some slight change in the conditions somewhere on the planet could lead to huge effects elsewhere. The academic meteorologists around DJ knew this; the question was what to do about it. The Department of Meteorology at the University of Maryland, as it happened, had led a new movement in forecasting and spurred the National Weather Service to change its approach to its own models. Before December 1992 the meteorologists had simply plugged the data they had into their forecasting model: wind speeds, barometric pressure, ocean temperatures, and so on. But most of the planet's weather went unobserved: there was no hard data. As a result, many of the model's inputs were just estimates—you didn't actually know the

wind speed or barometric pressure or humidity or anything else at every spot on the planet.

An idea pursued at Maryland and a couple of other places was to run the weather model over and over, with different initial weather conditions. Alter the conditions slightly, in reasonable ways. Vary the wind speed, or barometric pressure at 10,000 feet, or the ocean temperature, or whatever seemed reasonable to vary. (How you did this was its own art.) Do it twenty times and you wind up with twenty different forecasts. A range of forecasts generated a truer prediction of the weather than a single forecast, because it captured the uncertainty of each one. Instead of saying, "Here's where the hurricane is going," or "We have no idea where the hurricane is going," you could say, "We don't know for sure where the hurricane might go, but we have a cone of probability you can use to make your decisions."

"Ensemble forecasting," the new technique was called. It implied that every weather forecast—and not just hurricanes—should include a cone of uncertainty. (Why they don't is a great question.) "There's a storm coming on Saturday" means one thing if all the forecasts in the ensemble say the storm is coming. It means another if some of the forecasts say there is no chance of rain on Saturday and others say that a storm is all but certain. Really, the weather predictions should reflect this uncertainty. "Why is the newspaper always giving us a five-day forecast?" asked DJ. "It should be a two-day forecast sometimes. And it should be a fourteen-day forecast other times."

By the time DJ discovered the security hole in the government's database, the National Weather Service had taken to ensemble forecasting and was generating a dozen or more forecasts for each day. On some days the forecasts would be largely in agreement: slight changes in the estimates of current weather conditions did not lead to big changes in the future weather. At other times they varied radically. That is, sometimes the weather was highly chaotic and sometimes not. DJ quickly saw that instability was not in any way linked to severity: a Category 5 hurricane might keep on being a Cat 5 hurricane without a whole lot of doubt. Then, other times it wouldn't. "Why in the case of one storm are the forecasts all the same, and in the case of another they are all different?" he asked. Why was the weather sometimes highly predictable and other times less so? Or as DJ put it, "Why does a butterfly flapping its wings in Brazil cause or not cause a tornado in Oklahoma?"

With the government's data he was able to contribute a new idea: that the predictability of the weather might itself be quantified. "We all know the weather is chaotic," he said. "The question is: how chaotic. You should be able to assess when a forecast is likely to go seriously bad, versus when the weather is stable." In the end his thesis created a new statistic: how predictable the weather was at any given moment.

When he defended his thesis, in the summer of 2001, he was surprised by what the U.S. government's data had enabled him to do. "As a grad student you're just like, I

hope I have something that doesn't suck. You don't actually expect your stuff to work." He wasn't a meteorologist. Yet he'd found new ways to describe the weather. He'd also found, in himself, a more general interest: in data. What else might it be used to discover?

The relevance of that ambition became a bit clearer after the terrorist attacks of September 11, 2001. "There was a sense that this was, among other things, a failure of data analysis," he said. "If we had known how to distinguish signal from noise we'd have seen it and prevented it. 'Hey, why are all these guys suddenly taking flight lessons?' " The assassins' use of credit cards alone, properly analyzed, would have revealed they were up to no good. "The image of a good network is messy," said DJ. "It's really hard to fake messiness. It's hard to fake being an American with a credit card."

The big question now in DJ's world was: How, using data, do you identify threats to U.S. interests? By this time a young postdoc at Maryland, he attended a talk by a guy who ran something called the Defense Threat Reduction Agency. The agency, inside the U.S. Department of Defense, was charged with defending the country against weapons of mass destruction. It was trying to understand terrorist networks so it might disrupt them. "I hear the talk, and I was like, *Wait a second*," DJ recalled. "The idea that if you push a network a certain way it might collapse. Is the network stable or unstable? It's a lot like the question I was asking about weather forecasts." A terrorist network, like a thunderstorm, might be chaotic. Terrorist networks,

along with a lot of other security matters, might be better understood through chaos theory. "If you pull out a node in a terrorist cell, does it collapse? Or the opposite: How do we design our electricity grid so that if you take out a node it does NOT collapse?"

Thinking they would make use of his data skills, he went to work at the Department of Defense, where he expected to look for patterns in terrorist networks. But instead of sticking him at a computer, his new employer shipped him off to a couple of former Soviet republics, to track and understand the stockpiles of biological and chemical weapons left behind by the Russians. "They tell me, 'We need you to go to Uzbekistan and Kazakhstan,' and I'm like, 'I'm a *mathematician*.' That was the first question I asked: 'Why me?' They said, 'Hey, you're a doctor.' And I said, 'I'm not that kind of doctor.' And they said, 'Close enough, you'll figure it out.'" After that, they sent him to Iraq, to help rebuild the school system. All of the work was interesting, and a lot of it useful, but it didn't have much to do with his deep ambition. "People still didn't really appreciate how you can use data to transform," he said.

To his surprise, this was true even of people back home where he had grown up, in Silicon Valley, to which he soon returned. Even there he couldn't get a job doing what he wanted to do with data. "I was just trying to figure out where I could be helpful," he said. "Google passed on me. Yahoo! passed on me." His mom knew someone at eBay and so he finally was hired the undignified way. At eBay

he tried, and failed, to persuade his superiors to let him use the data on hand to find new ways to detect fraud.

At length he moved to a new, slow-growing company called LinkedIn, where job seekers posted their CVs and attempted to create their own little networks. His new bosses asked him to be Head of Analytics and Data Product Teams. There, for the first time, he found an audience receptive to his pitch. "The same tools you use to identify where bad guys are, you can do with job skills," he said. "You can show people where skills cluster. Where they might belong in the economy. If you're trained in the army in ordnance disposal, maybe you'd be good at mining." The analytics he'd created at LinkedIn had done exactly that—prodded an army bomb expert to find work setting explosives in mines.

Along with much more: in the space of a few years, the interest in data analysis went from curiosity to fad. The fetish for data overran everything from political campaigns to the management of baseball teams. Inside LinkedIn, DJ presided over an explosion of job titles that described similar tasks: analyst, business analyst, data analyst, research sci. The people in human resources complained to him that the company had too many data-related job titles. The company was about to go public, and they wanted to clean up the organization chart. To that end DJ sat down with his counterpart at Facebook, who was dealing with the same problem. What could they call all these data people? "Data scientist," his Facebook friend suggested. "We weren't trying to create a new field or anything, just

trying to get HR off our backs," said DJ. He replaced the job titles for some openings with "data scientist." To his surprise, the number of applicants for the jobs skyrocketed. "Data scientists" were what people wanted to be.

In the fall of 2014 someone from the White House called him. Obama was coming to San Francisco and wanted to meet with him. "He'd seen the power of data in his campaign," said DJ, "and he knew there was a new opportunity to use it to transform the country." When the White House asked him if he wanted to bring his wife to the meeting, DJ figured that Obama was looking for more than a conversation. Inside of eight years he'd gone from being a guy who couldn't get a job in Silicon Valley to being a guy the president of the United States wanted to offer a job he couldn't refuse. When Obama did ask DJ to move to Washington, it was DJ's wife who responded. "How do we know if any of this will be of any use?" she asked. "If your husband is as good as everyone says he is, he'll figure it out," said Obama. Which of course made it even harder for DJ to refuse.

DJ went to Washington. His assignment was to figure out how to make better use of the data created by the U.S. government. His title: Chief Data Scientist of the United States. He'd be the first person to hold the job. He made his first call at the Department of Commerce, to meet with Penny Pritzker, the commerce secretary, and Kathy Sullivan, the head of the National Oceanic and Atmospheric Administration. They were pleased to see him but also a bit taken aback that he had come. "They seemed a

little surprised I was there," recalled DJ. "I said, 'I'm the data guy and you're the data agency. This is where a huge amount of the data is.' And they're like, 'Yes, but how did you know?'"

Nobody understood what it did but, then, like so many United States government agencies, the Department of Commerce is seriously misnamed. It has almost nothing to do with commerce directly and is actually forbidden by law from engaging in business. But it runs the United States Census, the only real picture of who Americans are as a nation. It collects and makes sense of all the country's economic statistics—without which the nation would have very little idea of how it was doing. Through the Patent and Trademark Office it tracks all the country's inventions. It contains an obscure but wildly influential agency called the National Institute of Standards and Technology, stuffed with Nobel laureates, which does everything from setting the standards for construction materials to determining the definition of a "second" and of an "inch." (It's more complicated than you might think.) But of the roughly $9 billion spent each year by the Commerce Department, $5 billion goes to NOAA, and the bulk of that money is spent, one way or another, on figuring out the weather. Each and every day, NOAA collects twice as much data as is contained in the entire book collection of the Library of Congress. "Commerce is one of the most misunderstood jobs in the cabinet, because everyone thinks it works with

business," says Rebecca Blank, a former acting commerce secretary in the Obama administration and now chancellor of the University of Wisconsin. "It produces public goods that are of value to business, but that's different. Every secretary who comes in thinks Commerce does trade. But trade is maybe ten percent of what Commerce does—if that." The Department of Commerce should really be called the Department of Information. Or maybe the Department of Data.

Get to Know the U.S. Government had not been high on Donald Trump's to-do list, even after he learned that he'd be running it. On the Monday after the presidential election, the same thing that had happened across the rest of the U.S. government happened inside the Department of Commerce: nothing. Dozens of civil servants sat all day waiting to deliver briefings that would, in the end, never be heard. They'd expected Trump's campaign organization to send in Landing Teams to learn about what was being done there, and why. The problems that had been Obama's problems for the past eight years were about to become Trump's problems. But his people didn't seem to want to know about them. "They just didn't bring any bodies in at all," says a senior Commerce official. "There was just very little attention paid to any of the pieces. The Census—they just didn't seem interested in knowing any of that. It all seemed to be about trade. Or the size of the Commerce workforce."

Right up until early January, no one turned up at NOAA to figure out who should run the place and how

they would run it. But at the end of November Trump nominated Wilbur Ross, a seventy-nine-year-old Wall Street billionaire, to be the next secretary of commerce. A few weeks later Ross came in for a single meeting with Penny Pritzker. "He came by himself," recalled one of the people who greeted him. "I was shocked. Just this very old guy, all by himself. And it was pretty clear he had no idea what he was getting into. And he had no help."

He also soon had a problem: two billion or so missing dollars. A *Forbes* reporter named Dan Alexander, studying the financial disclosure forms Ross had been required to file with the Office of Government Ethics, had been struck by the discrepancy between how much money Ross said he had, and how much he'd told *Forbes* reporters that he had, over the course of many years. *How had $3.7 billion suddenly become $700 million?* Three point seven billion is what Ross had told *Forbes* he was worth. He'd sent *Forbes* a list of his assets every year for the past thirteen years, so that he would qualify for the magazine's annual list of the four hundred richest Americans. He'd always failed to answer *Forbes*'s follow-up questions, and so the people at *Forbes* who compiled the list reduced the number to $2.9 billion. To be conservative about it.

Alexander was now one of the *Forbes* staffers who compiled the magazine's rich list—and he had access to the *Forbes* files. "I thought this was kind of odd," he said. "It bugged me that it didn't add up. I called Ross up to see what he had to say about it. And he sounds like a credible guy." Ross claimed the explanation was simple: between

the election and the inauguration he had simply *given away* two billion dollars to a trust, owned by his heirs.

Alexander had first assumed that the scandal was that Wilbur Ross was hiding money from the U.S. government. But after pressing the Department of Commerce to fill in the giant holes in Ross's story, he realized that Ross had misled *Forbes*. For thirteen years. "I went back in the files," said Alexander. "We [at *Forbes*] had [initially] counted the money that belonged to his investors in one of his funds as his own money. I was stunned that anyone had let that slide. He lucked into a way to be on the list, without deserving to be on the list. But once he gets on the list, he lies. For years." The *Forbes* reporters were accustomed to having rich people mislead them about the size of their wealth, but nearly all of them had been trying to keep their names *off* the list. "In the history of the magazine only three people stand out as having made huge efforts to get on, or end up higher than they belonged," said Alexander. "One was [Saudi] Prince Alwaleed. The second was Donald Trump. And the third was Wilbur Ross."

The scandal wasn't that Wilbur Ross was hiding two billion dollars from the government, but that he'd never had the two billion dollars in the first place. Alexander wrote up his findings, after which, he says, "I got a bunch of calls from people who had worked with or for Wilbur Ross, to say how happy they were the truth finally came out." The former number-three man at Ross's old firm, who had worked with Ross for twenty-five years, spoke on the record. "Wilbur doesn't have an issue with bending

the truth," he said. This was the man Trump had chosen to guard the integrity of the data on which our society rests.

Yet inside the Department of Commerce there came, in the spring of 2017, a ray of hope. In March the Trump White House asked the help of a former senior climate policy adviser from the George W. Bush administration who had actually worked for eight years inside the Department of Commerce. "They came into the Department of Commerce," said the former Bush official, "and they discovered that it has got this thing in it called NOAA. And it's sixty percent of the Commerce Department budget. And they said, 'What the fuck is NOAA?' "

The Bush official flew to Washington, DC, to speak with Wilbur Ross about the place Ross was meant to have been running for the past several months. *It's not the Department of Commerce*, the Bush official told him in so many words. *It's the Department of Science and Technology.* It was a massive data-collecting enterprise, and the biggest collector of all was the National Weather Service. NOAA also regulated the fishing industry and mapped the ocean floor and maintained the fleet of ships and planes used in gathering information. It had collected climate and weather data going back to records kept at Monticello by Thomas Jefferson. Without that data, and the Weather Service that made sense of it, no plane would fly, no bridge would be built, and no war would be fought—at least not well. The weather data was also the climate data. "If you don't believe in climate change, you at least want to understand the climate," said the Bush official. And if you wanted to

understand the climate, you needed to take special care of NOAA's data.

There was no way the Bush official could get across all he wanted to tell the new commerce secretary in a single meeting. "NOAA is a beast," he said. "It's twelve thousand employees and they are decentralized—out in these little tiny offices all over the country. But it does more to protect Americans than any other agency except for Homeland Security and the Department of Defense." The Bush official did get to tell Ross his main point about NOAA. "It's incredible value and everyone shits on it," he said. "The people are great. They aren't in it for the money. They're in it for the mission." And he asked Ross a question: "What's your philosophy for running the department?"

"What do you mean?" asked Ross.

"It's not really the Department of Commerce," said the Bush official. "Its mission is a science and technology mission."

"Yeah, I don't think I want to be focusing on that," said Ross.

"It was clear to me that he had not thought about what the science and technology meant," said the Bush official. "He doesn't have a scientific bone in his body."

That was totally okay. The secretary of commerce could continue to pretend to be the Secretary of Business. But he sadly needed to put people in place under him who understood the science. The Bush official assumed he'd been brought in for just this reason: to help the new administration find the right person to run NOAA. He knew

qualified Republicans, inoffensive to Trump. He handed the Trump White House a list of half a dozen politically acceptable people who could do the job well enough.

Six months later, in October 2017, the White House announced its selection: Barry Myers.

Barry Myers hadn't been anywhere near the Bush official's list. He was the CEO of AccuWeather, one of the first for-profit weather companies. It had been founded by his meteorologist brother, Joel Myers, back in 1962. A third brother helped to run the company, which employed other family members, including Barry Myers's wife, Holly. The company was still privately owned by the Myers family, so it was hard to know exactly how big it was, or how much money it made, or how it made it. Staffers in the U.S. Senate charged with vetting Myers's nomination estimated that AccuWeather had roughly $100 million a year in revenue, and that it came mainly from selling ads on its website and selling weather forecasts to companies and governments willing to pay for them. Some weather geeks had recently discovered that the company had been selling the locations of people using its app, even when these individuals had declined to give AccuWeather permission to do this. At any rate, at his U.S. Senate hearings, Barry Myers estimated his AccuWeather shares to be worth roughly $57 million.

At first glance, the nomination made sense: a person deeply involved in weather forecasting was going to take over an agency that devoted most of its resources to under-

standing the weather. At second glance, both Barry Myers and AccuWeather were deeply inappropriate. For a start, Barry Myers wasn't a meteorologist or a scientist of any sort. He was a lawyer. "I was originally enrolled in meteorology as an undergraduate," he told the *Wall Street Journal* back in 2014. "I then dropped out of school because I was a horrible student. I was never interested in learning, which I look at now as sort of funny."

Then there was AccuWeather. It had started out making its money by repackaging and selling National Weather Service information to gas companies and ski resorts. It claimed to be better than the National Weather Service at forecasting the weather, but what set it apart from everyone else was not so much its ability to predict the weather as to market it. As the private weather industry grew, AccuWeather's attempts to distinguish itself from its competitors became more outlandish. In 2013, for instance, it began to issue a forty-five-day weather forecast. In 2016 that became a ninety-day weather forecast. "We are in the realm of palm reading and horoscopes here, not science," Dan Satterfield, a meteorologist on CBS's Maryland affiliate, wrote. "This kind of thing should be condemned, and if you have an AccuWeather app on your smartphone, my advice is to stand up for science and replace it."

Alone in the private weather industry, AccuWeather made a point of claiming that it had "called" storms missed by the National Weather Service. Here was a typical press release: "*On the evening of Feb. 24, 2018, several tornadoes swept across northern portions of the Lower Mississippi Valley*

causing widespread damage, injuries and unfortunately some fatalities. . . . AccuWeather clients received pinpointed SkyGuard® Warnings, providing them actionable information and more lead time than what was given by the government's weather service in issuing public warnings and other weather providers who rely on government warnings . . ."

All AccuWeather's press releases shared a couple of problems: 1) there was no easy way to confirm them, as the forecasts were private, and the clients unnamed; and 2) even if true they didn't mean very much. A company selling private tornado warnings can choose the predictions on which it is judged. When it outperforms the National Weather Service, it issues a press release bragging about its prowess. When it is outperformed by the National Weather Service it can lay low. But it is bound to be better at least every now and again: the dumb blackjack player is sometimes going to beat the card counter. "You have these anecdotes [from AccuWeather], but there is no data that says they are fundamentally improving on the National Weather Service tornado forecasts," says David Kenny, chief executive of the Weather Company, a subsidiary of IBM, which, among other things, forecasts turbulence for most of the U.S. commercial airline industry.

The closest thing to an authority on the relative accuracy of various weather forecasts is a website called ForecastAdvisor. It began, as so much weather research seems to, almost by accident. Its founder, Eric Floehr, was managing a team of software developers and went looking for material on which to practice a new programming lan-

guage. He stumbled upon weather forecasts—and a funny situation. All the forecasters were claiming to be better than each other: they couldn't all be right. "When I started in 2003, the private weather companies—AccuWeather, for example—are saying, 'We're the Number 1 forecast!' So I called them and said, 'You make this claim that you are the most accurate forecast: what are you basing it on?' They faxed me back an undergraduate paper written for a science fair that looked at forecasts for three months of one summer in Washington, DC. That was the best data they had to make that claim."

Over the next thirteen years, Floehr collected eight hundred million weather forecasts. "I was curious. Was there really a difference? '*I live in Paducah, Kentucky. Should I look at AccuWeather or the Weather Channel?*'" Lo and behold, there really was a difference. In the seemingly simple matter of predicting the high temperature for the day, some forecasters were better than others. None of them was consistently better all the time, however. Some were more accurate in some parts of the country than they were in others. Some were more accurate in some months of the year than in others. And there was no answering the question of who was better at tornado alerts or hurricane-track predictions or flood warnings, or at calling other life-threatening weather, because the private companies did not reveal their predictions of those events to anyone but their paying customers.

So Floehr analyzed everyone's ability to predict the high temperature on any given day. From 2003 up until 2011,

the National Weather Service's forecasts had been as good as the most accurate private weather forecast, including AccuWeather's. Since 2011, the private weather forecasters have been slightly more accurate than the National Weather Service. Still, says Floehr, "For sure I'm going to listen to the National Weather Service when they issue a tornado warning or a flash flood warning. I'm not going to trust right now AccuWeather or the Weather Channel."

Floehr's analysis uncovered two big trends in weather prediction. One was toward greater relative accuracy in the private sector—which of course was totally dependent on the National Weather Service data for its forecasts. The other was the astonishing improvement in all weather predictions. The five-day-out forecast in 2016 was as accurate as the one-day-out forecast had been in 2005. In just the last few years, for the first time in history, a meteorologist's forecast of how hot it will be nine days from now is better than just guessing.

Barry Myers liked to say that he was in competition with the federal government. If so, the competition was bizarre: the U.S. Department of Commerce gave him, for free, most of the raw material he needed to create his product. Without the weather satellites, weather radar, weather buoys, and weather balloons, there would be no weather forecasting worth listening to, much less paying for. Whatever AccuWeather—and any other private weather forecaster—might be doing to refine the National Weather Service's forecasts also depended on having those forecasts in the first place. "If the Weather Service forecast

wasn't there, all the private weather forecasts would get worse," says David Kenny.

But the National Weather Service was forbidden by law from advertising the value of its services—and if it even hinted at doing so, Barry Myers could apply pressure on it in all manner of ways. AccuWeather might make any sort of wild boast it wanted to about the accuracy of its weather prediction. It might disparage the very people who supplied it with the information it had used to make that prediction. The meteorologists at the National Weather Service had no real ability or even inclination to respond. "We had to drag them kicking and screaming into defending themselves against false charges," says a former Obama Commerce Department official. "They never claim credit. They always do these intensely self-critical how-can-we-do-better inquiries. It's a public safety mentality: they do what they do because they really sincerely and since they were eight years old love the science and the service, not because they care at all about credit or glory."

That was the sad truth—the public servants couldn't or wouldn't defend themselves, and few outside the U.S. government had a deep interest in sticking up for them. By the 1990s, Barry Myers was arguing with a straight face that the National Weather Service should be, with one exception, entirely forbidden from delivering any weather-related knowledge to any American who might otherwise wind up a paying customer of AccuWeather. The exception was when human life and property was at stake. Even here Myers hedged. "The National Weather Service does

not need to have the final say on warnings," he told the consulting firm McKinsey, which made a study of the strangely fraught relationship between the private weather sector and the government. "The customer and the private sector should be able to sort that out. The government should get out of the forecasting business."

In 2005 Rick Santorum, a senator from AccuWeather's home state of Pennsylvania and a recipient of Myers family campaign contributions, introduced a bill that would have written this idea into law. The bill was a little vague, but it appeared to eliminate the National Weather Service's website or any other means of communication with the public. It allowed the Weather Service to warn people about the weather just before it was about to kill them, but at no other time—and exactly how anyone would be any good at predicting extreme weather if he or she wasn't predicting all the other weather was left unclear.

Pause a moment to consider the audacity of that maneuver. A private company whose weather predictions were totally dependent on the billions of dollars spent by the U.S. taxpayer to gather the data necessary for those predictions, and on decades of intellectual weather work sponsored by the U.S. taxpayer, and on international data-sharing treaties made on behalf of the U.S. taxpayer, and on the very forecasts that the National Weather Service generated, was, in effect, trying to force the U.S. taxpayer to pay all over again for what the National Weather Service might be able to tell him or her for free.

After Santorum's bill failed to pass, AccuWeather's strategy

appeared, to those inside the Weather Service, to change. Myers spent more time interacting directly with the Weather Service. He got himself appointed to various NOAA advisory boards. He gave an AccuWeather board seat to Conrad Lautenbacher, who had run NOAA in the second Bush administration. He became an insistent presence in the lives of the people who ran the Weather Service. And wherever he saw them doing something that might threaten his profits, he jumped in to stop it. After the Joplin tornado, the Weather Service set out to build an app, to better disseminate warnings to the public. AccuWeather already had a weather app, Myers barked, and the government should not compete with it. ("Barry Myers is the reason we don't have the app," says a senior National Weather Service official.) In 2015, the Weather Company offered to help NOAA put its satellite data in the cloud, on servers owned by Google and Amazon. Virtually all the satellite data that came into NOAA wound up in places where no one could ever see it again. The Weather Company simply sought to render it accessible to the public. Myers threatened to sue the Weather Service if they did it. "He stopped it," said David Kenny. "We were willing to donate the technology to NOAA for free. We just wanted to do a science project to prove that we could."

Myers claimed that, by donating its time and technology to the U.S. government, the Weather Company might somehow gain a commercial advantage. The real threat to AccuWeather here was that many more people would have access to weather data. "It would have been a leap forward for all the people who had the computing power to do

forecasts," said Kenny. One senior official at the Department of Commerce at the time was struck by how far this one company in the private sector had intruded into what was, in the end, a matter of public safety. "You're essentially taking a public good that's been paid for with taxpayer dollars and restricting it to the privileged few who want to make money off it," he said.

By early 2018 Barry Myers had, by some mysterious process, gotten himself one Senate floor vote away from running NOAA. How he went about trying to secure that vote was deeply disturbing, at least in the eyes of the U.S. Senate staffers vetting his nomination. "We don't hear much from the White House," said one. "But the AccuWeather lobbyist is up here all the time. It's almost like it [NOAA] has been subcontracted to him, which is bizarre. It's Trump saying, 'If it is worth it to you, go get it.' Normally the White House would be doing this." Myers, for his part, was evasive. During the confirmation process, he was asked to name the people who sat on the AccuWeather board. Myers declined; the information belonged to the company and wasn't his own to disclose, he indicated. But just a short time earlier, in a private meeting, he had rattled the names off easily. (Several of them were members of his family.) He claimed he would sell his stake in AccuWeather but did not explain how or to whom. "He says he's going to sell his AccuWeather shares, but he could sell it to his brother for a dollar and buy it back for a dollar when he leaves office," says Walter Shaub, former head of the Office of Government Ethics.

In his bizarre competition with the National Weather Service, there were two ways for Barry Myers to win. His family business might consistently make better weather forecasts and earn the trust of paying customers through its virtuosity. Or it could make the National Weather Service forecasts worse—or at least less accessible. As a private citizen Myers devoted considerable energy to making the National Weather Service *seem* worse. As a public servant he could do much more. "Barry is uniquely dangerous, in a way a Scott Pruitt is not," said a Senate staffer. "Scott Pruitt does not understand the agency [Environmental Protection] he's trying to destroy. Barry's skills make him more effective in dismantling NOAA. There are a million little things he could do that we will never understand."

Another McKinsey study estimated that the entire industry generated somewhere between $2 billion and $4 billion a year in revenue and was growing fast. With reason. The annual cost of natural disasters in the 1980s had been $50 billion. Hurricane Sandy alone inflicted over $65 billion worth of damage. The private weather industry, unlike the National Weather Service, has a financial interest in catastrophe. The more spectacular and expensive the disasters, the more people will pay for warning of them. The more people stand to lose, the more money they will be inclined to pay. The more they pay, the more the weather industry can afford to donate to elected officials, and the more influence it will gain over the political process.

The dystopic endgame is not difficult to predict: the day you get only the weather forecast you pay for. A private

company will become better than the Weather Service at knowing where a hurricane will make landfall: What will it do with that information? Tell the public or trade it inside a hedge fund? You know what Hurricane Harvey is going to do to Houston before Houston knows: Do you help Houston? Or do you find clever ways to make money off Houston's destruction?

One version of the future revealed itself in March 2015. The National Weather Service had failed to spot a tornado before it struck Moore, Oklahoma. It had spun up and vanished very quickly, but, still, the people in the Weather Service should have spotted it. AccuWeather quickly issued a press release bragging that it had sent a tornado alert to its paying corporate customers in Moore twelve minutes before the tornado hit. The big point is that AccuWeather never broadcast its tornado warning. The only people who received it were the people who had paid for it—and God help those who hadn't. While the tornado was touching down in Moore, AccuWeather's network channel was broadcasting videos of . . . hippos, swimming.

When, at the request of the Trump White House, the former Bush Commerce Department official wrote up his list of people he believed were suited to run the National Oceanic and Atmospheric Administration, and the National Weather Service inside it, it never occurred to him to put Barry Myers's name on it. "I don't want someone who has a bottom line, or a concern with shareholders, in charge of saving lives and protecting property," he said. But it was more than that. To put Barry Myers in charge of NOAA

was to give him control over maybe the most valuable and necessary pile of data that the U.S. government collects. "The more people have access to the weather data, the better it is for the country," said the Bush official. "There's *so* much gold in there. People just don't know how to get to it."

DJ Patil had gone to Washington in 2014 to help people find that gold. He was the human expression of an executive order Obama had signed the year before, insisting that all unclassified government data be made publicly available and that it be machine-readable. DJ assumed he'd need to leave when the man who hired him left office, so that gave him just two years. "We did not have time to collect new data," he said. "We were just trying to open up what we had."

He set out to make as many connections as possible between the information and the people who could make new sense of it—to encourage them to use the data in novel and interesting ways. "I was looking to find people like me, when I was a student," he said. "We're going to open all the data and go to every economics department and say, 'Hey, you want a PhD?' In every agency there were questions to be answered. Most of the answers we have gotten have not come from government. They've come from the broad American public who has access to the data."

The opioid crisis was a case in point. The data scientists in the Department of Health and Human Services had opened up the Medicaid and Medicare data, which held information about prescription drugs. Journalists at ProPublica had combed through it and discovered odd concentrations of opioid prescriptions. "We would never have figured out that there *was* an opioid crisis without the data," said DJ.

The big pools of raw facts accumulated by the federal government are windows into American life. A team of researchers at Stanford University, led by an economist named Raj Chetty, used newly accessible data from the Internal Revenue Service to write a series of papers that addressed questions of opportunity in American life. One, titled "The Fading American Dream," asked a simple question: How likely is it that an American child will be better off than his parents? The IRS data allowed Chetty to study Americans across generations, and the census data let him compare them by race, gender, or whichever trait he wished to isolate. In the data he found an answer to his question, and much more. He discovered that while just over 90 percent of children born in 1940 went on to earn more than their parents, only 50 percent of children born in the 1980s did so. Every year, the economic future of an American child was a bit less bright. And the big reason was not lower rates of economic growth but the increasingly unequal distribution of money. More and more of the gains were being captured by the very rich. Mobility had a racial dimension as well: A white child born into the upper-income quintile was five times more likely to

stay there than to fall to the bottom. A black child born into the upper-income quintile was as likely to fall to the bottom as to remain rich.

More of America's problems than even DJ had imagined could be better understood and addressed with better access to the right information. The problem of excessive police force was another example. After a white policeman shot a defenseless black man in Ferguson, Missouri, the White House convened police chiefs from ten American cities, along with their data. The policing data was local and difficult to get ahold of—and that was DJ's point. He wanted to show what might be possible if the government collected the information. "We asked the question: What causes excessive use of police force?" Combing the data from the ten cities, a team of researchers from several American universities found a pattern that would have been hard to spot with the naked eye. Police officers who had just come from an emotionally fraught situation—a suicide, or a domestic abuse call in which a child was involved—were more likely to use excessive force. Maybe the problem wasn't as simple as a bad cop. Maybe it was the emotional state in which the cop had found himself. "Dispatch sent them right back out without time to decompress," said DJ. "Give them a break in between and maybe they behave differently."

A young guy in the White House pulled up stop-and-search rates from another pile of policing data. He discovered that a black person in a car was no more likely to be pulled over by the police than a white person. The difference was what happened next. "If you're black you're way more likely to get searched," said DJ. But then he noticed another pattern: not all the cops exhibited the same degree of racial bias. A few cops in one southern city were *ten times* more likely than others to search a black person they had pulled over. Right there in the White House, the young researcher showed the data to the city's police chief. "He genuinely had no idea," said DJ. "He was like, 'Can you please tell me more?' "

In the end, even DJ Patil was shocked by the possibilities that lurked in the raw piles of information the government had acquired. "I didn't grasp the scope at first," he said. And if you wanted to see the possibilities—the value that the entire society might reap from letting smart people loose on the data—you needed to look no further than David Friedberg.

In 2006 Friedberg was driving home in the rain to San Francisco from his job in Mountain View when he noticed how differently people behaved when it rained. The weather affected all sorts of businesses, though not so much Google, where Friedberg worked. The specific business that had caught Friedberg's eye was a bike rental company near Bayside Village on the Embarcadero. When it rained, no one rented bikes.

Obviously.

Friedberg had graduated from the University of California–Berkeley five years earlier, with a degree in

astrophysics. He was twenty-seven years old but could pass for sixteen. Because of where he lived and who he worked for, it was second nature for him to think, *If I can get my hands on data and quantify weather risk, I can sell weather insurance to the businesses that need it.* Ski resorts, airlines, utility companies, golf courses, packagers of beach vacations—there was really no end of industries, or even governments, that he might serve. Every inch of snow cost the City of New York $1.8 million dollars.

He found a few friends and angel investors to back him and hired a group of mathematicians to collect and analyze weather data. "Math people figure shit out," he said. His math people soon discovered the rich haul of weather data inside the Department of Commerce. They asked for and received the historical rainfall and temperature data from the National Weather Service's two hundred weather stations. They discovered that NOAA had collected, for the previous forty years, rainfall and temperature at every American airport, however small. They learned that NOAA maintained 158 radar installations, and that these recorded a big percentage of the rain that had fallen in America during the past fifty years—along with anything else that happened to be in the air. That's how the United States government had found the pieces of the *Columbia* after the space shuttle exploded in midair: using NOAA's radar.

The federal government has the sort of data on the weather that the Boston Red Sox has on Major League Baseball players. But unlike the Red Sox, it had made little

effort to exploit the value in it. The images from the radar stations, for instance. They were on tapes in a basement of a NOAA office in Asheville, North Carolina. To get the data into a form he could use, Friedberg paid NOAA to put it on hard drives and ship them to him. He then moved the data, for free, to the cloud. "That was the first data set we were able to get onto the cloud," said Ed Kearns, chief data officer at NOAA. "David showed Google and Amazon and Microsoft that there was a business case for taking it. Until we got it up, no one was able to reprocess the data."

Of course, without cloud computing there would have been no place to put the radar data. But once it was on the cloud it was generally accessible and could be used for any purpose. (Ornithologists at Cornell University would soon be using it to study bird migrations.) The math team at Friedberg's new company, which he called WeatherBill, used it to calculate the weather odds for some very specific situations. "What is risk?" asked Friedberg. "Risk is uncertainty about the outcome. The less data you have, the more uncertainty you have about the outcome." If you are the first person to cross the ocean on a ship, you are going to have trouble insuring yourself. If you are the thousandth ship, there is now data that certain kinds of ships do better than others, certain times of year are more treacherous than others, certain kinds of hulls are more durable, and so forth. "The more data we captured, the more we were able to determine the probabilities of some unfortunate event occurring," said Friedberg. "But there were private

companies, like AccuWeather and the Weather Company, that had issues with us getting access to weather data. In the end we agreed [with NOAA] we would not have access to the weather data *today*. We'd just get the historical data."

It took eighteen months before WeatherBill had a website on which anyone could come and insure himself against the weather. And people did turn up, in fits and spurts. The U.S. Open tennis tournament bought rain insurance, for example, as did the broadcaster that aired the matches. "Anything more than 0.01 inches of rain per hour means they can't play that hour," said Friedberg. Other interested parties included an Arizona ski resort, a pair of golf courses, a beach resort in Barbados, a car wash, and a hummus shop called Hummus Brothers. Friedberg hadn't known that people bought less hummus when it rained but, then, he was learning all sorts of odd stuff about people's exposure to the weather. Salad places did much better on sunny days; coffee shops did not.

But Friedberg also learned that it was harder to sell weather insurance than he had supposed. "He had this quaint supposition that there were all of these people looking for this online," says one of his former business partners. "And they weren't."

By 2008 Friedberg realized that if he wanted to meet the people who needed weather insurance, he'd have to hit the road and find them. That's when he stumbled on the California citrus packers. The year before, in 2007, there'd been a bad freeze. The citrus farmers were able to obtain some insurance through the federal government, but the

companies that packed and shipped the fruit were not. "If the temperature goes below 28 degrees for four hours or more, they have no business," said Friedberg. The California citrus packers had learned that the hard way. "Then we started talking to the growers," said Friedberg, "and they weren't fully covered, either. And we thought: if this is just citrus, agriculture must be big."

That was the turning point for David Friedberg. He realized that the people most exposed to the weather and most receptive to insuring themselves against it were farmers. The *Farmers' Almanac* had offered them weather predictions for the growing season since 1792, but those predictions had never been any better than guessing. The U.S. Department of Agriculture offered insurance against catastrophic crop loss but still left farmers with lots of exposure. There was a need. There was also a problem: to evaluate the weather risk to any one farmer's crop, Friedberg would need to predict not just the weather but how any given field responded to it. What kind of soil did it have? How well did it retain water? The question became: Where might he find this kind of data?

Once again, the U.S. government had it. NOAA had forty years' worth of infrared satellite images of all the land in the United States—again on tape drives in some basement. Plants absorb visible light and emit infrared light: you could calculate the biomass in a field by how much infrared light it emitted. Friedberg brokered a deal with Google, which had digitized the information and gave him access to it for free. "That's when we discovered that

farmers were lying about the dates they were planting," said Friedberg. The federal crop insurance program, seeking to minimize the risk of freeze, stipulated the earliest date that a farmer was allowed to plant. But the earlier the seeds went into the ground, the richer the crop. To qualify for the insurance, farmers had been claiming to have planted their seeds later than they had. The lie had been captured for decades by satellite, but no one had been able to see the data.

Inside the Department of Agriculture, Friedberg's math team found data on the size and shape of every one of America's twenty-six million fields. Inside the Department of the Interior, they found data on the soil composition of those fields. "They said, 'No one has ever asked us for this,'" said Friedberg. That one database was so big that it couldn't be transmitted over the internet. He'd had to pay the government agency to send it on hard drives, which he then sent to engineers at Amazon, who moved it all to the cloud. In each of the six years from 2007 to 2013, Friedberg's company used *forty times* more data than the year before. "All this data, it would never have existed if not for the government infrastructure that collected it," said Friedberg. "There's no private institution that on their own would have collected it. And without it we couldn't have made predictions. We would never have had a business without that data. But by the time we were done, we could really quantify the effects of weather on farming."

In 2011 Friedberg decided to sell exclusively to farmers, and WeatherBill changed its name to The Climate Corporation. "We needed to feel a little less Silicon Valley and less whimsical," said Friedberg. For the next few years he would spend half his time on the road, explaining himself to people whose first step was toward mistrust. "Farmers don't believe anything," he said. "There's always been some bullshit product for farmers. And the people selling it are usually from out of town."

He'd sit down in some barn or wood shop, pull out his iPad, and open up a map of whatever Corn Belt state he happened to be in. He'd let the farmer click on his field. Up popped the odds of various unpleasant weather events—a freeze, a drought, a hailstorm—and his crops' sensitivity to them. He'd show the farmer how much money he would have made in each of the previous thirty years if he had bought weather insurance. Then David Friedberg, Silicon Valley kid, would teach the farmer about his own fields. He'd show the farmer exactly how much moisture the field contained at any given moment—above a certain level, the field would be damaged if worked on. He'd show him the rainfall and temperature every day—which you might think the farmer would know, but then the farmer might be managing twenty or thirty different fields, spread over several counties. He'd show the farmer the precise stage of growth of his crop, the best moments to fertilize, the optimum eight-day window to plant his seeds, and the ideal harvest date.

The fertilizer was a big deal to them. "The biggest expense farmers have is fertilizer," said Friedberg. "They'll spend a hundred bucks an acre on corn seed and two hun-

dred bucks on fertilizer. And their net profit might be a hundred bucks an acre. If it rains right after you fertilize, the fertilizer washes away. So how do you decide when to plant and when to fertilize? I had guys come up to me after and say, 'You saved me four hundred grand last year.'"

Farming had always involved judgment calls that turned on the instincts of the farmer. The Climate Corporation had turned farming into decision science, and a matter of probabilities. The farmer was no longer playing roulette but blackjack. And David Friedberg was helping him to count the cards. "For a lot of these guys it was like, 'My mind is blown,'" Friedberg recalled. "They didn't believe that the knowledge could be created. All the new technology they had ever seen in their lives was physical. New machines, new seeds, new kinds of fertilizer. All these had just been tools for the farmer to use. None of them had replaced the farmer." No one ever asked Friedberg the question: If my knowledge is no longer useful, who needs me? But it was a good question. "There is stuff the farmer picks up on that we haven't got data on yet," he said. "For example, are there bugs in the field? But over time that'll go to zero. Everything will be observed. Everything will be predicted."

About a year after they started selling insurance to farmers, the people at the Climate Corporation noticed something funny was going on. The farmers buying their weather insurance were spending a lot of time playing with the software to which the insurance gave them access. "We found the farmers logging in just to see the data on

their fields," said Friedberg. To insure American farmland, he'd needed to understand the fields better than the farmers did themselves: now they knew it. "We thought we were in the insurance business, but we were actually in the knowledge business," said Friedberg. "It went from being insurance to being recommendations for farmers." That first year, in 2011, the Climate Corporation generated $60 million in sales, just from selling weather insurance to farmers. Three years later they were insuring 150 million acres of American farmland—the bulk of the Corn Belt—and teaching the farmers how to farm them more efficiently. Six years after venture capitalists valued David Friedberg's new company at $6 million, Monsanto bought it for $1.1 billion.

And yet through the entire experience, David Friedberg had this growing sense of unease. "When you come from San Francisco and grew up in Silicon Valley, every measure is about progress," he said. "The progress in society. The progress in the economy. The progress of technology. And you kind of get used to that. And you think that's the norm in the way the world operates, because you see everything getting better. Then you get on a plane and if you land anywhere but a big city, it feels the same. It's total stagnation. It's 'we've been farming the same six fields for the last seventy years.' It's getting married at nineteen or twenty. It's the opposite of progression. Life is about keeping up. Life is about keeping everything the same."

People in the places he'd traveled lived from paycheck to paycheck. They were exposed to risks in ways that he was

not: the weather was just one of those risks. He began to notice other kinds of data—for instance, that 40 percent of Americans can't cover an unexpected expense of a thousand bucks. The farmers usually weren't so bad off, but their situation was inherently precarious and threatened by modernity. Farmers didn't work on desktop computers, and so they'd largely skipped the initial internet revolution. But they had mobile phones, and in 2008, when the 3G networks went up in rural America, farmers finally got online. "The problem with the internet is that it shows everyone on earth what they're missing," said Friedberg. "And if you can't get to it, you feel you are getting fucked. That there is this very visceral and obvious shift that is happening in the world that you're missing out on."

At the same time David Friedberg was helping farmers to secure their immediate economic future, he was threatening their identity. *Your family has been tilling this same soil for a century, and yet this data-crunching machine I've built in just a few years can do it better.* The phrase was a whisper underlying every conversation he'd had with a farmer.

Friedberg played in a high-stakes poker game with some friends in the tech world. In their last game before the 2016 presidential election, he offered to bet anyone who would take the other side that Donald Trump would win.

After Trump took office, DJ Patil watched with wonder as the data disappeared across the federal government. Both the Environmental Protection Agency and the Department

of the Interior removed from their websites the links to climate change data. The USDA removed the inspection reports of businesses accused of animal abuse by the government. The new acting head of the Consumer Financial Protection Bureau, Mick Mulvaney, said he wanted to end public access to records of consumer complaints against financial institutions. Two weeks after Hurricane Maria, statistics that detailed access to drinking water and electricity in Puerto Rico were deleted from the FEMA website. In a piece for FiveThirtyEight, Clare Malone and Jeff Asher pointed out that the first annual crime report released by the FBI under Trump was missing nearly three-quarters of the data tables from the previous year. "Among the data missing from the 2016 report is information on arrests, the circumstances of homicides (such as the relationships between victims and perpetrators), and the only national estimate of annual gang murders," they wrote. Trump said he wanted to focus on violent crime, and yet was removing the most powerful tool for understanding it.

And as for the country's first chief data scientist—well, the Trump administration did not show the slightest interest in him. "I basically knew that these guys weren't going to listen to us," said DJ, "so we created these exit memos. The memos showed that this stuff pays for itself a thousand times over." He hoped the memos might give the incoming administration a sense of just how much was left to be discovered in the information the government had collected. There were questions crying out for answers: for instance, what was causing the boom in traffic fatali-

ties? The Department of Transportation had giant pools of data waiting to be searched. One hundred Americans were dying every day in car crashes. The thirty-year trend of declining traffic deaths has reversed itself dramatically. "We don't really know what's going on," said DJ. "Distracted driving? Heavier cars? Faster driving? More driving? Bike lanes?"

The knowledge to be discovered in government data might shift the odds in much of American life. You could study the vaccination data, for instance, and create heat maps for disease. "If you could randomly drop someone with measles somewhere in the United States, where would you have the biggest risk of an epidemic?" said DJ. "Where are epidemics waiting to happen? These questions, when you have access to data, you can do things. Everyone is focused on how data is a weapon. Actually, if we don't have data, we're screwed."

His memos were never read, DJ suspects. At any rate, he's never heard a peep about them. And he came to see there was nothing arbitrary or capricious about the Trump administration's attitude toward public data. Under each act of data suppression usually lay a narrow commercial motive: a gun lobbyist, a coal company, a poultry company. "The NOAA webpage used to have a link to weather forecasts," he said. "It was highly, highly popular. I saw it had been buried. And I asked: Now, why would they bury that?" Then he realized: the man Trump nominated to run NOAA thought that people who wanted a weather forecast should have to pay him for it. There was a rift in

American life that was now coursing through American government. It wasn't between Democrats and Republicans. It was between the people who were in it for the mission, and the people who were in it for the money.

The first time DJ Patil met Kathy Sullivan, he'd gone to talk to her about how she might better use data. He wound up learning from her how he might better approach his new mission. "She said something very insightful. She said working for the government, you need to imagine you are tied down, Gulliver-style. And if you want to even wiggle your big toe, first you need to ask permission. And that if you can imagine that and still imagine getting things done, you'll get things done."

The single most important source of data for the weather models are the satellites. The geostationary satellites hover over the equator, taking pictures of whatever is happening beneath them. The polar satellites circle the globe from North Pole to South Pole and gather data from the entire planet. They take soundings of the temperature and moisture in the atmosphere; measure vegetation coverage; monitor ozone levels; detect hot spots and so are able to report fires before people on the ground even know they have been lit; and feed weather forecasting models not just in the United States but in Europe and Asia. Without the information supplied by the polar satellites, weather forecasts everywhere would be worse. You'd be more likely to turn up at the airport and find that your flight had

been canceled, or to be surprised by a wildfire, or to be hit without warning by a storm. "We ran the no-satellite experiment in Galveston in 1900," says Tim Schmit, a career NOAA researcher who has spent the last twenty-two years creating new and better satellite images of Earth. "Ten thousand people died."

Kathy Sullivan's life after her astronaut career had been one ambitious science project after another. She'd spent the first three years as NOAA's chief scientist. From there she'd gone on to run the Center of Science and Industry, a 320,000-square-foot museum and research center in Columbus, Ohio. After a decade of running that, she was hired in 2006 by Ohio State University to be the first director of their new science and math education center. When she returned to NOAA, in 2011, a polar satellite launched in the 1990s was approaching the end of its useful life. Its replacement was late, mired in political controversy, and facing cuts to a budget it had already exceeded. "She walks in the door and finds that the decisions made by a lot of other people are about to screw us all," said DJ Patil. "Now it's a question of national security. Because you won't be able to see the storms." A storm that went unseen, to DJ's way of thinking, belonged in the same category as a terrorist who went undetected.

The Clinton administration had asked three different agencies—the Department of Defense, NASA, and NOAA—to manage the polar satellites. The collaboration hadn't gone well. "The dynamic was a typical Washington sociopathic thing mixed up with a lack of leadership," said

a former NOAA official. "Three agencies is hard. Because when you're busy or something annoys you, you can just assume or pretend that someone else will handle it. It's also hard because nobody wants to be responsible when things go badly. It's hard to control headlines and explain complicated things. Congress sends agencies very mixed signals, changes budgets, moves on to new things, speaks with many voices. Administrations and Congress don't often agree or even know about all the things the agencies are working on. Everybody blames someone else, and whoever is better at the blame game usually comes out on top. And the Department of Defense always comes out on top because it has the most resources and protective reflexes and friends."

The Obama administration had broken up the marriage between NASA and the Department of Defense and handed the entire mess to NOAA. But the NOAA to which Kathy Sullivan returned had drifted further in the direction it had been heading when she'd left. While the weather forecasts from inside it had gotten better and better, the political climate outside it had gotten worse and worse. Working at NOAA—or anyplace else in the federal government—could not be more different from working at NASA. When you were an astronaut, everyone loved you. When you told people that you worked for NASA they were usually curious, and even a bit informed. There was a reason for this, over and above the drama of the work: NASA had been encouraged, right from the start, to promote itself. "NASA was allowed to tell its story

to the world," Kathy said. "There was a conscious need to publicize, because it was meant to restore confidence. NASA had heroes." NOAA didn't have heroes or drama. Or, rather, it had drama, and people who had done genuinely heroic things, but the American public never heard about any of it. It had people like Tim Schmit, the satellite guy, whose work had saved thousands of American lives. "NOAA has a hidden utility problem," said Kathy. "You cannot market NOAA. You *really* cannot market NOAA. Over the last several decades they not only don't get marketed. They are routinely slandered."

The relationship between the people and their government troubled her. The government was the mission of an entire society: why was the society undermining it? "I'm routinely appalled by how profoundly ignorant even highly educated people are when it comes to the structure and function of our government," she said. "The sense of identity as Citizen has been replaced by Consumer. The idea that government should serve the citizens like a waiter or concierge, rather than in a 'collective good' sense."

Her first big task upon returning to NOAA was to fix the polar satellite, and she did it. "She's unflappable with whiny politicians and lawyers," says a former NOAA official, who watched Sullivan attack the problem. "She was good at saying, 'Stop bothering my people and let them do their job.'" She got a new polar satellite, launched in November 2017, back on schedule, but with a twist: she arranged it so that the problems that had bedeviled her predecessors would not trouble her successors. "Of the many

incredibly stupid things that a person can do on this planet, one is to build and buy a single satellite, when you know you'll need more of them," she said. There was no reason that NOAA could not budget for, and begin to plan, the next two, three, or four satellites; there were even economies of scale for some of the complicated parts. The problem was that no one in government liked to pay now if they could pay later. Nevertheless, she somehow persuaded the relevant parties in Congress and NOAA to make a deal for multiple satellites.

The ins and outs of how she'd done all this would have made for an excellent Harvard Business School case study—or a briefing memo for the new Trump administration. But that memo would never be read. The first Trump budget proposed removing the money in NOAA's budget that she'd secured for future satellites. The Trump people would never call her, but if they had she would have offered them one simple piece of advice. "You need to figure out what you want your leadership team to be intentional about—because if they aren't intentional about it, it won't happen. There's hundreds of things that will naturally happen. And then there are the things that won't." One of the things that wouldn't happen is satellites getting built on time, within budget. Another was that Americans would die, if you didn't work hard to figure out what was going on inside their heads.

That had been her next big project. A Weather-Ready Nation, she called it. The Joplin tornado had been the catalyst. It had various ambitions—making communities more

responsive to the weather, making fishing stocks more resilient to the climate—but at its heart was the desire to better prepare Americans to face threats. Kathy had helped to install Louis Uccellini as head of the National Weather Service; he shared her passion for the problem. The meteorologists inside the Weather Service were bothered that people didn't respond as expected to their warnings. But then they were weather geeks. Scientists. "I can't trace exactly where or when or how the realization dawned [on us] that the jargon-laden bulletins were not comprehensible to users," said Kathy. "Or that people didn't respond to raw data; they respond to other human beings, trusted voices. Or that the punch line—what this storm may do to you—was often buried after many paragraphs of geeky weather details. Or that normal humans don't understand probabilities and cannot translate a wind speed or rain rate into tangible worries about the roof coming off or being knee-deep in water. You don't particularly care what the wind speed at five hundred millibars is. You want to know: What's it going to do to my house?"

So they set out to understand the people on the receiving end of the forecasts. It wasn't enough to farm the problem out to others. They needed people in NOAA studying the way Americans responded to warnings, and to risk. NOAA was an agency staffed by hard scientists facing a problem that cried out for psychologists and behavioral economists. "The odd group, whatever the odd group is, needs to be in the room," she said. "There's all sorts of inclinations *not* to do that. The existing powers say,

'Leave me alone, and let me do what I want to do.'" She wanted to start a conversation inside the agency, with the understanding that they couldn't predict exactly where it might lead.

It reminded her of something that had happened just after the *Challenger* explosion. American cities were planning to name streets and schools for the astronauts, but that had felt inadequate to her—and to the astronauts' spouses. Everyone who'd been close to the astronauts wanted the meaning of their lives to be better understood through their deaths. "They all had this shared joy of bringing science and technology education to lots of people," said Kathy. "We asked, how do we continue that?"

By the end of 1986, the astronauts' families had decided to create a science education program—though of what sort they did not yet know. The spouses asked Kathy to figure it out. She started by bringing them all together, to explain how uncomfortable it was going to be to create an entirely new thing when they didn't know exactly what it would be. They'd need to invite many odd groups into the room and give them the power to influence the project. "I told them, 'It's your legacy to the crew. But to do it you need to create a network of people who feel they can shape it. The conversation really matters. Converse means exchange with. It does not mean transmit at. That's how you get new thinking.'" She'd heard a line once that still resonated with her: *The only thing any of us can do completely on our own is to have the start of a good idea.*

She found all sorts of odd groups, outsiders to the space

project, unknown to the astronauts' families, who might be relevant to the new mission: teachers, museum professionals, curriculum supervisors, textbook publishers, exhibition designers, video-tech types, and so on. Plus, an architect. She gathered all these people in Biosphere 2, in Oracle, Arizona, "to get everyone out of their ruts." Pretty quickly the architect turned the event into a presentation of his plan for the building. Kathy and the others could see that he hadn't listened to a word anyone had said. She let him go the next day. In the end, the group discussion led to a course aimed at middle-school students. There are now fifty-two Challenger Centers around the world, and they have taught four and a half million students.

In the aftermath of the Joplin tornado, the odd group—the new kids in school—were the psychologists and behavioral economists. In 2014 Kathy helped to persuade Congress to write into law the idea that social science was part of NOAA's mission. The agency could now hire people to collect a different kind of data—data that would enable them to figure out what exactly was going on inside the minds of the American people, so that it might save their lives.

The funny thing about tornadoes is that no one knows how powerful they are until they've hit something. The National Weather Service can tell you days in advance what to make of a hurricane—the strength of its winds, and the size of its storm surge, along with the likelihood

of its hitting your city instead of someone else's. As you sit on your porch in New Orleans deciding whether you should get in your car and drive to Memphis to avoid a hurricane, you have a pretty good idea what you are in for if you don't. Tornadoes aren't like that. Like the rest of the weather in the continental United States, they move from west to east, but the paths they take are random. Their force can be judged only after the fact, by the damage they've done. If a hurricane is another night in a bad marriage, a tornado is a blind date.

The scale for judging tornadoes, after the fact, runs from 0 to 5. It's called the Fujita scale. What makes it different from most scales is that it is consistently terrifying from beginning to end. An F1 tornado merely peels roof surfaces off houses and knocks cars off the road. By F2, mobile homes are being destroyed and cows are flying through the air.

Kim Klockow was seven years old, playing in a field in Naperville, Illinois, when she caught sight of her first tornado. She didn't know what she was seeing. "I saw the booby clouds," she recalled—the breast-shaped mammatus clouds that accompany big storms. "I was looking at the anvil of the storm." No one ever actually saw the tornado until it wiped out some of Plainfield, Illinois, on August 28, 1990. It had eluded radar and, wrapped in a rainstorm, had been invisible to the naked eye. The National Weather Service didn't even issue a warning until an hour after the event. Afterward it would go down as the only F5 tornado ever recorded in the Chicago suburbs. In an F5, cars become

missiles and big, well-constructed houses simply vanish. Kim's parents had driven her through Plainfield two days later, and she'd seen buildings she'd been inside of reduced to rubble or entirely gone, like in *The Wizard of Oz*. "You don't think of buildings as being dangerous," she said. "You think of buildings as being a place you were safe."

That tornado had killed twenty-nine people, injured hundreds more, and traumatized the region. The following year, as another storm approached, people were on edge. When the wind kicked up and the hail began to ricochet off the pavement, Kim was in the neighboring city of Joliet, with her mother and two-year-old sister, registering for French lessons. Her mother grabbed them and fled. As they sped toward home, Kim could see her mother watching behind them. "We were actually being chased by the storm," she recalled. "The hail sounded like bullets hitting the car." For some reason her mother insisted that the windows remain down: hail fell onto Kim's lap. "My mother was saying the same thing over and over, but I didn't know what it was. She was saying Hail Marys." They peeled into the driveway and her mother screamed at her, "Get into the house, and get downstairs!" She'd run and hid—and came away with the feeling that it was only by luck that her house had not been blown away. "After that," said Kim, "any weather information we got, I wanted to know. This is actually the story of every meteorologist. We are a whole field of people who are child trauma cases."

One hot May morning I picked Kim Klockow up from

her office at the NWS Storm Prediction Center, in the National Weather Center Building, in Norman, Oklahoma. The center is a joint venture between the University of Oklahoma and NOAA, and about as perfectly situated as an institution can be. The south-central United States is the planet's convective sweet spot: here the warm air from the Gulf of Mexico collides with the cool air tumbling down over the Rocky Mountains and creates storms with more energy than nuclear bombs. Texas has twice as many tornadoes as Oklahoma, but Oklahoma has them in about a fourth the space. Kansas has about a third more tornadoes each year than Oklahoma, but Kansas is a third again bigger than Oklahoma and has a third fewer people. If you have some need or desire to witness dramatic collisions between people and weather, Oklahoma is your place. "Being here during a serious tornado event is better than football," says Hank Jenkins-Smith, who runs the University of Oklahoma's National Institute for Risk and Resilience—which is as aptly sited as the Storm Prediction Center. At the top of the National Weather Center Building is a skybox, facing west, and equipped with special blast-proof glass, to watch the approaching tornadoes.

Kim came to the University of Oklahoma in 2006 as a graduate student to study . . . well, she hadn't been sure what she was going to study. She'd received her undergraduate degree in both meteorology and economics and, up to that point, focused on the economic impact of storms. What happens to the finances of a community hit by a tornado, for instance. The work interested her, but

she also felt something was missing. "I just felt that classical economics wasn't really hitting on the questions that meteorologists were asking," she said.

Her frustration led her first into behavioral economics, which was no more than psychology made respectable to the sort of people who tended to think psychology was all bullshit. She set out to investigate a problem: How do people respond to risk? How might you influence that response, to their benefit? If you told someone that a tornado might be headed his way in a week, he'd give you a funny look and go about his business. If you pointed out to that same person the tornado bearing down on his house, he'd dive for cover. She wanted to figure out when and why complacency turned to alarm and when and why alarm turned into action.

In December 2010 she was finishing up her thesis when an adviser suggested that what she really needed to do was some fieldwork. Go out and interview real-live Americans who had responded to the news that their lives might be at risk. "They said, 'If anything happens in 2011, we want you to do a case study,'" said Kim. "Then Joplin happens."

For complicated reasons, she set out to survey people not in Joplin but in Alabama and Mississippi. A few weeks before the catastrophe in Missouri, tornadoes had wreaked havoc in those states, despite excellent warnings from the National Weather Service. What became known as the 2011 Super Outbreak spawned 360 tornadoes that killed 324 and injured thousands more.

In its wake a pair of ideas sprang up and gained traction—

both inside and outside the Weather Service. The first was that the twenty-minute warnings that had been issued had not given people enough time to escape. Powerful congressmen from tornado-prone states insisted that the National Weather Service needed to improve its ability to predict tornadoes to the point where they could warn people an hour in advance. And the National Weather Service had simply nodded and accepted the challenge. "Everyone in the Weather Service is so drawn to the mission of helping other people," said Kim. "That's what was so crushing about 2011. *Oh, I may have just spent my entire career possibly doing nothing.*"

But Kim wondered about the wisdom of their new ambition. "It's hard to talk to dead people about the decisions they made," she said. "It's one of the challenges we have. But I was trying to ask what they would do if they'd had more time." She interviewed survivors in Alabama and Mississippi and came away with a startling insight: time might be beside the point. It wasn't that people who had apparently ignored the government's alerts had been oblivious to them. "They were *all* aware of the warnings," she said. "It isn't that people wantonly disregard warnings. It's that they think it won't hit *them*." The paper Kim subsequently coauthored pointed out that people associate "home" with "safety." This feeling was reinforced each and every day that nothing horrible happened inside of it. People acquired a "false confidence that they would not be hit." Some inner calculation led them to believe that, if it's never happened here, it never will.

The people who had failed to seek shelter in the way that, say, a meteorologist thinks they should have done had one thing in common: they lived in homes that had never been struck by a tornado. They inhabited a region prone to tornadoes; they had lived through many tornado warnings; but right up until 2011 they themselves had been spared a direct hit. They offered Kim lots of explanations for their immunity to catastrophic risk. They claimed that tornadoes never crossed the river they lived on, for instance. Or that tornadoes always split as they approached their town. Or that tornadoes always followed the highway. Or that tornadoes never struck the old Indian burial grounds. People who lived on the west side of a big city felt more exposed than people on the east side: they believed buildings offered protection. A lot of people seemed to believe that hills did, too. "Where tornadoes go is totally random," Kim said. "The steering winds are in the upper atmosphere. But people are not thinking of the forces of the atmosphere. They are thinking of their place on the ground." Psychologists have long known that people see patterns where none exist. Londoners during the Blitz felt they'd deduced the targets of German bombers by where the bombs had fallen, when the bombs had been dropped randomly over the city. Americans routinely made the same mistake with the weather.

Soon we were driving west together, Kim Klockow and I. A few minutes after leaving the Storm Prediction Center, we passed from Norman into Moore, and from one

wan row of shopping malls and car dealerships to another. Here was another curious example of man's attitude toward the things that might kill him—and another illustration of Kim's point. The people in Norman think that tornadoes don't hit them; the people in Moore believe they are especially prone to being hit by tornadoes. Moore's sense of doom dates back to May 3, 1999, when a tornado crossed the freeway and cut through the town. It was a mile wide and generated wind speeds of 302 miles per hour, the highest ever recorded on earth. It killed thirty-six people, including a woman who had sheltered exactly as experts had instructed, by lying in a bathtub and covering herself with a mattress. (A car crashed through her roof and landed on her.)

On May 20, 2013, another F5 tornado struck Moore and killed twenty-four people, including seven children in a school, after an interior wall collapsed on them. Between those two events, Moore had been hit by two F4 tornadoes and been dealt glancing blows by several small ones. By 2013 its reputation as a magnet for tornadoes was sealed. "The perception of risk of the people in Moore is about twice that of people living in Norman," said Kim. Moore is the only town in Oklahoma to have adopted building codes to defend itself against the wind; it has even devised a scheme that allows worried parents to bus their children to schools that have storm shelters. "The people in Norman are less likely to start preparing during a tornado watch than the people in Moore," said Kim. "The people in Norman think that Moore is more likely to be hit than

Norman. And this might be the most educated population, about tornado risk, in the world. *Hundreds* of meteorologists live in Norman."

The road to the weather of the future is straight and hot. It leads after an hour or so to the city of El Reno. "You can still see this one," said Kim. "In the trees." Eleven days after the 2013 Moore tornado, there had been another spin-up, right here. Within minutes, what became known as the El Reno tornado was 2.6 miles wide, the widest tornado ever seen, and headed for Oklahoma City. "Tornadoes leave scars that are visible from space, when they are big enough," Kim says.

The second idea that gained traction after the 2011 tornadoes was that people simply failed to appreciate what happened when a tornado hit a mobile home, or a car, or really anything that wasn't bolted to the ground. If the warnings highlighted the potential destruction, the thinking went, people might pay them more attention. "Impact based warnings," the new warnings were called, though the differences between them and the old warnings were fairly subtle. The Weather Service did not generally communicate directly with the public. It issued warnings to local emergency managers and the TV meteorologists, who then passed on what they'd been told. But the Weather Service now encouraged the weather media to help people to imagine what might happen if they did not seek shelter. "The idea was the people just don't know how bad it is," said Kim. "If they knew how bad it is, they'd take action."

COMPLETE DESTRUCTION OF ENTIRE NEIGHBORHOODS IS LIKELY. MANY WELL-BUILT HOMES AND BUSINESSES WILL BE COMPLETELY SWEPT FROM THEIR FOUNDATION. DEBRIS WILL BLOCK MOST ROADWAYS. MASS DEVASTATION IS HIGHLY LIKELY, MAKING THE AREA UNRECOGNIZABLE TO SURVIVORS.

And so on.

The market for weather news in Oklahoma is fiercely competitive. The local TV weather anchors already felt pressure to make the reality more interesting than it was. "They glom onto the worst-case scenario days before we can have any confidence," says Kim. "A government agency does not have an incentive to hype. Private companies have an incentive to hype. The problem when you hype is that you reduce confidence in *all* weather forecasts, because no one knows the source of the information." About thirty minutes before the El Reno tornado reached Oklahoma City, a TV weatherman named Mike Morgan told his viewers that anyone who wasn't underground was doomed. Most people had no underground place to go. The soil in Oklahoma is a sandy clay floating on a high water table: the place on the planet where people most desperately need to dig a hole to hide happens also to be a place in which it is expensive to dig. Though a car might be the single worst place to be in a tornado, tens of thousands of Oklahomans fled by car. Instantly the southbound lanes of the interstate became a parking lot. The El Reno tornado bore down on what amounted to a miles-long traffic jam. . . .

And then it lifted. By sheer luck the El Reno tornado killed only eight people—most of whom had been fleeing it. What didn't happen did not get nearly as much attention as it deserved, in Kim's view. "If it hadn't lifted, if it had continued on its path, the estimate of the fatalities would have been Katrina-level. It's the worst catastrophe that almost happened. In the most tornado-savvy population in the world. It was really jarring."

El Reno had been her turning point. "It struck me: How could we think we could help people without understanding people?" she said. "The way we have approached things is by learning about the threat. We've ignored the people being threatened." She thought that impact based warnings were intellectually dishonest: How could you warn about the impact of a storm whose force you would only be able to discern after the fact? She was also pretty sure that people knew what a tornado could do to them. The people in Alabama and Mississippi knew. So did the people in Joplin. Their problem, as she saw it, was a different sort of failure of the imagination. People could not imagine that all those tornadoes that had wound up hitting other people could instead have hit *them*. The sirens had become fake news. The government needed to find ways to make the news feel real.

A few months later, she moved to Washington, DC, on a congressional fellowship and went to work for a senator who sat on the committee that oversaw the Commerce Department. "I'm gunning for something inside NOAA," she said. "You have to have people on the inside

to make the change." In late 2014 her ambition collided with Kathy Sullivan's, and NOAA hired Kim Klockow to be its first, and only, social scientist. She became the odd group in the room.

She'd spent three years in the job. She'd hoped to create a social science unit on the top of the agency that could both direct a research program and spread what it learned through the Weather Service. "The problem with our science is that it is new," she said. "And we don't know how to make people not die. We need data on what led a person to do what they did. We need observations of humans responding to weather information." She'd made some progress. She'd also been frustrated. "Barry Myers [AccuWeather's CEO] turned up at a meeting and said that I shouldn't be doing what I was doing," she said. "Because it's marketing. But it's not marketing. It's saving lives. The question became: What can we do in this space without interfering with the profits of AccuWeather?"

And then Trump was elected. She'd planned to return to Oklahoma anyway, but now she did it with a sense that she might be better off starting small, rather than trying to change the entire Weather Service from the top. "The inspiration came from Dr. Sullivan—she advised me to rely on 'small bets' to make significant organizational change, not to try to force big, sudden change from the top."

It was May 2017, and Kim Klockow had been back in an office at the University of Oklahoma only a few weeks when the meteorologists in the Storm Prediction Center forecast a storm in the Texas Panhandle. She hopped into

a car with another meteorologist and went west, to where the weather came from. "When I was in DC I lost my sense of direction," she said. "In DC this is not material knowledge." She'd found the storm in Texas, and then turned around and followed it from behind into Oklahoma. The little girl once terrified by the storm that was chasing her was now a woman chasing a storm. In Oklahoma, as often happened, the storm met an atmosphere more favorable to it, and it grew. "I saw it," she said. "It was a beast." She'd arrived just outside of Elk City when she heard the Weather Service issue its tornado warning—and so she'd stopped. "You don't chase into a city," she said. "You don't chase to see death and destruction."

At length, she and I drive the hot, flat road past the Cherokee Trading Post & Boot Outlet and arrive in Elk City. Elk City is where we'd been heading all along.

Lonnie Risenhoover had been managing emergencies in Beckham County in one way or another for forty years. Before he became emergency manager for the entire county, he'd worked as a fireman in Elk City, where he was born and raised. His great-grandfather had moved there in the late nineteenth century, before Oklahoma was even a state, and the family had remained ever since. There were only about twenty-five thousand people in the whole of Beckham County, about half of those in Elk City, and Lonnie knew most of them. He'd seen all the storms, too, but the county had been lucky that way. "Most of the tornadoes are real rural," he said. "'Well, we had a tornado and Joe's chicken coop just blowed away.'" *Tornayda.* The one thing the storms had in common was the hysteria about them generated by the TV news stations in Oklahoma City. "If there's an icicle hanging off the corner of the house it's 'hey, there's an icicle hangin' off the corner of the house, we're gonna go live with it!'" *A-sicle.*

The information Lonnie took seriously came directly from the National Weather Service. ("If the Weather Service had a TV channel, everyone would just watch that.") Every morning he woke up and checked NWSChat—the Weather Service's tool for communicating with local emergency managers. The morning of May 16, 2017, had a slightly different feel to it than usual, though Lonnie didn't immediately put his finger on why. They said a storm was coming from the Panhandle, but storms were always coming from the Panhandle. There was no tornado warning.

But a tornado wasn't like a winter storm. The models hadn't gotten to the point where they could predict a tornado before it happened, in the way they could bigger weather systems. The Weather Service could only issue a tornado warning after it had *seen* the tornado, either with its radar or one of its spotters. "What I noticed," said Lonnie, "was that they'd changed some of the language they used. They said 'tornado emergency.' It used to be just a 'tornado warning.'"

He left the chat more worried than usual. The storm might be a problem, he thought.

The Elk City Fire Department had a few tornado spot-

ters, but they just sat at fixed points: the city had blind spots. "The western part of Beckham County, we didn't have many storm spotters," Lonnie said. "And I'm basically a one-man shop. So I can do everything I need to do in my vehicle." His truck had so much gear in it that you didn't want to ask what it all was, for fear that the explanations would never end. From his truck he could measure the wind speed, see the radar, and stay in touch with the Weather Service, even if his phone lost service. He got into his truck and drove west, to find a place from which he could see as much of the earth's surface as possible.

If you were just passing through you'd think Beckham County was essentially flat. Brownish-yellow wheat fields and pastureland as far as the eye can see. In his forty years of storm spotting, Lonnie had come to know every slight undulation in the terrain. In twenty minutes he was parked on some of the highest ground in the county, facing southwest. When the meteorologists from the Storm Prediction Center go out to chase storms, they chase them from behind, to make sure they aren't overtaken by the tornado. Lonnie just sat there, waiting for the tornado to come at him. "My wife used to go with me," he said. "Now she won't. She says, 'You scare me.'"

Then he saw it. Or maybe he didn't. "I seen a funnel," he said. "But I wasn't going to start calling it a tornado until I start seeing grass or something else it's picking up." Whatever he was seeing vanished after maybe a minute. He couldn't tell how fast it might be moving toward him, or how far away it was. He didn't want to trigger a warning unnecessarily—if he did that, people might not believe the next one. At the same time, what he was hearing just then from the National Weather Service was not normal. They hadn't seen the tornado, but they were acting almost as if they had. "I kept getting information," he said. "They were feeding me a lot of information. And I thought, This is really, really going to be bad."

He was utterly exposed. Alone, out in a massive storm that might, or might not, be concealing a tornado. He wheeled his truck around and hauled ass. Instead of heading straight back toward Elk City, he drove south, along the width of the storm. As he drove, he reported what he was seeing to the Weather Service, and the Weather Service was reporting what it knew to him. The anemometer on top of his truck recorded the speed of the winds being sucked *into* the storm: 79 miles per hour. The Weather Service told him they'd had reports of hail that was bigger than baseballs. Traveling 80 miles an hour down a dirt road in a pelting rain, he was all the time thinking about what to do: Wait, to make sure he'd seen what he'd seen? Or phone the Weather Service and trigger a tornado warning that set off the town siren? "So you sit here and make this decision," he said. "And I think: Who is going to dispute my word? So I called the Weather Service."

He came upon a sight that pulled him up short: downed power lines. The poles that had held them were gone. As if they had never been there. The tornado had crossed his path and leaped ahead of him: how he did not know. He'd thought the storm was chasing him; now, apparently, he

was chasing the storm. Then he saw it, but it took him a moment to realize what he was seeing. It wasn't like a tornado in the movies. "It looks like the cloud was on the ground," he said. "It was a thousand yards wide."

For the next twenty minutes he followed the cloud's trail of destruction. Dead cows everywhere. Shattered oak trees. A school bus turned into a twisted pile of metal. Cars piled on top of each other, upside down, in a pond. He knew the landscape well enough to see what it was missing: big trees, telephone poles, mobile homes. "You could say, 'There used to be a house there,'" he said. One house he passed was only partially destroyed. It looked as if some giant had tried to dissect it: the front half had been ripped away so that he could see all the way back into the television room. The big red barn that had been right next to it had vanished without a trace. The house belonged to Miss Finley, an old woman who lived alone. Lonnie's job wasn't emergency rescue—he was meant to be the eyes on the storm—but he stopped anyway, to see if he could find her. As he searched the ruins, a truck came flying up. "It was Miss Finley's son," said Lonnie. "He said she had gone to the town shelter."

When you are chasing a cloud, there's a question of how fast to go. Lonnie perhaps went too fast. Soon he found himself staring at a subdivision of new homes, all destroyed. "I'm looking over at these houses, and all I see is sticks," he said. Debris was now crashing around his truck. He looked up and saw a huge piece of tin. "I got large stuff falling out the sky," he said. "I can't go any further."

All along, his phone had been ringing. The Weather Channel. CNN. MSNBC. All these TV people were calling to find out what had happened. The truth is, he didn't know, and it took him a bit of time to figure it out. It turned out that more than two hundred homes in Elk City had been destroyed, along with thirty-eight businesses. A lot of property had been lost. But—and here's what shocked him—people had mostly kept out of harm's way. Karen Snyder had refused to leave her cats and had been found, alive and well, with the ruins of her house on top of her. Gene Mikles had called the sheriff to ask if he should seek shelter, had been told that he should, and had started to the shelter but then returned to his home to grab his phone. He'd been found dead on the ground outside. "Only one fatality and eight bruises," said Lonnie. "What I think happened is that people listened to the warning." The town shelter had been so crowded that they'd had to lead people into the basement of the fire station.

On the morning of May 16, 2017, purely by chance, a team of researchers in the Storm Prediction Center had been testing a new tornado model. Even after they varied their assumptions about the conditions of the atmosphere, the model generated tornadoes. The images were clear and consistent: later the researchers said it was as if they had seen the storm in the real world. Everyone in the weather business believed this was the future: the ability to predict a tornado, in theory, before it spun up. The ability to imagine it, with precision, before you could see it. Now it was happening. The researchers informed the

Weather Service meteorologist on duty, and the meteorologist issued a different kind of alert. Not a warning, but a warning that a warning was very likely coming; and it had prodded Lonnie to behave as he might not have done. It made him feel the threat was real—that the storm might hit *him*. That feeling had caused him to trigger a warning a few minutes earlier than he might otherwise have done. "The main thing I was so excited about is we were able to set off the sirens thirty minutes before it hit," he said.

Lonnie Risenhoover knew nothing about what had happened inside the Storm Prediction Center. "That was a prototype," he said. "It was the first time they'd used it. I didn't know it." But he knew what he was hearing from the Weather Service staff sounded different from what he usually heard. They'd given him, in effect, a clearer sense of the odds. They'd done what Kim Klockow had been advocating for: don't tell people what the tornado will do to them if it hits them. Instead, persuade them that the threat is real. "People in Oklahoma, they're going to credit the media," said Lonnie. "Because that's where they are getting their information. But who they should credit is the Weather Service. The Weather Service—they don't give themselves enough credit. They say, 'We're just doing a job.' But I don't know where we'd be without them."

At dinner one night I played a game with Kim Klockow and her friends Hank Jenkins-Smith and Carol Silva, the co-directors of the University of Oklahoma's Center for Risk & Crisis Management. They'd devoted their lives to studying people's response to risk. I'd wondered who, and

what, was most likely to survive a tornado. If you were a tree, for instance, you'd much rather be a willow than an oak, as a willow tree bends. The risk experts all agreed they'd bet money on a horse over a cow, and on a dog over a cat. ("Dogs are more likely to obey.") They became less certain when we turned to the more complicated matter of human beings. Because they were intellectually honest academics, they were reluctant to generalize. "People aren't necessarily good at managing one kind of risk just because they are good at managing another kind of risk," said Carol. "People will be deathly afraid of one kind of risk and blasé about another."

Still, they played along, in a hypothetical game of survival. They all agreed that you'd obviously bet money on a rich person over a poor person. ("People who live in mobile homes are thirty times more likely to die.") They'd take a parent over a pet owner, as animals aren't allowed in public storm shelters. ("Pets will kill you.") They argued a bit, but finally decided they'd take a woman over a man, as men tended to be more risk-seeking. "Men go outside and look around," said Carol. "You see this in the tornado videos on YouTube. The wife sticking her head out the door screaming at her husband, 'Hey, git your ass inside!' " Finally, I asked: a liberal or a conservative? Eighty-three and a half percent of Beckham County had voted for Donald Trump. What did that say about their ability to survive a tornado? The liberal has the advantage of trusting the government's warning, said Hank, but the conservative has advantages, too. It depended on what kind of conservative

he was, they decided. If he was a radical individualist, he was a bad risk: you'd bet on the liberal to survive. But if the conservative belonged to a strong social network—a church, say—he might hear a tornado warning, and trust it, before it was too late. "What you need is one person inside the network who is a trusted source, who trusts the government," said Hank. You need Lonnie Risenhoover.

I had in mind a final game of survivor, but I never got around to asking them about it. Who is more likely to survive a tornado: the person who has personally experienced one, or the person who has not, and *why*? The advantage of experience is more or less obvious; the disadvantage of not having had the experience less so. But it might be the more important factor. All kinds of things might happen to you in life. By sheer accident only a few of them do. That tiny subset shapes your view of the world, to an alarming degree. If a tornado has never hit your town, you think it never will. You might try to imagine what will befall you if it does. The reality of the thing will still shock you.

In the weeks after the Elk City tornado, Lonnie Risenhoover toured the damage with various government officials. A man from the Federal Emergency Management Agency came through to determine who was eligible for disaster relief. While driving the man around Elk City, Lonnie spotted Miss Finley. Her house was a ruin and her barn was gone: surely she was eligible for relief. Lonnie stopped so the FEMA guy might speak with her. "You know," said Miss Finley, "for the last ten years I prayed for a tornado to come and take that barn. I didn't think it

would take the house, too." She seemed to think her reasoning self-evident. The FEMA guy said he didn't understand: Why had she been praying for a tornado to take her barn? "Every time I pull out of the driveway I'm looking at that red barn," she said. "And every time I pull into the driveway I'm looking at the red barn." At which point Lonnie asked the FEMA guy if he was ready to leave. He wasn't. He was still puzzled: Why did it bother the woman to look at her red barn? "That barn," said Miss Finley, "is where my husband committed suicide ten years ago."

And so you might have good reason to pray for a tornado, whether it comes in the shape of swirling winds, or a politician. You imagine the thing doing the damage that you would like to see done, and no more. It's what you fail to imagine that kills you.