

LIFE IN THE ZONE

What we're still learning from Chernobyl

By Steve Featherstone



We stood inside a dilapidated barn in the Ukrainian village of Pisky, waiting for swallows to fly into the nets we'd strung across the doors. It was a sultry June day, and the stagnant air reeked of cow urine. The two evolutionary biologists I was assisting wondered aloud why there were so few birds this year. Anders Møller, research director at the National Center for Scientific Research, Paris-Sud University, reasoned that a sudden cold snap the previous fall had killed many of the swallows. His colleague,

Steve Featherstone's last article for Harper's Magazine, "Human Quicksand," appeared in the September 2008 issue.

Tim Mousseau, professor of biological sciences at the University of South Carolina, blamed Pisky itself, or what remained of it. Barn swallows are the avian equivalent of dogs. They have adapted to living with humans since the beginning of civilization, and there weren't many humans left in Pisky. But neither scientist pointed to the obvious culprit.

"What about radiation?" I asked.

"And then there's radiation," Tim said with a wink. "But you have to prove it."

Pisky lies just outside the Zone of Alienation, the official name given to a vast region in northern Ukraine

contaminated by fallout in 1986 when a reactor at the Chernobyl Nuclear Power Plant exploded. Pisky's residents were never evacuated. Nonetheless, it became a ghost town. Radiation levels there are five times above normal. Low-slung brick barns, the architectural signature of the old Soviet collective-farm system, sit empty and neglected in weed-choked fields.

I went outside for some fresh air. Gennadi Milinevsky, an owlish astrophysicist from Kiev who helped Tim and Anders with their experiments, was talking to a woman wearing a purple tracksuit and rubber galoshes, the apparent owner of this ramshackle

mud farm. *Nyah nyah nyah*, the woman muttered, tapping an iron mallet against her thigh. A wiry man stumbled around the corner of the barn, smiling crazily. He had a deeply tanned face and glassy, bloodshot blue eyes. He raised two fingers to his puckered lips.

"He wants cigarette," Gennadi translated. Sorry, I said. The man kept talking. "He was liquidator," Gennadi said. "He drive tractor. You know liquidator?" I nodded. It was the sort of bland locution favored by Soviet apparatchiks. More than 700,000 miners, soldiers, and construction workers were mobilized from every corner of the Soviet Union to clean up—or liquidate—Chernobyl's aftermath, often equipped with nothing more than shovels. Anybody who lived this close to the Zone was either a liquidator or related to one. They are like ghosts drifting across the poisoned landscape. The man put his fingers to his mouth again.

"He wants money," Gennadi said, "for bread." I handed the man a wrinkled fifty-hryvnia banknote and went back into the barn. Tim and Anders sat in Gennadi's car, taking blood samples from the swallows they'd netted. They caught thirty swallows that day, less than half the number they'd caught five years earlier.

In April, Japan upgraded the severity of the disaster at the Fukushima nuclear power plant from 5 to 7 on the international scale of nuclear catastrophes, officially making it equivalent to Chernobyl. The scale, which measures the total amount of radiation released as well as health and environmental impacts, obscures fundamental differences between the two events. Chernobyl's radioactive inventory was released in a cataclysmic explosion and fire that burned out of control for ten days, spreading significant radioactive fallout over half the globe. The radioactive emissions at Fukushima, estimated at 10 percent of Chernobyl's, have leaked out slowly over the course of weeks, much of it ending up in the sea. But the equivalence also obscures a deeper shift in the way that we think about the unthinkable. Fukushima has raised practical questions about the future of nuclear power, but

the questions raised by Chernobyl were existential. The radioactive cloud that was released transgressed physical boundaries as easily as it undermined flimsy political dichotomies: East versus West, good versus evil, communism versus capitalism. A nightmare for an uncertain age, Chernobyl heralded the end of the Cold War and prefigured the diffuse terrors of the dawning millennium.

Lately, Chernobyl's reputation has undergone a peculiar transformation. In many articles that appear on its anniversary, the nightmare has changed to a comeback story. The Zone is no longer a wasteland, the story goes, but rather a lush wildlife refuge renewed by the irrepressible

FUKUSHIMA RAISED PRACTICAL QUESTIONS ABOUT NUCLEAR POWER, BUT THE QUESTIONS RAISED BY CHERNOBYL WERE EXISTENTIAL

forces of nature. Eager to rebrand the Zone as Europe's largest nature preserve, the Ukrainian government has introduced a small herd of endangered Przewalski's horses to the Zone and has dabbled in niche tourism. End-times enthusiasts can now take day trips to the forbidden city of Pripjat, a postapocalyptic Disney World complete with a creepy amusement park and authentic Soviet-themed sets.

The notion that an Arcadia has risen from Chernobyl's rubble isn't entirely unfounded. Wolves, moose, black storks, lynx, eagle owls, otters, and many other rare species have been spotted there. Some scientists believe that the absence of human activity has benefited the Zone's plant and animal life, outweighing the negative effects of radiation. But Tim and Anders don't buy it. Over the past decade, they've published more than twenty scientific papers suggesting that the Zone's ecosystem is little more than a sickly clone of the natural world outside its borders.

"It's not a lunar landscape," Tim explained to me. "It's not a complete void of life. It's much more insidious than that. Because everything's still there, it's just being modified at some low level."

After rolling up our nets in Pisky, we drove to Chernobyl, our base for the next six days. On the way, I was alert to any sign of affliction or blight in the passing landscape, but the blank verdure of the fields and the forest beyond revealed nothing extraordinary. Hand-painted billboards appeared occasionally, advertising the Zone's beauty with depictions of pointy green pines and slender white birches set on the banks of curving blue ribbons of water. The scenes would be charmingly naïve in the manner of grade-school artwork but for the Orwellian captions printed beneath them. **FORESTS ARE THE PEOPLE'S WEALTH**, one billboard proclaimed. **PROTECT THE FORESTS!**

Chernobyl was an ancient town, and had 10,000 residents at the time of its evacuation. Today it serves as an administrative outpost and garrison for the police who patrol the Zone's 1,100 square miles, mostly searching for looters and poachers. Near the center of town we passed under a mysterious square arch made of pipe, wrapped in frayed canvas and connected to a latticework of pipes that snaked above the unruly grass. Stray cats and dogs roamed the streets, as well as men in woodland camouflage. We pulled into the parking lot of a building that resembled a self-storage shed, with corrugated metal walls painted mustard yellow. It is Chernobyl's only hotel, shipped here prefab from Finland soon after the disaster. Eleven bare flagpoles stood out front, a sullen reminder of the days when international delegations descended upon Chernobyl to sort out what had happened and what to do. Anders stood at the hotel's entrance, fingering the needles of a hemlock tree that he gleefully pronounced a mutant.

"It is especially pleasing because it is by the front door," he said. Anders has the ruddy complexion and misanthropic frame of mind of a man who spends a lot of time outdoors, away from people.

"How can you tell?" I asked. While I hadn't expected to see giant spiders stalking Chernobyl's derelict neighborhoods, the mutant hemlock looked just like the other trees, a little bushier maybe.

Anders gave me a thin smile. “Well, I’ve only seen perhaps a few hundred thousand of these trees in my life,” he said, “but okay.” He plucked a spindly blue wildflower from the ground and twirled it between his fingers.

“Mutant?” I said.

“*Myosotis stricta*,” Anders said, “the straight forget-me-not.” He mashed the flower against a microscope slide, scribbled some notes in his field book, and began walking down a side street, his pale blue eyes scanning the dense

to a nuclear reactor. That’s technically true, but meltdowns aren’t all created equal. In 1979, Three Mile Island’s Unit 2 reactor experienced a partial meltdown. Years later, when technicians cracked open the reactor’s pressure vessel, the thick steel capsule that contains the nuclear-fuel rods, they were surprised to find that nearly half of the rods had melted. But the molten fuel hadn’t burned through the vessel’s thick steel liner. A full accounting of the

fuel assembly loaded in the core melted so completely and quickly that it flowed like lava into the reactor building’s basement, burning through layers of concrete and steel. The reactor contained 211 tons of nuclear fuel. Nobody knows exactly how much was ejected in the explosion or vaporized in the fire, but the lowest estimate is around 8 tons. Chernobyl released 400 times as much radiation as the Hiroshima bomb, and it dispersed its inventory of radionuclides in a way that



undergrowth for additional specimens. There was a haunted stillness to the air, which smelled sweetly of chestnut and locust blossoms. Across the street, clouds of gnats rose into the slanting light as two stout women swung scythes into a wall of weeds. The liquid notes of a nightingale’s song mingled with opera playing on some unseen radio. Overhead, I glimpsed a swift’s black silhouette splitting the sky. Two swifts, Anders corrected me, flying in tandem. And they were mating, he said. It occurred to me that despite their ignorance of the corruption of the earth passing under their wings, the amorous swifts, like every other living thing in the Zone, were probably radioactive.

A meltdown is often thought to be the worst thing that can happen

chaotic situation unfolding at the Fukushima plant won’t be possible for some time, but it’s clear from the released radionuclides—iodine-131, cesium-137—that some if not all of the fuel rods in three reactors were damaged when dropping water levels allowed temperatures to soar, as were the fuel rods in the spent-fuel storage pools in four reactor buildings. When the spent fuel rods heated up, they began to crack, which released huge amounts of hydrogen gas that likely exploded and blew the thin metal roofs off the reactor buildings. Did the rods at Fukushima get hot enough to melt? We won’t know for certain until radiation levels drop enough for technicians to inspect the reactors.

A steam explosion literally blew the 2,200-ton lid off Chernobyl’s Unit 4 reactor, exposing its nuclear core. The

was inherently more polluting. It was in essence a nuclear volcano. Within a week of the bomb’s detonation, 90 percent of its radiation had dissipated. But in many European countries the consumption of berries, mushrooms, and wild game is to this day restricted because of contamination from Chernobyl’s fallout.

The area around the hotel in Chernobyl is considered “clean” by Zone standards, with about three times the background radiation found elsewhere in Europe. Still, it was high enough to sharpen one’s sense of mortality. On our first morning, as we gathered in the parking lot before breakfast, a cuckoo called from the trees. According to Ukrainian folklore, Gennadi said, the number of calls corresponded to how long you will live.

“I’d rather avoid counting them,” I said.

Anders frowned as if I'd disputed the law of gravity. "It does not matter," he said. "That is how long you will live."

Before entering the modest dining room of the canteen across the street, we were required to stand on a radiation detector. The machine looked like a doctor's scale made from the back end of a '59 Cadillac. I slid my hands inside two chrome-plated brackets and stared at three lamps the size of taillights. In a few seconds the machine rendered its judgment with a green flicker. I was clean.

As we ate, a French film crew shuffled in, disheveled and bleary-eyed. They were making a documentary about wildlife in the Zone, and they'd arranged a few days of shooting with Tim and Anders. The director, Antoine, was a short, frenetic man wearing black Ray-Bans. He leaned over Tim's shoulder.

"Maybe we can talk about different sequences?" Antoine asked. He suggested that they start by filming Tim and Anders leaving the hotel to work in the Zone. Did Tim have a Geiger counter with a big display on it? Something that would look good on camera?

"I think so," Tim said.

"We can even turn on the beeper," Anders added drily.

"Perfect!" Antoine said.

After breakfast Tim and Anders made a show of hauling their gear up and down the hotel stairs for an hour. With each take, Anders grew more exasperated. TV was the stupidest thing ever invented, he railed. It turned people into fat zombies. We were waiting by the car for Antoine's signal when two thrushes flew overhead. The sight of them seemed to calm Anders, and he admitted that the documentary might not be a bad thing if it drew attention to what was happening to the Zone's wildlife.

Driving north out of town to the reactor complex, we passed a road sign announcing the village of Kopachi. There was no village, just a cluster of grassy mounds where houses once stood. Hundreds of such mounds dotted the Zone, marking places where liquidators had buried material too radioactive to leave exposed—houses, vehicles, even the topsoil itself—all bulldozed into trenches and pincush-

ioned with triangular yellow radiation-warning signs.

The trees thinned out to make room for columns of giant transmission towers strung together with miles of dead wire. And then, looming above the tree line, appeared the red and white candy-striped ventilation stack of Unit 4, now faded and dull. Everybody turned to look. Through breaks in the trees I caught glimpses of the "sarcophagus," a hulking gray edifice that entombs the remnants of Chernobyl's reactor. The road branched, and the sarcophagus fell away behind us. Leonid, our driver, turned onto an unpaved access road and stopped next to a burial mound. Nobody seemed alarmed by his choice of parking space.

"What's the radiation level here?" I asked Tim. He shrugged.

"Two, maybe three microsieverts per hour," he said, as if he were guessing the temperature. He pulled out a color-coded contour map of the Zone and laid it on the hood of the car. He traced our route from Chernobyl, his finger coming to rest on an area called the Red Forest, a blotch the shade of rare sirloin indicating some of the highest concentrations of radioactive isotopes in the world.

"Don't put anything on the ground," Anders said sharply. "Don't touch the vegetation. Don't put your fingers in your mouth while you're here. *Don't!*"

Antoine filmed Anders doing a bird census, a scientifically rigorous form of bird watching. Following a course laid out in his GPS, Anders walked across a scrubby meadow, stopping every fifty yards or so for five minutes to count all the birds he could see or hear. He scribbled a dozen names in his black field book, but I could identify only the hoopoe's eerie low-pitched *whoop-whoop*. Radiation levels increased steadily as we entered a forest of Scots pine. It began to rain, and black flies swarmed around our heads. The documentary's producer, an urbane young Parisian named Luc, showed me his dosimeter. It was pinned at its maximum 9.99 microsieverts per hour ($\mu\text{Sv/hr}$). Anders's dosimeter gave a reading of 23 $\mu\text{Sv/hr}$ —more than a hundred times the background radiation around the hotel in Chernobyl. Deep in the forest, Luc said with ner-

vous excitement, radiation levels reached as high as 300 $\mu\text{Sv/hr}$.

"Silence!" Antoine shouted.

"That means in three hours you get your maximum," Luc whispered, referring to the annual limit of 1,000 μSv .¹

Anders and the film crew pressed farther into the forest, but I hung back to take photos. The forest floor was strewn with slabs of broken concrete, rolls of rusted chain-link fencing, ceramic pipes, rotten wooden crates, and old vodka bottles. A park bench rested atop a pile of debris as if inviting us to sit and admire the view. For a time I could hear Antoine shouting "*Action!*" and "*Arrêt!*" Then it was dead quiet apart from the click of my camera's shutter and the lonely echo of a cuckoo calling for a mate.

Without a dosimeter I felt as though I were walking through a minefield. I had no idea what lurked beneath the carpet of pine needles and moss, so I decided to retrace my steps back to the car. I stumbled into a copse of pines that formed a rough circle. The trees all had aluminum identification tags wired around their trunks, and a rusted sign was stuck in the ground at the edge of the circle. The sign was illegible, but I was pretty sure it wasn't an invitation to hang around. I threw my tripod over my shoulder and ran. Once I hit the meadow, breathing hard, I slowed to a walk and promptly swallowed a black fly. Raising my hand reflexively to my mouth, I remembered Anders's warning: *Don't!* I hacked the black fly's sodden little corpse to my lips and spat it out.

Most of what we know about the effects of radiation on human beings comes from the Life Span Study (LSS), a body of medical data collected over decades by the Radiation Effects Research Foundation (RERF) from Japanese atomic-bomb survivors. Thanks to the LSS, we know the amount of radiation it takes to cause your large intestine

¹ The Environmental Protection Agency estimates that the average U.S. resident receives a radiation dose of 3,600 μSv annually from all sources, natural and manmade. The International Council on Radiological Protection recommends that people not exceed 1,000 μSv annually.

to slough its lining, and how much it takes to raise your risk of getting leukemia after age fifty. While it provides the basis for virtually every international health standard regarding acute radiation exposure, the LSS is a poor tool for predicting what might happen to people chronically exposed to low doses of radiation. To wit, no advisory body in the world has identified a “safe” dose of radiation. Standards designed to protect nuclear workers and cancer patients are based on the principle that *any* exposure to radiation can harm you. Over a bottle of Ukrainian cognac one night at the hotel, I asked Tim whether he worried about getting cancer from working in the Zone.

“Relative to cognac and smoking, you mean?” He winked. For argument’s sake, he continued, let’s say that you had a one in a thousand chance of dying from the radiation here. That risk wasn’t equivalent to smoking; it wasn’t cumulative; the probability remained one in a thousand no matter how many times you visited. Tim tapped cigarette ash into an empty water glass. But maybe the health risk *was* cumulative, he mused. Maybe in each of the twelve years he’d been coming to the Zone he’d ingested a certain amount of radiation that incrementally upped his odds of getting cancer. He took a drag on his cigarette, exhaled out the open window, and said, “But I would argue that everything we eat, everything we drink, all this processed food, all the pesticides that contaminate everything in our highly technological, artificial life—it all adds up.”

In other words, modern society has invented so many ways to poison us that a few extra gamma rays get lost in the noise of our dying. Background radiation is everywhere, always has been. Cosmic rays from above. Radon gas from below. Uranium pulsing in the polished granite vaults of New York City’s Grand Central Terminal. Fly in an airplane, get a CAT scan, and you receive an extra dose. And then there’s the radiation we carry in our flesh and bones, souvenirs from decades of nuclear-weapons testing. If

you live in the Northern Hemisphere there’s probably a little bit of Chernobyl in you right now. Is all this radiation making us sick? Maybe. Maybe not. There’s no analogue to the LSS for Chernobyl, no organization like RERF compiling medical data on the millions of people directly affected by the fallout, and thus no reliable statistics for diseases associated with low-level radiation exposure. As far as we know, potato chips will kill us long before plutonium.

On our third day in the Zone it was raining, and a gray mist hung over the green fields. According to Tim’s radiation maps, we were following a lobe of heavy fallout that pointed west from the reactor like a pink finger. Far on the horizon I could see the giant mesh radar array belonging to Chernobyl-2, a former Soviet military station. Beyond the ten-kilometer checkpoint the road turned into an obstacle course of potholes and fallen tree branches. Leonid sawed the steering wheel back and forth, muttering to himself with every jolt. Trees and bushes encroached on the road, at times scraping the doors.

“I like this forest, almost jungle,” said Igor Chizevsky, a technician at the Chernobyl EcoCenter and our official guide. His job was to make sure we didn’t stray into sensitive areas like Chernobyl-2, even though it had been decommissioned long ago and pictures of it were easy to find on the Internet. Soviet-era paranoia has a long half-life. On my first day in Chernobyl, an irate military officer interrogated me in the street for taking pictures of a Lenin statue. Igor bailed me out, but not before the officer berated him for not keeping a closer eye on me. I bought him a bottle of brandy for the trouble I’d caused.

By the time we reached the village of Vesnyanoe, the greenery had swallowed the road altogether. Leonid turned down a grassy lane that ended at an abandoned collective farm. There were about a dozen outbuildings made of red brick rising from a sea of meadow grass. Leonid parked on an asphalt pad that used to be the floor of a large tractor shed. The

shed’s metal walls had been carted off by looters long ago.²

I helped carry the bird nets and poles into a cow barn identical to the one in Pisky. Swallows darted in and out of broken windows, chattering in alarm. In 2001 Tim and Anders published their first paper together on barn swallows, linking the partial albinism they discovered in some birds to elevated radiation levels. The paper made news outside academic circles because everybody likes a good mutant story, and Tim had photos to go with it. In Pisky, he’d shown me a barn swallow with partial albinism. White flecks were sprinkled in among the rust-colored feathers of the bird’s throat. It didn’t look like much, but genetic mutations that find expression in an organism’s physical appearance are often subtle.

The film crew didn’t want me in their footage, so I grabbed a dosimeter and went exploring in the abandoned village. The first building I came to was an old brick schoolhouse. Rain drummed on the metal roof as I stood in the vestibule, adjusting to the darkness. A doll’s head lay on a shelf next to some dusty canning jars, and the warped plank floor was littered with children’s shoes and faded rubber toys—a pink whale, a blue cat. There was an organic quality to the ribbons of wallpaper heaped along the baseboards, as if the walls were shedding their skin. Outside, trees and bushes had grown right up to the brick. I walked to a ruined store in the center of town. A fallen tree had staved in the roof, and rain streamed down the splintered rafters. There was nothing inside. The store had probably been cleaned out in the first few weeks after the meltdown. Turning to go, I caught sight of a wooden abacus lying on the floor amid piles of rotting leaves. When I was growing up in the anticommunist fervor of the Eighties, it would have been a comfort to know that citizens of the Evil Empire tallied their grocery bills with an abacus.

² *Illegal salvage is a cottage industry in the Zone. In 2008, Ukraine’s state security service arrested several men at a checkpoint for attempting to steal a helicopter used in the Chernobyl cleanup. The men planned to convert the chopper, whose contamination level was thirty times the legal limit, into a theme café.*

I canvassed the rest of the village, wading through stinging nettles and pushing aside coils of bramble, mindful of falling into hidden wells. I felt my way through darkened rooms, treading warily on floorboards spongy with rot. I heard nothing but the scrape of my boots and the steady patter of rain on the leaves outside. During the Zone's evacuation, people were told to leave everything behind, that they'd be coming back in a few days. They never did, of course, but few clues to their existence remained. Looters had stripped the Zone bare, right down to the lightbulbs. In Vesnyanoe and other villages I visited, I found only a few sticks of broken furniture, a keyless accordion, and a hand-carved curry brush that would make a quaint decoration in some oligarch's summer dacha. Once, in the drawer of an overturned dresser, I discovered a framed collage of black-and-white family portraits. Many of the photos showed a grim man with blunt features and thick hair swept back off his square forehead in the style of Stalin. In one blurry picture the man was in a coffin adorned with flowers, dressed in a suit, his limp hands propped on his chest in a gesture of supplication.

When I returned to the collective farm the others were standing around waiting for Antoine to finish interviewing Tim and Anders. Gennadi opened his trunk and came at me with a snow brush. "Your trousers," he said, and vigorously brushed the backs of my legs. I hadn't noticed that I was streaked with a chalky white dust from rubbing against plaster walls.

"Radiation-remove device," Igor joked.

Gennadi dropped the snow brush in a garbage bag to keep it from contaminating the stuff in his trunk. Sasha, the French crew's guide, leaned against his van, smoking a cigarette. His strong cheekbones and deep-set green eyes seemed oddly familiar.

"I think I've seen that guy on the Internet," I whispered to Igor, "eating an apple in the Zone. He's crazy."

Igor pointed to his chest. "I took picture," he said proudly. He translated what I'd said to Sasha, who grinned and told Igor that he wasn't afraid to eat the apple, that he was still alive, wasn't he? And now look—the picture of him

eating the apple had made him famous in New York! "I remember some anecdote," Igor said, turning serious for a moment. "One question: You can eat apple from Chernobyl?"

"You can?" I said.

"Yes, of course," he said. "Eat, you can. But your shit, need bury in ground three meter."

Igor suggested we check out a big pond behind the barn. He pried open a gap in a barbed-wire fence, and we slipped through it and crossed a field of coarse grass. The sun came out, and a soft breeze silvered the birch and willow trees shading the shoreline. The bulrushes clattered. Fish nipped at insects, sending ripples over the pond's lily-covered surface.

"Steve, you come here," Igor shouted. "Very beautiful picture."

I circled the edge of the pond. There was Igor, standing next to the carcass of a moose calf. The calf lay on its side, half submerged. A black water beetle the size of a tea saucer clawed at its nose, and frogs squatted on its bloated rib cage, snapping at flies. The breeze shifted, filling our nostrils with the stench of rotting meat. As we backpedaled toward the barn, Igor asked me not to tell our "French friends" about the dead moose. I suspected that he didn't want Antoine to exploit it for propaganda. The existence of moose, even a dead one, was more anecdotal proof that the Zone was a teeming wildlife preserve.

But Antoine didn't need a moose to prove his point. He just would have to expand his scope to include some of the Zone's less photogenic wildlife, like ticks. Later that night, I killed two that I found in my underwear. And at dinner I brushed a tick off Igor's shoulder, crushing it beneath a drinking glass. Then Anders reached over and pinched one off my shirt. Instead of killing the tick, he dropped it on his plate, folded his arms, and watched it crawl away.

"Some joys must be shared," he said.

One cloudy afternoon, we went to Pripyat to scout for barn-swallow nesting sites. The city was once a workers' paradise, purpose-built in 1970 for Chernobyl plant staff and their families. At the time of the ac-

cident, 45,000 people were living there and enjoying all the modern conveniences the Soviet Union had to offer. Now it's become the Zone's public face, a monument to life at the zenith of Soviet power. Its buildings and streets have been well documented in photographs and films, and even digitized in loving detail as a setting for violent video games such as *Call of Duty 4*.

Just beyond the checkpoint into the city we drove past a four-foot-tall Jesus hanging from a varnished crucifix, and cruised slowly down a wide boulevard littered with poplar branches. Ten-story apartment towers rose amid plazas and parks that had reverted to meadow and forestland. We stopped at a former heavy-equipment repair facility that Tim suspected of harboring a barn-swallow colony. A few birds flew in and out of the open mechanic's bays, but from the ground we couldn't see any roosts. We climbed a flight of rickety metal stairs and entered a warren of offices and locker rooms on the second floor. The detritus of looters cluttered the narrow hallways: overalls, rubber boots, gas masks with the filters pried out. Employment records with black-and-white ID photos glued to them were spilled across the floor of a washroom. We found the skeleton of one swallow trapped inside a double windowpane, but no evidence of a colony.

On the way back to the hotel, Tim asked Gennadi to swing by the Chernobyl plant. It was close by, and he wanted me to see it. We pulled up next to a monument to Chernobyl victims in the middle of an empty parking lot and got out to gaze at the sarcophagus. It was bigger and more decrepit than I'd expected, like a battle-worn concrete aircraft carrier run aground. Somewhere in its dark, dripping chambers was a species of mutant black fungus that, according to some scientists, possessed the unique ability to feed on radiation. Remote-controlled robots piloted into the heart of the sarcophagus have sent back pictures of bizarre heaps of corium. A by-product of the meltdown, corium is a highly radioactive slag of liquefied concrete, steel, sand, chunks of the reactor's graphite moderator, nuclear-fuel rods, and God knows what else. Nobody can

get near the stuff to remove it. I asked what the radiation levels were this close to the reactor. Tim took a drag on his cigarette and flicked the butt into the parking lot.

"Oh, it's an X-ray kind of day," he said.

"You like go see big fish?" Gennadi inquired.

"Sure," I said, and went to grab my camera gear. Gennadi stopped me. "You cannot take picture," he said. "Is forbidden."

The parking lot was adjacent to the reactor's cooling pond. I'd read something about giant catfish living in it, some as big as torpedoes. We stood on a rail trestle over the pond, tearing apart bread slices left over from lunch. The bread bobbed around for a while, white blobs dissolving into the black water. Nothing happened.

"Now is cold weather, and wind," Gennadi said. "When is very calm, big fish coming."

Then, in a series of lazy splashes, the bread chunks began to disappear, one by one. It was too overcast to see the catfish, but I could imagine their sluggish bodies sliding down to the murky bottom of the cooling pond and settling there in a puff of radioactive sediment.

There are three basic types of ionizing radiation: alpha, beta, and gamma. Like X-rays, gamma rays are very high-frequency photons. They pass easily through most materials, including flesh. Gamma rays strip away electrons from atoms, disrupting cellular chemistry. In high doses, they can destroy tissue, which is the principle behind cancer radiotherapy. Unlike gamma rays, the other two types of radiation, alpha and beta, are composed of subatomic particles with mass. They don't travel nearly as far as gamma rays, and they can't penetrate anything much thicker than a sheet of paper. But if you inhale a mote of radioactive dust, eat contaminated food, or absorb radionuclides through an open wound, alpha or beta radiation can do a lot of damage. Lodged in your lung, a molecule of plutonium, which is a powerful beta emitter, will ravage nearby cells until it's flushed out weeks or years later (if at all) through natural biochemical processes.

In the Zone we were defenseless against gamma radiation. We could only heed our dosimeters and try to minimize exposure. To prevent contamination from alpha and beta particles, we wore rubber boots in the worst areas. At the end of the day, we scuffed them in the "clean" grass along the roadside and wrapped them in garbage bags before getting into our vehicles. In the field, we ate food that Gennadi had bought in Kiev off a bath towel that he spread across the trunk of his old Ford sedan. We washed our hands constantly, and we never touched our faces while outside, at least not consciously.

On our last day in the Zone, we returned to the Red Forest to gather oak leaves for an experiment. It was cold and drizzling. Tim opened a box of disposable Tyvek suits, the kind worn by hazmat workers. This time we were going into the "real" Red Forest, he explained. We set off across a meadow, skirting burial mounds, our legs swishing in unison. In the forest I recognized piles of debris from the last time I was there, but I soon lost track of where I was. The pine trees grew closer, dimming the watery gray light filtering down from the needled canopy. The inert silence of the forest was occasionally broken by a crow's raspy croak or the shrill whistle of a flycatcher. An hour passed before we found what could only generously be defined as an oak tree. Three feet tall and lacking a central trunk, it resembled a bush. We stripped off the few yellowish leaves clinging to its spindly branches, stuffed them in a Ziploc bag, and moved on.

The pine forest yielded to open meadow. A crosshatch pattern of scorched trees lay in the rough grass, and more blackened trunks stood out like rotten teeth amid stands of white birch saplings. These were remnants of the "real" Red Forest, a large tract of evergreens adjacent to the Chernobyl reactor that got hit by the worst of the fallout. (Almost overnight, the evergreens died and their needles turned orange, hence the name.) Soviet liquidators razed the forest, sprayed the area with a polymer to keep radioactive dust from blowing around, and replanted it. The natural forces of decay and regeneration had been subverted. I stopped next to a thirty-foot Scots pine resting

on the ground. After twenty-five years, its black branches were still perfectly intact, as if it had been dipped in pitch and laid out to dry. In a healthy forest, the tree would've been a heap of mulch. Radiation, Tim and Anders hypothesized, had effectively mummified it by inhibiting microbial decomposition. The dosimeter I'd borrowed was reading 116 $\mu\text{Sv/hr}$, an order of magnitude higher than anything we'd yet recorded. I slid the device back into my pocket and jogged to catch up with Tim.

In our white Tyvek suits, we trekked across clearings where nothing grew except rubbery patches of lichen the color of overcooked peas. The conifers began to take on shapes like poorly cultivated bonsai shrubs. Stunted by radiation, they lacked symmetry, and their gnarled branches twisted in all directions except up. Consulting his GPS, Tim pushed through a dense willow thicket and halted at the edge of a swamp. To reach the woods on the other side we'd have to bushwhack around it. We zigzagged over the knobby terrain, hopping from one tussock of sedge to another. Just as we gained the other side of the swamp, the Tyvek bootie covering my right foot snagged on a willow branch and tore completely away. My foot plunged past the ankle into the cold brown water.

"Fuck!" I shouted.

"You're wearing boots, right?" Tim said, looking over his shoulder. I lifted my foot to show him my dripping running shoe. His eyes widened. "Oh," he said.

"Yeah," I said. "Sneakers." But that was only half the story. The previous day I'd stepped on a large-bore trocar at an abandoned veterinary clinic. It punched through the sole of my rubber boot and sank deep into the ball of my right foot, which had throbbed painfully ever since. That was my excuse for slogging through a radioactive swamp in a pair of running shoes—comfort. I mentioned none of this to Tim. I lurched behind him through the woods like a zombie, trying not to put too much weight on my injured foot, the ripped Tyvek pant leg flapping behind me. We found another oak tree on a greasy patch of dirt and leaves that had been torn up by wild boar. Kneeling on a blue tarp, Tim scraped fungus from the oak's branches with a trowel. My dosimeter gave a reading of 90 $\mu\text{Sv/hr}$. I squatted down and

switched the selector to read alpha and beta radiation, in addition to gamma. The reading shot above three digits.

"113 and counting," I said.

"Looks like you found yourself a hot particle," Tim said.

"125, 126..." As the number ticked upward, I did the math in my head: 600 times the radiation level at the hotel in Chernobyl; 1,400 times the background level of my home in upstate New York. Sitting here for forty-five minutes was equal to getting a chest X-ray.

"Probably a few molecules of plutonium," Tim said. I imagined comic-book rays of green light shooting through me and felt a vertiginous tingle in my legs. Given the radioactive baptism I received back at the swamp, it was probably a good idea to avoid any unnecessary exposure. I leapt to my feet. Tim laughed and flapped his arms like a chicken. "*Bawk-bawk-bawk!*" he cackled.

We left the Zone for good later that afternoon. The sun broke out from behind the clouds as we approached the last checkpoint at Dytyatky. The checkpoint guard walked around Gennadi's car, holding a wand attached to a large metal box. For a moment I thought he might detect my wet sneakers and pants, which were balled up inside a garbage bag in the trunk. But the gate opened, and we drove the two-lane road toward Kiev. Babushkas sat in the shade, selling strawberries and spiky bunches of the herb sweet flag in preparation for Holy Trinity Day, when Ukrainians remember their dead. Gennadi stopped the car in Mikhilivschyna, a large tract of forest thirty miles from Chernobyl that Tim and Anders used as a control area (background radiation there is only .03 $\mu\text{Sv/hr}$). Tim always packed extra shoes, and he lent me a worn pair of black Reeboks. I bent down to tie them and noticed a bunch of red ants tugging at a molted cicada shell. I couldn't recall ever seeing a single ant or hearing a cicada's buzz when I was in the Zone. Then a grasshopper ricocheted off my shin.

"Is it me, or are there more bugs around here?" I asked Tim.

"You noticed?" he said. "It's pretty striking."

Two months earlier he and Anders had published the first extensive study of insects in the Zone, and their findings mirrored their work on bird populations. Basically, as radiation levels increased,

the numbers of critters decreased. Mikhilivschyna, by contrast, hummed with everyday life. Dragonflies, robber flies, and iridescent blue butterflies filled the air. Fat honeybees droned among clusters of purple and pink wildflowers. In the forest, dozens of bird species hidden in the dark understory contributed chirps and warbles. Hunting for oak leaves, we came to a clearing that had been trampled by wild boar. Tim scooped up a handful of crumbly black soil. Lots of turnover here, he said, referring to the high rate of decomposition. Towering over us was a giant oak whose branches started fifty feet above the ground. We'd need a cherry picker to collect any leaves. Tim slapped the oak's massive trunk. "It's the same basic composition," he said. "The Chernobyl area is just a much simpler version."

The environmental impact of fallout from the damaged reactors at Fukushima will take a long time to assess, but it's safe to say that it won't begin to approach the level of damage wrought by Chernobyl. Towns may have to be abandoned for years while Japanese authorities figure out how best to decontaminate them, but there will be no Japanese version of the Red Forest, no partial-albino barn swallows. The pine trees will grow straight and true. The birds will sing from their branches. And fallow spinach fields dusted by cesium-137 and strontium-90 will buzz with the rough music of cicadas, even if there are no people around to hear it.

I accompanied Tim and Anders on our last day together to a dairy farm in Voronkov. The swallow colony there serves as a control group. They sat at a battered table inside a barn, surrounded by Ziploc bags stuffed with glass vials, boxes of microscope slides, and a plastic cup of Nemiroff vodka that they used to sterilize the thermometer. Tim filled out worksheets and labeled vials filled with blood and sperm. Anders handled the birds, playing them like a concert pianist. Every movement of his fingers—tapping beaks, spreading wings, jabbing lancets—was calibrated to cause the minimum amount of discomfort. By the time he reached the final procedure, to gauge a bird's stress reaction, he seemed relieved. He stood by

the open door, cradling a swallow in his palm. The bird rested on its back for a few seconds, getting its bearings, and then disappeared in a metallic blue flash. Smiling crookedly, Anders glanced at his wristwatch and called out the time to Tim.

Along with Gennadi and two other Ukrainian volunteers, I was entrusted with the delicate tasks of counting eggs and disentangling the birds from the nets. I was pretty good at it by then. Once, three swallows flew into the net at the same time. I slid two of them into a linen sack and hung it on a nail. The third swallow had black Sharpie smudges on its white underbelly, marking it as a returnee. I ducked under the net and stepped into the courtyard. The bird felt weightless in my hand, like a sachet of dry twigs wrapped in tissue paper. It cocked its head as if to ask whether I was going to let it live. I tossed it into the air. The swallow dipped toward the ground, righted itself, then hurtled into the sky to join the others wheeling and chattering above the courtyard.

As they processed the last few birds, Tim and Anders were in a buoyant mood. They debated where we should celebrate that night, their banter oscillating between Anders's droll misanthropy and Tim's chummy good humor. Anders reached into a linen sack, pulled out a swallow, and laid it on the table. Its tiny black feet were curled against its downy belly. "Dead?" Tim asked. Anders nodded. Too many birds in one bag, he mumbled. The blame fell on me, but there was no way to tell whether it was my bird or one of the volunteers'. I began to explain how there weren't enough sacks for all the birds, but the contempt on Anders's face stopped me cold.

"I didn't know," I said. "I'm sorry."

"Well," Anders said, and cleared his throat. He didn't finish his sentence. But I knew what he was thinking. We owed the bird more than the casual cruelty of our ignorance. Anders scooped up the dead swallow and pinched its wing tips together. He fastened them with a metal clip attached to a digital scale by a metal rod, just as he had done with all the other birds. Then he held up the scale and called out the swallow's weight, as the swallow dangled from the rod in perverse imitation of flight. ■