"Alan Weisman offers us a sketch of where we stand as a species that is both illuminating and terrifying. His tone is conversational and his affection for both Earth and humanity transparent."
—Barry Lopez, author of *Arctic Dreams*

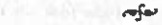
"Fascinating, mordant, deeply intelligent, and beautifully written, *The World Without Us* depicts the spectacle of humanity's impact on the planet Earth in tragically poignant terms that go far beyond the dry dictates of science. This is a very important book for a species playing games with its own destiny."
—James Howard Kunstler, author of *The Long Emergency*

"Weisman's enthralling tour of the world of tomorrow explores what little will remain of ancient times while anticipating, often poetically, what a planet without us would be like."
—*Publishers Weekly* (starred review)

"The imaginative power of *The World Without Us* is compulsive and nearly hypnotic—make sure you have time to be kidnapped into Alan Weisman's alternative world before you sit down with the book, because you won't soon return. This is a text that has a chance to change people, and so make a real difference for the planet."
—Charles Wohlforth, author of the *Los Angeles Times* Book Prize–winning *The Whale and the Supercomputer*

"Weisman is a thoroughly engaging and clarion writer fueled by curiosity and determined to cast light rather than spread despair. His superbly well-researched and skillfully crafted stop-you-in-your-tracks report stresses the underappreciated fact that humankind's actions create a ripple effect across the web of life."
—*Booklist* (starred review)

THE WORLD WITHOUT US



ALAN WEISMAN

PICADOR
THOMAS DUNNE BOOKS
ST. MARTIN'S PRESS
NEW YORK

Portions of this book have appeared previously in different form in *Discover* magazine and the *Los Angeles Times Magazine.*

Book design by Ellen Cipriano

ISBN-13: 978-0-312-42790-0
ISBN-10: 0-312-42790-5

First published in the United States by St. Martin's Press

10 9 8 7 6

Printed on recycled paper

In memory of
Sonia Marguerite

with lasting love
from a world without you

CHAPTER 1

A Lingering Scent of Eden

YOU MAY NEVER have heard of the Białowieża Puszcza. But if you were raised somewhere in the temperate swathe that crosses much of North America, Japan, Korea, Russia, several former Soviet republics, parts of China, Turkey, and Eastern and Western Europe—including the British Isles—something within you remembers it. If instead you were born to tundra or desert, subtropics or tropics, pampas or savannas, there are still places on Earth kindred to this *puszcza* to stir your memory, too.

Puszcza, an old Polish word, means "forest primeval." Straddling the border between Poland and Belarus, the half-million acres of the Białowieża Puszcza contain Europe's last remaining fragment of old-growth, lowland wilderness. Think of the misty, brooding forest that loomed behind your eyelids when, as a child, someone read you the Grimm Brothers' fairy tales. Here, ash and linden trees tower nearly 150 feet, their huge canopies shading a moist, tangled understory of hornbeams, ferns, swamp alders and crockery-sized fungi. Oaks, shrouded with half a millennium of

moss, grow so immense here that great spotted woodpeckers store spruce cones in their three-inch-deep bark furrows. The air, thick and cool, is draped with silence that parts briefly for a nutcracker's croak, a pygmy owl's low whistle, or a wolf's wail, then returns to stillness.

The fragrance that wafts from eons of accumulated mulch in the forest's core hearkens to fertility's very origins. In the Białowieża, the profusion of life owes much to all that is dead. Almost a quarter of the organic mass aboveground is in assorted stages of decay—more than 50 cubic yards of decomposing trunks and fallen branches on every acre, nourishing thousands of species of mushrooms, lichens, bark beetles, grubs, and microbes that are missing from the orderly, managed woodlands that pass as forests elsewhere.

Together those species stock a sylvan larder that provides for weasels, pine martens, raccoons, badgers, otters, fox, lynx, wolves, roe deer, elk, and eagles. More kinds of life are found here than anywhere else on the continent—yet there are no surrounding mountains or sheltering valleys to form unique niches for endemic species. The Białowieża Puszcza is simply a relic of what once stretched east to Siberia and west to Ireland.

The existence in Europe of such a legacy of unbroken biological antiquity owes, unsurprisingly, to high privilege. During the 14th century, a Lithuanian duke named Władysław Jagiełło, having successfully allied his grand duchy with the Kingdom of Poland, declared the forest a royal hunting preserve. For centuries, it stayed that way. When the Polish-Lithuanian union was finally subsumed by Russia, the Białowieża became the private domain of the tsars. Although occupying Germans took lumber and slaughtered game during World War I, a pristine core was left intact, which in 1921 became a Polish national park. The timber pillaging resumed briefly under the Soviets, but when the

Nazis invaded, a nature fanatic named Hermann Göring decreed the entire preserve off-limits, except by his pleasure.

Following World War II, a reportedly drunken Josef Stalin agreed one evening in Warsaw to let Poland retain two-fifths of the forest. Little else changed under communist rule, except for construction of some elite hunting dachas—in one of which, Viskuli, an agreement was signed in 1991 dissolving the Soviet Union into free states. Yet, as it turns out, this ancient sanctuary is more threatened under Polish democracy and Belarusian independence than it was during seven centuries of monarchs and dictators. Forestry ministries in both countries tout increased management to preserve the Puszcza's health. Management, however, often turns out to be a euphemism for culling—and selling—mature hardwoods that otherwise would one day return a windfall of nutrients to the forest.

IT IS STARTLING to think that all Europe once looked like this Puszcza. To enter it is to realize that most of us were bred to a pale copy of what nature intended. Seeing alders with trunks seven feet wide, or walking through stands of the tallest trees here—gigantic Norway spruce, shaggy as Methuselah—should seem as exotic as the Amazon or Antarctica to someone raised among the comparatively puny, second-growth woodlands found throughout the Northern Hemisphere. Instead, what's astonishing is how primally familiar it feels. And, on some cellular level, how complete.

Andrzej Bobiec recognized it instantly. As a forestry student in Krakow, he'd been trained to manage forests for maximum productivity, which included removing "excess" organic litter lest it harbor pests like bark beetles. Then, on a visit here he was

Five-hundred-year-old oaks. Białowieża Puszcza, Poland.

PHOTO BY JANUSZ KORBEL.

stunned to discover 10 times more biodiversity than in any forest he'd ever seen.

It was the only place left with all nine European woodpecker species, because, he realized, some of them only nest in hollow, dying trees. "They can't survive in managed forests," he argued to his forestry professors. "The Białowieża Puszcza has managed itself perfectly well for millennia."

The husky, bearded young Polish forester became instead a forest ecologist. He was hired by the Polish national park service. Eventually, he was fired for protesting management plans that chipped ever closer to the pristine core of the Puszcza. In various international journals, he blistered official policies that asserted that "forests will die without our thoughtful help," or that justified cutting timber in the Białowieża's surrounding buffer to "reestablish the primeval character of stands." Such convoluted thinking, he accused, was rampant among Europeans who have hardly any memory of forested wilderness.

To keep his own memory connected, for years he daily laced his leather boots and hiked through his beloved Puszcza. Yet although he ferociously defends those parts of this forest still undisturbed by man, Andrzej Bobiec can't help being seduced by his own human nature.

Alone in the woods, Bobiec enters into communion with fellow *Homo sapiens* through the ages. A wilderness this pure is a blank slate to record human passage: a record he has learned to read. Charcoal layers in the soil show him where gamesmen once used fire to clear parts of the forest for browse. Stands of birch and trembling aspen attest to a time when Jagiełło's descendants were distracted from hunting, perhaps by war, long enough for these sun-seeking species to recolonize game clearings. In their shade grow telltale seedlings of the hardwoods that were here

before them. Gradually, these will crowd out the birch and aspen, until it will be as if they were never gone.

Whenever Bobiec happens on an anomalous shrub like hawthorn or on an old apple tree, he knows he's in the presence of the ghost of a log house long ago devoured by the same microbes that can turn the giant trees here back into soil. Any lone, massive oak he finds growing from a low, clover-covered mound marks a crematorium. Its roots have drawn nourishment from the ashes of Slavic ancestors of today's Belorusians, who came from the east 900 years ago. On the northwest edge of the forest, Jews from five surrounding shtetls buried their dead. Their sandstone and granite headstones from the 1850s, mossy and tumbled by roots, have already worn so smooth that they've begun to resemble the pebbles left by their mourning relatives, who themselves long ago departed.

Andrzej Bobiec passes through a blue-green glade of Scots pine, barely a mile from the Belarusian border. The waning October afternoon is so hushed, he can hear snowflakes alight. Suddenly, there's a crashing in the underbrush, and a dozen wisent—*Bison bonasus,* European bison—burst from where they've been browsing on young shoots. Steaming and pawing, their huge black eyes glance just long enough for them to do what their own ancestors discovered they must upon encountering one of these deceptively frail bipeds: they flee.

Just 600 wisent remain in the wild, nearly all of them here—or just half, depending on what's meant by *here.* An iron curtain bisects this paradise, erected by the Soviets in 1980 along the border to thwart escapees to Poland's renegade Solidarity movement. Although wolves dig under it, and roe deer and elk are believed to leap it, the herd of these largest of Europe's mammals

remains divided, and with it, its gene pool—divided and mortally diminished, some zoologists fear. Once, following World War I, bison from zoos were brought here to replenish a species nearly extirpated by hungry soldiers. Now, a remnant of a Cold War threatens them again.

Belarus, which well after communism's collapse has yet to remove statues of Lenin, also shows no inclination to dismantle the fence, especially as Poland's border is now the European Union's. Although just 14 kilometers separate the two countries' park headquarters, to see the Belovezhskaya Pushcha, as it is called in Belorusian, a foreign visitor must drive 100 miles south, take a train across the border to the city of Brest, submit to pointless interrogation, and hire a car to drive back north. Andrzej Bobiec's Belorusian counterpart and fellow activist, Heorhi Kazulka, is a pale, sallow invertebrate biologist and former deputy director of Belarus's side of the primeval forest. He was also fired by his own country's park service, for challenging one of the latest park additions—a sawmill. He cannot risk being seen with Westerners. Inside the Brezhnev-era tenement where he lives at the forest's edge, he apologetically offers visitors tea and discusses his dream of an international peace park where bison and moose would roam and breed freely.

The Pushcha's colossal trees are the same as those in Poland; the same buttercups, lichens, and enormous oak leaves; the same circling white-tailed eagles, heedless of the razor-wire barrier below. In fact, on both sides, the forest is actually growing, as peasant populations leave shrinking villages for cities. In this moist climate, birch and aspen quickly invade their fallow potato fields; within just two decades, farmland gives way to woodland. Under the canopy of the pioneering trees, oak, maple, linden, elm, and spruce regenerate. Given 500 years without people, a true forest could return.

The thought of rural Europe reverting one day to original forest is heartening. But unless the last humans remember to first remove Belarus's iron curtain, its bison may wither away with them.

CHAPTER 2

Unbuilding Our Home

"'If you want to destroy a barn,' a farmer once told me,
'cut an eighteen-inch-square hole in the roof.
Then stand back.'"

—architect Chris Riddle
Amherst, Massachusetts

ON THE DAY after humans disappear, nature takes over and immediately begins cleaning house—or houses, that is. Cleans them right off the face of the Earth. They all go.

If you're a homeowner, you already knew it was only a matter of time for yours, but you've resisted admitting it, even as erosion callously attacked, starting with your savings. Back when they told you what your house would cost, nobody mentioned what you'd also be paying so that nature wouldn't repossess it long before the bank.

Even if you live in a denatured, postmodern subdivision where heavy machines mashed the landscape into submission, replacing unruly native flora with obedient sod and uniform saplings, and paving wetlands in the righteous name of mosquito control—even then, you know that nature wasn't fazed. No

matter how hermetically you've sealed your temperature-tuned interior from the weather, invisible spores penetrate anyway, exploding in sudden outbursts of mold—awful when you see it, worse when you don't, because it's hidden behind a painted wall, munching paper sandwiches of gypsum board, rotting studs and floor joists. Or you've been colonized by termites, carpenter ants, roaches, hornets, even small mammals.

Most of all, though, you are beset by what in other contexts is the veritable stuff of life: water. It always wants in.

After we're gone, nature's revenge for our smug, mechanized superiority arrives waterborne. It starts with wood-frame construction, the most widely used residential building technique in the developed world. It begins on the roof, probably asphalt or slate shingle, warranted to last two or three decades—but that warranty doesn't count around the chimney, where the first leak occurs. As the flashing separates under rain's relentless insistence, water sneaks beneath the shingles. It flows across four-by-eight-foot sheets of sheathing made either of plywood or, if newer, of woodchip board composed of three- to four-inch flakes of timber, bonded together by a resin.

Newer isn't necessarily better. Wernher Von Braun, the German scientist who developed the U.S. space program, used to tell a story about Colonel John Glenn, the first American to orbit the Earth. "Seconds before lift-off, with Glenn strapped into that rocket we built for him and man's best efforts all focused on that moment, you know what he said to himself? 'Oh, my God! I'm sitting on a pile of low bids!' "

In your new house, you've been sitting under one. On the one hand, that's all right: by building things so cheaply and lightly, we use fewer of the world's resources. On the other hand, the massive trees that yielded the great wooden posts and beams that still support medieval European, Japanese, and early American

walls are now too precious and rare, and we're left to make do with gluing together smaller boards and scraps.

The resin in your cost-conscious choice of a woodchip roof, a waterproof goo of formaldehyde and phenol polymer, was also applied along the board's exposed edges, but it fails anyway because moisture enters around the nails. Soon they're rusting, and their grip begins to loosen. That presently leads not only to interior leaks, but to structural mayhem. Besides underlying the roofing, the wooden sheathing secures trusses to each other. The trusses—premanufactured braces held together with metal connection plates—are there to keep the roof from splaying. But when the sheathing goes, structural integrity goes with it.

As gravity increases tension on the trusses, the ¼-inch pins securing their now-rusting connector plates pull free from the wet wood, which now sports a fuzzy coating of greenish mold. Beneath the mold, threadlike filaments called hyphae are secreting enzymes that break cellulose and lignin down into fungi food. The same thing is happening to the floors inside. When the heat went off, pipes burst if you lived where it freezes, and rain is blowing in where windows have cracked from bird collisions and the stress of sagging walls. Even where the glass is still intact, rain and snow mysteriously, inexorably work their way under sills. As the wood continues to rot, trusses start to collapse against each other. Eventually the walls lean to one side, and finally the roof falls in. That barn roof with the 18-by-18-inch hole was likely gone inside of 10 years. Your house's lasts maybe 50 years; 100, tops.

While all that disaster was unfolding, squirrels, raccoons, and lizards have been inside, chewing nest holes in the drywall, even as woodpeckers rammed their way through from the other direction. If they were initially thwarted by allegedly indestructible siding made of aluminum, vinyl, or the maintenance-free,

portland-cement-cellulose-fiber clapboards known as Hardie planks, they merely have to wait a century before most of it is lying on the ground. Its factory-impregnated color is nearly gone, and as water works its inevitable way into saw cuts and holes where the planks took nails, bacteria are picking over its vegetable matter and leaving its minerals behind. Fallen vinyl siding, whose color began to fade early, is now brittle and cracking as its plasticizers degenerate. The aluminum is in better shape, but salts in water pooling on its surface slowly eat little pits that leave a grainy white coating.

For many decades, even after being exposed to the elements, zinc galvanizing has protected your steel heating and cooling ducts. But water and air have been conspiring to convert it to zinc oxide. Once the coating is consumed, the unprotected thin sheet steel disintegrates in a few years. Long before that, the water-soluble gypsum in the sheetrock has washed back into the earth. That leaves the chimney, where all the trouble began. After a century, it's still standing, but its bricks have begun to drop and break as, little by little, its lime mortar, exposed to temperature swings, crumbles and powders.

If you owned a swimming pool, it's now a planter box, filled with either the offspring of ornamental saplings that the developer imported, or with banished natural foliage that was still hovering on the subdivision's fringes, awaiting the chance to retake its territory. If the house's foundation involved a basement, it too is filling with soil and plant life. Brambles and wild grapevines are snaking around steel gas pipes, which will rust away before another century goes by. White plastic PVC plumbing has yellowed and thinned on the side exposed to the light, where its chloride is weathering to hydrochloric acid, dissolving itself and its polyvinyl partners. Only the bathroom tile, the chemical properties of its fired ceramic not unlike those of fossils,

is relatively unchanged, although it now lies in a pile mixed with leaf litter.

After 500 years, what is left depends on where in the world you lived. If the climate was temperate, a forest stands in place of a suburb; minus a few hills, it's begun to resemble what it was before developers, or the farmers they expropriated, first saw it. Amid the trees, half-concealed by a spreading understory, lie aluminum dishwasher parts and stainless steel cookware, their plastic handles splitting but still solid. Over the coming centuries, although there will be no metallurgists around to measure it, the pace at which aluminum pits and corrodes will finally be revealed: a relatively new material, aluminum was unknown to early humans because its ore must be electrochemically refined to form metal.

The chromium alloys that give stainless steel its resilience, however, will probably continue to do so for millennia, especially if the pots, pans, and carbon-tempered cutlery are buried out of the reach of atmospheric oxygen. One hundred thousand years hence, the intellectual development of whatever creature digs them up might be kicked abruptly to a higher evolutionary plane by the discovery of ready-made tools. Then again, lack of knowledge of how to duplicate them could be a demoralizing frustration—or an awe-arousing mystery that ignites religious consciousness.

If you were a desert dweller, the plastic components of modern life flake and peel away faster, as polymer chains crack under an ultraviolet barrage of daily sunshine. With less moisture, wood lasts longer there, though any metal in contact with salty desert soils will corrode more quickly. Still, from Roman ruins we can guess that thick cast iron will be around well into the

future's archaeological record, so the odd prospect of fire hydrants sprouting amidst cacti may someday be among the few clues that humanity was here. Although adobe and plaster walls will have eroded away, the wrought iron balconies and window grates that once adorned them may still be recognizable, albeit airy as tulle, as corrosion eating through the iron encounters its matrix of indigestible glass slag.

Once, we built structures entirely from the most durable substances we knew: granite block, for instance. The results are still around today to admire, but we don't often emulate them, because quarrying, cutting, transporting, and fitting stone require a patience we no longer possess. No one since the likes of Antoni Gaudí, who began Barcelona's yet-unfinished Sagrada Familia basilica in 1880, contemplates investing in construction that our great-great-grandchildren's grandchildren will complete 250 years hence. Nor, absent the availability of a few thousand slaves, is it cheap, especially compared to another Roman innovation: concrete.

Today, that brew of clay, sand, and a paste made of the calcium of ancient seashells hardens into a man-made rock that is increasingly the most affordable option for *Homo sapiens urbanus*. What happens, then, to the cement cities now home to more than half the humans alive?

Before we consider that, there's a matter to address regarding climate. If we were to vanish tomorrow, the momentum of certain forces we've already set in motion will continue until centuries of gravity, chemistry, and entropy slow them to an equilibrium that may only partly resemble the one that existed before us. That former equilibrium depended on a sizeable amount of carbon locked away beneath Earth's crust, much of which we've now relocated

into the atmosphere. Instead of rotting, the wood frames of houses may be preserved like the timbers of Spanish galleons wherever rising seas pickle them in salt water.

In a warmer world, the deserts may grow drier, but the parts where humans dwelled will likely again be visited by what attracted those humans in the first place: flowing water. From Cairo to Phoenix, desert cities rose where rivers made arid soils livable. Then, as population grew, humans seized control of those aquatic arteries, diverting them in ways that allowed for even more growth. But after people are gone, the diversions will soon follow them. Drier, hotter desert climates will be complemented by wetter, stormier mountain weather systems that will send floods roaring downstream, overwhelming dams, spreading over their former alluvial plains, and entombing whatever was built there in annual layers of silt. Within them, fire hydrants, truck tires, shattered plate glass, condominia, and office buildings may remain indefinitely, but as far from sight as the Carboniferous Formation once was.

No memorial will mark their burial, though the roots of cottonwoods, willows, and palms may occasionally make note of their presence. Only eons later, when old mountains have worn away and new ones risen, will young streams cutting fresh canyons through sediments reveal what once, briefly, went on here.

CHAPTER 3

The City Without Us

THE NOTION THAT someday nature could swallow whole something so colossal and concrete as a modern city doesn't slide easily into our imaginations. The sheer titanic presence of a New York City resists efforts to picture it wasting away. The events of September 2001 showed only what human beings with explosive hardware can do, not crude processes like erosion or rot. The breathtaking, swift collapse of the World Trade Center towers suggested more to us about their attackers than about mortal vulnerabilities that could doom our entire infrastructure. And even that once-inconceivable calamity was confined to just a few buildings. Nevertheless, the time it would take nature to rid itself of what urbanity has wrought may be less than we might suspect.

IN 1939, A World's Fair was held in New York. For its exhibit, the government of Poland sent a statue of Władysław Jagiełło.

The founder of the Białowieża Puszcza had not been immortalized in bronze for preserving a chunk of primeval forest six centuries earlier. By marrying its queen, Jagiełło had united Poland and his duchy of Lithuania into a European power. The sculpture portrays him on horseback following his victory at the Battle of Grünwald in 1410. Triumphant, he hoists two swords captured from Poland's latest vanquished enemy, the Teutonic Knights of the Cross.

In 1939, however, the Poles weren't faring so well against some descendants of those Teutonic Knights. Before the New York World's Fair ended, Hitler's Nazis had taken Poland, and the sculpture couldn't be returned to its homeland. Six sad years later, the Polish government gave it to New York as a symbol of its courageous, battered survivors. The statue of Jagiełło was placed in Central Park, overlooking what today is called Turtle Pond.

When Dr. Eric Sanderson leads a tour through the park, he and his flock usually pass Jagiełło without pausing, because they are lost in another century altogether—the 17th. Bespectacled under his wide-brimmed felt hat, a trim beard graying around his chin and a laptop jammed in his backpack, Sanderson is a landscape ecologist with the Wildlife Conservation Society, a global squadron of researchers trying to save an imperiled world from itself. At its Bronx Zoo headquarters, Sanderson directs the Mannahatta Project, an attempt to re-create, virtually, Manhattan Island as it was when Henry Hudson's crew first saw it in 1609: a pre-urban vision that tempts speculation about how a posthuman future might look.

His team has scoured original Dutch documents, colonial British military maps, topographic surveys, and centuries of assorted archives throughout town. They've probed sediments, analyzed fossil pollens, and plugged thousands of bits of biological data into imaging software that generates three-dimensional

panoramas of the heavily wooded wilderness on which a metropolis was juxtaposed. With each new entry of a species of grass or tree that is historically confirmed in some part of the city, the images grow more detailed, more startling, more convincing. Their goal is a block-by-city-block guide to this ghost forest, the one Eric Sanderson uncannily seems to see even while dodging Fifth Avenue buses.

When Sanderson wanders through Central Park, he's able to look beyond the half-million cubic yards of soil hauled in by its designers, Frederick Law Olmstead and Calvert Vaux, to fill in what was mostly a swampy bog surrounded by poison oak and sumac. He can trace the shoreline of the long, narrow lake that lay along what is now 59th Street, north of the Plaza Hotel, with its tidal outlet that meandered through salt marsh to the East River. From the west, he can see a pair of streams entering the lake that drained the slope of Manhattan's major ridgeline, a deer and mountain lion trail known today as Broadway.

Eric Sanderson sees water flowing everywhere in town, much of it bubbling from underground ("which is how Spring Street got its name"). He's identified more than 40 brooks and streams that traversed what was once a hilly, rocky island: in the Algonquin tongue of its first human occupants, the Lenni Lenape, *Mannahatta* referred to those now-vanished hills. When New York's 19th-century planners imposed a grid on everything north of Greenwich Village—the jumble of original streets to the south being impossible to unsnarl—they behaved as if topography were irrelevant. Except for some massive, unmoveable schist outcrops in Central Park and at the island's northern tip, Manhattan's textured terrain was squashed and dumped into streambeds, then planed and leveled to receive the advancing city.

Later, new contours arose, this time routed through rectilinear forms and hard angles, much as the water that once sculpted

Manhattan, circa 1609, juxtaposed with Manhattan, circa 2006, showing infilling that has extended the island's southern tip.

the island's land was now forced underground through a lattice of pipes. Eric Sanderson's Mannahatta Project has plotted how closely the modern sewer system follows the old watercourses, although man-made sewer lines can't wick away runoff as efficiently as nature. In a city that buried its rivers, he observes, "rain still falls. It has to go somewhere."

As it happens, that will be the key to breaching Manhattan's hard shell if nature sets about dismantling it. It would begin very quickly, with the first strike at the city's most vulnerable spot: its underbelly.

New York City Transit's Paul Schuber and Peter Briffa, superintendent of Hydraulics and level one maintenance supervisor of

Hydraulics Emergency Response, respectively, understand perfectly how this would work. Every day, they must keep 13 million gallons of water from overpowering New York's subway tunnels.

"That's just the water that's already underground," notes Schuber.

"When it rains, the amount is . . ." Briffa shows his palms, surrendering. "It's incalculable."

Maybe not actually incalculable, but it doesn't rain any less now than before the city was built. Once, Manhattan was 27 square miles of porous ground interlaced with living roots that siphoned the 47.2 inches of average annual rainfall up trees and into meadow grasses, which drank their fill and exhaled the rest back into the atmosphere. Whatever the roots didn't take settled into the island's water table. In places, it surfaced in lakes and marshes, with the excess draining off to the ocean via those 40 streams—which now lie trapped beneath concrete and asphalt.

Today, because there's little soil to absorb rainfall or vegetation to transpire it, and because buildings block sunlight from evaporating it, rain collects in puddles or follows gravity down sewers—or it flows into subway vents, adding to the water already down there. Below 131st Street and Lenox Avenue, for example, a rising underground river is corroding the bottom of the A, B, C, and D subway lines. Constantly, men in reflective vests and denim rough-outs like Schuber's and Briffa's are clambering around beneath the city to deal with the fact that under New York, groundwater is always rising.

Whenever it rains hard, sewers clog with storm debris—the number of plastic garbage bags adrift in the world's cities may truly exceed calculation—and the water, needing to go somewhere, plops down the nearest subway stairs. Add a nor'easter, and the surging Atlantic Ocean bangs against New York's water

table until, in places like Water Street in lower Manhattan or Yankee Stadium in the Bronx, it backs up right into the tunnels, shutting everything down until it subsides. Should the ocean continue to warm and rise even faster than the current inch per decade, at some point it simply won't subside. Schuber and Briffa have no idea what will happen then.

Add to all that the 1930s-vintage water mains that frequently burst, and the only thing that has kept New York from flooding already is the incessant vigilance of its subway crews and 753 pumps. Think about those pumps: New York's subway system, an engineering marvel in 1903, was laid underneath an already-existing, burgeoning city. As that city already had sewer lines, the only place for subways to go was below them. "So," explains Schuber, "we have to pump uphill." In this, New York is not alone: cities like London, Moscow, and Washington built their subways far deeper, often to double as bomb shelters. Therein lies much potential disaster.

Shading his eyes with his white hard hat, Schuber peers down into a square pit beneath the Van Siclen Avenue station in Brooklyn, where each minute 650 gallons of natural groundwater gush from the bedrock. Gesturing over the roaring cascade, he indicates four submersible cast-iron pumps that take turns laboring against gravity to stay ahead. Such pumps run on electricity. When the power fails, things can get difficult very fast. Following the World Trade Center attack, an emergency pump train bearing a jumbo portable diesel generator pumped out 27 times the volume of Shea Stadium. Had the Hudson River actually burst through the PATH train tunnels that connect New York's subways to New Jersey, as was greatly feared, the pump train—and possibly much of the city—would simply have been overwhelmed.

In an abandoned city, there would be no one like Paul Schuber and Peter Briffa to race from station to flooded station

whenever more than two inches of rain falls—as happens lately with disturbing frequency—sometimes snaking hoses up stairways to pump to a sewer down the street, sometimes navigating these tunnels in inflatable boats. With no people, there would also be no power. The pumps will go off, and stay off. "When this pump facility shuts down," says Schuber, "in half an hour water reaches a level where trains can't pass anymore."

Briffa removes his safety goggles and rubs his eyes. "A flood in one zone would push water into the others. Within 36 hours, the whole thing could fill."

Even if it weren't raining, with subway pumps stilled, that would take no more than a couple of days, they estimate. At that point, water would start sluicing away soil under the pavement. Before long, streets start to crater. With no one unclogging sewers, some new watercourses form on the surface. Others appear suddenly as waterlogged subway ceilings collapse. Within 20 years, the water-soaked steel columns that support the street above the East Side's 4, 5, and 6 trains corrode and buckle. As Lexington Avenue caves in, it becomes a river.

Well before then, however, pavement all over town would have already been in trouble. According to Dr. Jameel Ahmad, chairman of the civil engineering department at New York's Cooper Union, things will begin to fall apart during the first month of March after humans vacate Manhattan. Each March, temperatures normally flutter back and forth around 32°F as many as 40 times (presumably, climate change could push this back to February). Whenever it is, the repeated freezing and thawing make asphalt and cement split. When snow thaws, water seeps into these fresh cracks. When it freezes, the water expands, and cracks widen.

Call it water's retaliation for being squished under all that cityscape. Almost every other compound in nature contracts when frozen, but H_2O molecules do the opposite, organizing themselves into elegant hexagonal crystals that take up about 9 percent more space than they did when sloshing around in a liquid state. Pretty six-sided crystals suggest snowflakes so gossamer it's hard to conceive of them pushing apart slabs of sidewalk. It's even more difficult to imagine carbon steel water pipes built to withstand 7,500 pounds of pressure per square inch exploding when they freeze. Yet that's exactly what happens.

As pavement separates, weeds like mustard, shamrock, and goosegrass blow in from Central Park and work their way down the new cracks, which widen further. In the current world, before they get too far, city maintenance usually shows up, kills the weeds, and fills the fissures. But in the post-people world, there's no one left to continually patch New York. The weeds are followed by the city's most prolific exotic species, the Chinese ailanthus tree. Even with 8 million people around, ailanthus—otherwise innocently known as the tree-of-heaven—are implacable invaders capable of rooting in tiny chinks in subway tunnels, unnoticed until their spreading leaf canopies start poking from sidewalk grates. With no one to yank their seedlings, within five years powerful ailanthus roots are heaving up sidewalks and wreaking havoc in sewers—which are already stressed by all the plastic bags and old newspaper mush that no one is clearing away. As soil long trapped beneath pavement gets exposed to sun and rain, other species jump in, and soon leaf litter adds to the rising piles of debris clogging the sewer grates.

The early pioneer plants won't even have to wait for the pavement to fall apart. Starting from the mulch collecting in gutters, a layer of soil will start forming atop New York's sterile hard shell, and seedlings will sprout. With far less organic material

available to it—just windblown dust and urban soot—precisely that has happened in an abandoned elevated iron bed of the New York Central Railroad on Manhattan's West Side. Since trains stopped running there in 1980, the inevitable ailanthus trees have been joined by a thickening ground cover of onion grass and fuzzy lamb's ear, accented by stands of goldenrod. In some places, the track emerges from the second stories of warehouses it once serviced into elevated lanes of wild crocuses, irises, evening primrose, asters, and Queen Anne's lace. So many New Yorkers, glancing down from windows in Chelsea's art district, were moved by the sight of this untended, flowering green ribbon, prophetically and swiftly laying claim to a dead slice of their city, that it was dubbed the High Line and officially designated a park.

In the first few years with no heat, pipes burst all over town, the freeze-thaw cycle moves indoors, and things start to seriously deteriorate. Buildings groan as their innards expand and contract; joints between walls and rooflines separate. Where they do, rain leaks in, bolts rust, and facing pops off, exposing insulation. If the city hasn't burned yet, it will now. Collectively, New York architecture isn't as combustible as, say, San Francisco's incendiary rows of clapboard Victorians. But with no firemen to answer the call, a dry lightning strike that ignites a decade of dead branches and leaves piling up in Central Park will spread flames through the streets. Within two decades, lightning rods have begun to rust and snap, and roof fires leap among buildings, entering paneled offices filled with paper fuel. Gas lines ignite with a rush of flames that blows out windows. Rain and snow blow in, and soon even poured concrete floors are freezing, thawing, and starting to buckle. Burnt insulation and charred wood add nutrients to

Manhattan's growing soil cap. Native Virginia creeper and poison ivy claw at walls covered with lichens, which thrive in the absence of air pollution. Red-tailed hawks and peregrine falcons nest in increasingly skeletal high-rise structures.

Within two centuries, estimates Brooklyn Botanical Garden vice president Steven Clemants, colonizing trees will have substantially replaced pioneer weeds. Gutters buried under tons of leaf litter provide new, fertile ground for native oaks and maples from city parks. Arriving black locust and autumn olive shrubs fix nitrogen, allowing sunflowers, bluestem, and white snakeroot to move in along with apple trees, their seeds expelled by proliferating birds.

Biodiversity will increase even more, predicts Cooper Union civil engineering chair Jameel Ahmad, as buildings tumble and smash into each other, and lime from crushed concrete raises soil pH, inviting in trees, such as buckthorn and birch, that need less acidic environments. Ahmad, a hearty silver-haired man whose hands talk in descriptive circles, believes that process will begin faster than people might think. A native of Lahore, Pakistan, a city of ancient mosaic-encrusted mosques, he now teaches how to design and retrofit buildings to withstand terrorist attacks, and has accrued a keen understanding of structural weakness.

"Even buildings anchored into hard Manhattan schist, like most New York skyscrapers," he notes, "weren't intended to have their steel foundations waterlogged." Plugged sewers, deluged tunnels, and streets reverting to rivers, he says, will conspire to undermine subbasements and destabilize their huge loads. In a future that portends stronger and more-frequent hurricanes striking North America's Atlantic coast, ferocious winds will pummel tall, unsteady structures. Some will topple, knocking down others. Like a gap in the forest when a giant tree falls, new

growth will rush in. Gradually, the asphalt jungle will give way to a real one.

THE NEW YORK Botanical Garden, located on 250 acres across from the Bronx Zoo, possesses the largest herbarium anywhere outside of Europe. Among its treasures are wildflower specimens gathered on Captain Cook's 1769 Pacific wanderings, and a shred of moss from Tierra del Fuego, with accompanying notes written in watery black ink and signed by its collector, C. Darwin. Most remarkable, though, is the NYBG's 40-acre tract of original, old-growth, virgin New York forest, never logged.

Never cut, but mightily changed. Until only recently, it was known as the Hemlock Forest for its shady stands of that graceful conifer, but almost every hemlock here is now dead, slain by a Japanese insect smaller than the period at the end of this sentence, which arrived in New York in the mid-1980s. The oldest and biggest oaks, dating back to when this forest was British, are also crashing down, their vigor sapped by acid rain and heavy metals such as lead from automobile and factory fumes, which have soaked into the soil. It's unlikely that they'll come back, because most canopy trees here long ago stopped regenerating. Every resident native species now harbors its own pathogen: some fungus, insect, or disease that seizes the opportunity to ravish trees weakened by chemical onslaught. As if that weren't enough, as the NYBG forest became an island of greenery surrounded by hundreds of square miles of gray urbanity, it became the primary refuge for Bronx squirrels. With natural predators gone and no hunting permitted, there's nothing to stop them from devouring every acorn or hickory nut before it can germinate. Which they do.

There is now an eight-decade gap in this old forest's understory. Instead of new generations of native oaks, maple, ash, birch, sycamore and tulip trees, what's mainly growing are imported ornamentals that have blown in from the rest of the Bronx. Soil samplings indicate some 20 million ailanthus seeds sprouting here. According to Chuck Peters, curator of the NYBG's Institute of Economic Botany, exotics such as ailanthus and cork trees, both from China, now account for more than a quarter of this forest.

"Some people want to put the forest back the way it was 200 years ago," he says. "To do that, I tell them, you've got to put the Bronx back the way it was 200 years ago."

As human beings learned to transport themselves all over the world, they took living things with them and brought back others. Plants from the Americas changed not only ecosystems in European countries but also their very identities: think of Ireland before potatoes, or Italy before tomatoes. In the opposite direction, Old World invaders not only forced themselves on hapless women of vanquished new lands, but broadcast other kinds of seed, beginning with wheat, barley, and rye. In a phrase coined by the American geographer Alfred Crosby, this ecological imperialism helped European conquerors to permanently stamp their image on their colonies.

Some results were ludicrous, like English gardens with hyacinths and daffodils that never quite took hold in colonial India. In New York, the European starling—now a ubiquitous avian pest from Alaska to Mexico—was introduced because someone thought the city would be more cultured if Central Park were home to each bird mentioned in Shakespeare. Next came a Central Park garden with every plant in the Bard's plays, sown with the lyrical likes of primrose, wormwood, lark's heel, eglantine, and cowslip—everything short of *Macbeth*'s Birnam Wood.

To what extent the Mannahatta Project's virtual past resembles the Manhattan forest to come depends on a struggle for North America's soil that will continue long after the humans that instigated it are gone. The NYBG's herbarium also holds one of the first American specimens of a deceptively lovely lavender stalk. The seeds of purple loosestrife, native to North Sea estuaries from Britain to Finland, likely arrived in wet sands that merchant ships dug from European tidal flats as ballast for the Atlantic crossing. As trade with the colonies grew, more purple loosestrife was dumped along American shores as ships jettisoned ballast before taking on cargo. Once established, it moved up streams and rivers as its seeds stuck to the muddy feathers or fur of whatever it touched. In Hudson River wetlands, communities of cattail, willow, and canary grass that fed and sheltered waterfowl and muskrats turned into solid curtains of purple, impenetrable even to wildlife. By the 21st century, purple loosestrife was at large even in Alaska, where panicked state ecologists fear it will fill entire marshes, driving out ducks, geese, terns, and swans.

Even before Shakespeare Garden, Central Park designers Olmstead and Vaux had brought in a half-million trees along with their half-million cubic yards of fill to complete their improved vision of nature, spicing up the island with exotica like Persian ironwoods, Asian katsuras, cedars of Lebanon, and Chinese royal paulownias and ginkgos. Yet once humans are gone, the native plants left to compete with a formidable contingent of alien species in order to reclaim their birthright will have some homeground advantages.

Many foreign ornamentals—double roses, for example—will wither with the civilization that introduced them, because

they are sterile hybrids that must propagate through cuttings. When the gardeners that clone them go, so do they. Other pampered colonials like English ivy, left to fend for themselves, lose to their rough American cousins, Virginia creeper and poison ivy.

Still others are really mutations, forced by highly selective breeding. If they survive at all, their form and presence will be diminished. Untended fruits such as apples—an import from Russia and Kazakhstan, belying the American Johnny Appleseed myth—select for hardiness, not appearance or taste, and turn gnarly. Except for a few survivors, unsprayed apple orchards, defenseless against their native American scourges, apple maggots and leaf miner blight, will be reclaimed by native hardwoods. Introduced garden plot vegetables will revert to their humble beginnings. Sweet carrots, originally Asian, quickly devolve to wild, unpalatable Queen Anne's lace as animals devour the last of the tasty orange ones we planted, says New York Botanical Garden vice president Dennis Stevenson. Broccoli, cabbage, Brussel sprouts, and cauliflower regress to the same unrecognizable broccoli ancestor. Descendants of seed corn planted by Dominicans in Washington Heights parkway medians may eventually retrace their DNA back to the original Mexican *teosinte,* its cob barely bigger than a sprig of wheat.

The other invasion that has accosted natives—metals such as lead, mercury, and cadmium—will not wash quickly from the soil, because these are literally heavy molecules. One thing is certain: when cars have stopped for good, and factories go dark and stay that way, no more such metals will be deposited. For the first 100 years or so, however, corrosion will periodically set off time bombs left in petroleum tanks, chemical and power plants, and hundreds of dry cleaners. Gradually, bacteria will feed on residues

of fuel, laundry solvents, and lubricants, reducing them to more-benign organic hydrocarbons—although a whole spectrum of man-made novelties, ranging from certain pesticides to plasticizers to insulators, will linger for many millennia until microbes evolve to process them.

Yet with each new acid-free rainfall, trees that still endure will have fewer contaminants to resist as chemicals are gradually flushed from the system. Over centuries, vegetation will take up decreasing levels of heavy metals, and will recycle, redeposit, and dilute them further. As plants die, decay, and lay down more soil cover, the industrial toxins will be buried deeper, and each succeeding crop of native seedlings will do better.

And although many of New York's heirloom trees are endangered if not actually dying, few if any are already extinct. Even the deeply mourned American chestnut, devastated everywhere after a fungal blight entered New York around 1900 in a shipment of Asian nursery plants, still hangs on in the New York Botanical Garden's old forest—literally by its roots. It sprouts, sends up skinny shoots two feet high, gets knocked back by blight, and does it again. One day, perhaps, with no human stresses sapping its vigor, a resistant strain will finally emerge. Once the tallest hardwood in American eastern forests, the resurrected chestnut trees will have to coexist with robust non-natives that are probably here to stay—Japanese barberry, Oriental bittersweet, and surely ailanthus. The ecosystem here will be a human artifact that will persist in our absence, a cosmopolitan botanical mixture that would never have occurred without us.

Which may not be bad, suggests New York Botanical Garden's Chuck Peters. "What makes New York a great city now is its cultural diversity. Everyone has something to offer. But botanically, we're xenophobic. We love native species, and want aggressive, exotic plant species to go home."

He props his running shoe against the whitish bark of a Chinese Amur cork tree, growing among the last of the hemlocks. "This may sound blasphemous, but maintaining native biodiversity is less important than maintaining a functioning ecosystem. What matters is that soil is protected, that water gets cleaned, that trees filter the air, that a canopy regenerates new seedlings to keep nutrients from draining away into the Bronx River."

He inhales a lungful of filtered Bronx air. Trim and youthful in his early fifties, Peters has spent much of his life in forests. His field research has revealed that pockets of wild palm nut trees deep in the Amazon, or of durian fruit trees in virgin Borneo, or of tea trees in Burma's jungles, aren't accidents. Once, humans were there, too. The wilderness swallowed them and their memory, but its shape still bears their echo. As will this one.

In fact, it has done so since soon after *Homo sapiens* appeared here. Eric Sanderson's Mannahatta Project is re-creating the island as the Dutch found it—not some primordial Manhattan forest no human had set foot on, because there wasn't one. "Because before the Lenni Lenape arrived," explains Sanderson, "nothing was here except for a mile-thick slab of ice."

About 11,000 years ago, as the last ice age receded northward from Manhattan, it pulled along the spruce and tamarack taiga that today grows just below the Canadian tundra. In its place came what we know as the temperate eastern forest of North America: oak, hickory, chestnut, walnut, hemlock, elm, beech, sugar maple, sweet gum, sassafras, and wild filbert. In the clearings grew shrubs of chokecherry, fragrant sumac, rhododendron, honeysuckle, and assorted ferns and flowering plants. Spartina and rose mallow appeared in the salt marshes. As all this foliage filled these warming niches, warm-blooded animals followed, including humans.

A dearth of archeological remains suggests that the first New Yorkers probably didn't settle, but camped seasonally to pick berries, chestnuts, and wild grapes. They hunted turkey, heath hens, ducks, and white-tailed deer, but mainly they fished. The surrounding waters swarmed with smelt, shad, and herring. Brook trout ran in Manhattan streams. Oysters, clams, quahogs, crabs, and lobsters were so abundant that harvesting them was effortless. Large middens of discarded mollusk shells along the shores were the first human structures here. By the time Henry Hudson first saw the island, upper Harlem and Greenwich Village were grassy savannas, cleared repeatedly with fire by the Lenni Lenape for planting. By flooding ancient Harlem fire pits to see what floats to the top, Mannahatta Project researchers have learned that the Lenni Lenape cultivated corn, beans, squash, and sunflowers. Much of the island was still as green and dense as the Białowieża Puszcza. But well before its famous transfiguration from Indian land to colonial real estate, priced to sell at 60 Dutch guilders, the mark of *Homo sapiens* was already on Manhattan.

IN THE MILLENNIAL year 2000, a harbinger of a future that might revive the past appeared in the form of a coyote that managed to reach Central Park. Subsequently, two more made it into town, as well as a wild turkey. The rewilding of New York City may not wait until people leave.

That first advance coyote scout arrived via the George Washington Bridge, which Jerry Del Tufo managed for the Port Authority of New York and New Jersey. Later, he took over the bridges that link Staten Island to the mainland and Long Island. A structural engineer in his forties, he considers bridges among the

loveliest ideas humans ever conceived, gracefully spanning chasms to bring people together.

Del Tufo himself spans an ocean. His olive features bespeak Sicily; his voice is pure urban New Jersey. Bred to the pavement and steel that became his life's work, he nonetheless marvels at the annual miracle of baby peregrine falcons hatching high atop the George Washington's towers, and at the sheer botanical audacity of grass, weeds, and ailanthus trees that defiantly bloom, far from topsoil, from metal niches suspended high above the water. His bridges are under a constant guerrilla assault by nature. Its arsenal and troops may seem ludicrously puny against steel-plated armor, but to ignore endless, ubiquitous bird droppings that can snag and sprout airborne seeds, and simultaneously dissolve paint, would be fatal. Del Tufo is up against a primitive but unrelenting foe whose ultimate strength is its ability to outlast its adversary, and he accepts as a fact that ultimately nature must win.

Not on his watch, though, if he can help it. First and foremost, he honors the legacy he and his crew inherited: their bridges were built by a generation of engineers who couldn't possibly have conceived of a third of a million cars crossing them daily—yet 80 years later, they're still in service. "Our job," he tells his men, "is to hand over these treasures to the next generation in better shape than when we accepted them."

On a February afternoon he heads through snow flurries to the Bayonne Bridge, chatting with his crew over his radio. The underside of the approach on the Staten Island side is a powerful steel matrix that converges in a huge concrete block anchored to the bedrock, an abutment that bears half the load of the Bayonne's main span. To stare up directly into its labyrinthine load-bearing I-beams and bracing members, interlocked with half-inch-thick steel plates, flanges, and several million half-inch

rivets and bolts, recalls the crushing awe that humbles pilgrims gaping at the soaring Vatican dome of St. Peter's Cathedral: something this mighty is here forever. Yet Jerry Del Tufo knows exactly how these bridges, without humans to defend to them, would come down.

It wouldn't happen immediately, because the most immediate threat will disappear with us. It's not, says Del Tufo, the incessant pounding traffic.

"These bridges are so overbuilt, traffic's like an ant on an elephant." In the 1930s, with no computers to precisely calculate tolerances of construction materials, cautious engineers simply heaped on excess mass and redundancy. "We're living off the overcapacity of our forefathers. The GW alone has enough galvanized steel wire in its three-inch main cables to wrap the Earth four times. Even if every other suspender rope deteriorated, the bridge wouldn't fall down."

Enemy number one is the salt that highway departments spread on the roadways each winter—ravenous stuff that keeps eating steel once it's done with the ice. Oil, antifreeze, and snowmelt dripping from cars wash salt into catch basins and crevices where maintenance crews must find and flush it. With no more people, there won't be salt. There will, however, be rust, and quite a bit of it, when no one is painting the bridges.

At first, oxidation forms a coating on steel plate, twice as thick or more as the metal itself, which slows the pace of chemical attack. For steel to completely rust through and fall apart might take centuries, but it won't be necessary to wait that long for New York's bridges to start dropping. The reason is a metallic version of the freeze-thaw drama. Rather than crack like concrete, steel expands when it warms and contracts when it cools. So that steel bridges can actually get longer in summer, they need expansion joints.

In winter, when they shrink, the space inside expansion joints opens wider, and stuff blows in. Wherever it does, there's less room for the bridge to expand when things warm up. With no one painting bridges, joints fill not only with debris but also with rust, which swells to occupy far more space than the original metal.

"Come summer," says Del Tufo, "the bridge is going to get bigger whether you like it or not. If the expansion joint is clogged, it expands toward the weakest link—like where two different materials connect." He points to where four lanes of steel meet the concrete abutment. "There, for example. The concrete could crack where the beam is bolted to the pier. Or, after a few seasons, that bolt could shear off. Eventually, the beam could walk itself right off and fall."

Every connection is vulnerable. Rust that forms between two steel plates bolted together exerts forces so extreme that either the plates bend or rivets pop, says Del Tufo. Arch bridges like the Bayonne—or the Hell Gate over the East River, made to hold railroads—are the most overbuilt of all. They might hold for the next 1,000 years, although earthquakes rippling through one of several faults under the coastal plain could shorten that period. (They would probably do better than the 14 steel-lined, concrete subway tubes beneath the East River—one of which, leading to Brooklyn, dates back to horses and buggies. Should any of their sections separate, the Atlantic Ocean would rush in.) The suspension and truss bridges that carry automobiles, however, will last only two or three centuries before their rivets and bolts fail and entire sections fall into the waiting waters.

Until then, more coyotes follow the footsteps of the intrepid ones that managed to reach Central Park. Deer, bear, and finally

wolves, which have reentered New England from Canada, arrive in turn. By the time most of its bridges are gone, Manhattan's newer buildings have also been ravaged, as wherever leaks reach their embedded steel reinforcing bars, they rust, expand, and burst the concrete that sheaths them. Older stone buildings such as Grand Central—especially with no more acid rain to pock their marble—will outlast every shiny modern box.

Ruins of high-rises echo the love song of frogs breeding in Manhattan's reconstituted streams, now stocked with alewives and mussels dropped by seagulls. Herring and shad have returned to the Hudson, though they spent some generations adjusting to radioactivity trickling out of Indian Point Nuclear Power Plant, 35 miles north of Times Square, after its reinforced concrete succumbed. Missing, however, are nearly all fauna adapted to us. The seemingly invincible cockroach, a tropical import, long ago froze in unheated apartment buildings. Without garbage, rats starved or became lunch for the raptors nesting in burnt-out skyscrapers.

Rising water, tides, and salt corrosion have replaced the engineered shoreline, circling New York's five boroughs with estuaries and small beaches. With no dredging, Central Park's ponds and reservoir have been reincarnated as marshes. Without natural grazers—unless horses used by hansom cabs and by park policemen managed to go feral and breed—Central Park's grass is gone. A maturing forest is in its place, radiating down former streets and invading empty foundations. Coyotes, wolves, red foxes, and bobcats have brought squirrels back into balance with oak trees tough enough to outlast the lead we deposited, and after 500 years, even in a warming climate the oaks, beeches, and moisture-loving species such as ash dominate.

Long before, the wild predators finished off the last descendants of pet dogs, but a wily population of feral house cats

persists, feeding on starlings. With bridges finally down, tunnels flooded, and Manhattan truly an island again, moose and bears swim a widened Harlem river to feast on the berries that the Lenape once picked.

Amid the rubble of Manhattan financial institutions that literally collapsed for good, a few bank vaults stand; the money within, however worthless, is mildewed but safe. Not so the artwork stored in museum vaults, built more for climate control than strength. Without electricity, protection ceases; eventually museum roofs spring leaks, usually starting with their skylights, and their basements fill with standing water. Subjected to wild swings in humidity and temperature, everything in storage rooms is prey to mold, bacteria, and the voracious larvae of a notorious museum scourge, the black carpet beetle. As they spread to other floors, fungi discolor and dissolve paintings in the Metropolitan beyond recognition. Ceramics, however, are doing fine, since they're chemically similar to fossils. Unless something falls on them first, they await reburial for the next archaeologist to dig them up. Corrosion has thickened the patina on bronze statues, but hasn't affected their shapes. "That's why we know about the Bronze Age," notes Manhattan art conservator Barbara Appelbaum.

Even if the Statue of Liberty ends up at the bottom of the harbor, Appelbaum says, its form will remain intact indefinitely, albeit somewhat chemically altered and possibly encased in barnacles. That might be the safest place for it, because at some point thousands of years hence, any stone walls still standing—maybe chunks of St. Paul's Chapel across from the site of the World Trade Center, built in 1766 from Manhattan's own hard schist—must finally fall. Three times in the past 100,000 years, glaciers have scraped New York clean. Unless humankind's Faustian affair with carbon fuels ends up tipping the atmosphere past

the point of no return, and runaway global warming transfigures Earth into Venus, at some unknown date glaciers will do so again. The mature beech-oak-ash-ailanthus forest will be mowed down. The four giant mounds of entombed garbage at the Fresh Kills landfill on Staten Island will be flattened, their vast accumulation of stubborn PVC plastic and of one of the most durable human creations of all—glass—ground to powder.

After the ice recedes, buried in the moraine and eventually in geologic layers below will be an unnatural concentration of a reddish metal, which briefly had assumed the form of wiring and plumbing. Then it was hauled to the dump and returned to the Earth. The next toolmaker to arrive or evolve on this planet might discover and use it, but by then there would be nothing to indicate that it was us who put it there.

CHAPTER 4

The World Just Before Us

1. An Interglacial Interlude

FOR MORE THAN 1 billion years, sheets of ice have been sliding back and forth from the poles, sometimes actually meeting at the equator. The reasons involve continental drift, the Earth's mildly eccentric orbit, its wobbly axis, and swings in atmospheric carbon dioxide. For the last few million years, with the continents basically where we find them today, ice ages have recurred fairly regularly and lasted upwards of 100,000 years, with intervening thaws averaging 12,000 to 28,000 years.

The last glacier left New York 11,000 years ago. Under normal conditions, the next to flatten Manhattan would be due any day now, though there's growing doubt that it will arrive on schedule. Many scientists now guess that the current intermission before the next frigid act will last a lot longer, because we've managed to postpone the inevitable by stuffing our atmospheric quilt with extra insulation. Comparisons to ancient bubbles in Antarctic ice cores reveal there's more CO_2 floating around today than at any time in the past 650,000 years. If people cease to exist tomorrow and we never send another carbon-bearing