



About a third of all land on earth has been claimed by desert—almost twenty million square miles—and the percentage is likely to increase with

An aerial photograph of a desert landscape, likely the Sahara. The scene is dominated by rolling sand dunes in shades of orange and tan. Several tall palm trees are scattered across the dunes, their long shadows cast across the sand. The overall atmosphere is one of vastness and aridity.

A REPORTER AT LARGE

THE GREAT OASIS

Can a wall of trees stop the Sahara from spreading?

BY BURKHARD BILGER

global warming. "The desert always menaces," the French botanist André Aubréville warned. Photograph by George Steinmetz.

In the Al Hajar Mountains of northern Oman, at the eastern edge of the Arabian Desert, high above the white terraces and minarets of Muscat, rain comes rarely and then in floods. *Hajar* means “rock” in Arabic, and the mountains are made of little else—a fractal landscape of umber and dusty limestone, thrust from the sea more than sixty-five million years ago and still shaped more by salt water than by sweet. When the clouds burst, as they do a few times a year, the rain skitters from the slopes like oil from a griddle, gathers into rivulets and swiftly moving sheets, and tumbles into the wadies that wind between peaks. The ancient Omanis built networks of aqueducts and underground *falajes* to funnel the water to their crops. Oases of mango, date palm, sweet lemon, and lime still survive on this system, their fruit knuckled in on itself against the heat, smaller and more pungent than their Indian ancestors. But on most slopes the only traces of green are a few umbrella-thorn trees, *Acacia tortilis*, anchored to the bare rock. Their roots can descend more than a hundred feet in search of groundwater.

“It used to be much wetter here when I was a boy,” Hamad Reesi said, as our S.U.V. lurched up a gravel switchback in the foothills. “You never had to buy fodder for your goats.” Ali al-Abdullatif nodded, then yanked the steering wheel to one side to avoid a dropoff. Next to him, Pieter Hoff dozed in the passenger seat. Abdullatif is the chairman of the Horticultural Association of Oman, a slender, cultivated man more comfortable potting plants than going on desert excursions. Hoff is a Dutch inventor and former tulip and lily grower who had come to Oman to test an experimental tree-planting device. We’d spent the past few hours bumping over back roads, stopping every few minutes to look at trees that might be good for Hoff’s project: hardy natives like *Ziziphus spina-christi*, said to have provided the thorns for Jesus’ crown, and *Salvadora persica*, the toothbrush tree. Its fibrous twigs were laced with fluoride and antiseptics. Word had it that this area was home to one of the last baobabs in northern Oman, but we’d got lost trying to find it and had picked up Reesi, a local farmer, as a guide. The great tree was deep in the mountains, he said. We would never reach it on our own.

Abdullatif and Reesi wore the traditional white robes and embroidered prayer caps of Omani Muslims. They were born and raised here—although Abdullatif had done his horticultural training in England, at Canterbury College, in Kent—and had seen the country transformed, in forty years, from a near-medieval land of warring tribes to a unified and oil-rich sultanate. When Abdullatif was a boy, firewood was still gathered by Bedouin nomads and brought in by camel; water arrived by donkey in goatskin bags and barrels once filled with ghee. Now the coast was dotted with desalinization plants and it was sometimes hard to tell that Oman was a desert nation. Along the boulevards and highways of Muscat, the medians were as lush as croquet lawns. Weeping casuarina trees lined the shoulders between beds of petunia, bougainvillea, and topiary trimmed like battlements. The sultan was said to be an environmentalist—he’d recently decreed the construction of the country’s first botanical garden—and he wanted his capital green.

The illusion didn’t last beyond the city limits. Most of Oman averages less than six inches of rain a year—barely enough to sustain native plants, much less thirsty exotics like the petunias. On the northern coast, long known as the country’s fertile crescent, so much groundwater has been tapped for farms, orchards, and date-palm plantations that salt water has seeped into the aquifers. “Look at this,” Abdullatif told us at one point, gesturing at a line of dead palms along the road, their fronds decaying to dust on the ground. “Complete destruction.”

When we reached the top of the first pass, Abdullatif pulled onto an overlook and killed the engine. The sun was setting, the road getting harder to follow, and he seemed ready to turn back. “I don’t like the drops on the sides here,” he said, as he got out of the car. “These sheer drops. They do not make me feel very secure.” After a while, Hoff shook himself awake and joined Abdullatif outside. Tall and pale, with a bladelike nose and a thinning crown of blond hair, he was built for cooler climes. Perched beside the dusky, heavy-lidded Abdullatif, he looked like an egret about to snack on a lizard.

“What if the car stops?” he said. “Is there a hotel here?”

“Yes, a very big, open hotel. We have one banana left. We share it.”

Hoff laughed. To the west, the high peaks of the Al Hajar rose rank upon rank into the coppery sky, the empty plains half in shadow below them. “We have a saying in Holland,” he said. “If you call out in the desert, no one will hear you.” But I knew what he was thinking: not so long ago, these mountains were covered with desert junipers and groves of bitter olive. What would it take to bring them back?

The desert is a good place for visionaries. It can flower in the mind even as it withers at your feet. About a third of all land on the planet has been claimed by it—almost twenty million square miles—and the percentage increases every year. Where rain is scarce and the ground is stripped of trees, where soil is eroded by the steady beat of sun, hooves, and seasonal farming, a landscape can turn to dust in a generation. “These are real deserts that are being born today, under our eyes,” the French botanist André Aubréville warned in 1949, when he popularized the term “desertification.” “The desert always menaces.” In the past century, over most of the globe, the amount of dust in the air has doubled.

It’s an old story in some ways. Deserts have been advancing and retreating for much of the earth’s history, driven by tectonic shifts and planetary wobbles beyond our control. The Sahara and the Arabian Peninsula haven’t been green for thousands of years. What has changed is the fact that global warming is making climates more extreme. Regional rainfall is hard to predict in the long term, but most models agree on the over-all pattern. “The wet will get wetter and the dry will get dryer,” Isaac Held, a research scientist with the National Oceanic and Atmospheric Administration, told me. By the end of the century, according to the Intergovernmental Panel on Climate Change, rainfall could decrease by fifteen to twenty per cent in the Middle East and by twenty-five per cent in North Africa. “That’s a lot,” Held said. The recent drought and famine in Somalia, which has killed tens of thousands of people and driven many more into Kenya and Ethiopia, is a preview of things to come.

To Hoff, the solution seems straightforward. If we can replant the forests lost to desertification, he says, we can provide

food, fuel, shade, and shelter on an enormous scale. We can conserve water, fertilize the soil, protect wildlife, and cool the atmosphere. Every year, human industry sends about nine billion tons of carbon into the air. An acre of trees, planted in a desert, could pull two to three tons of that carbon back down. "Multiplied by five billion, we have solved the problem," Hoff says.

The math is a little fuzzy, admittedly. Five billion acres is an area twice the size of Europe. Even if all of it could be reforested, the trees would gradually stop sequestering carbon as they matured. Still, the benefits would be dramatic and the idea isn't as far-fetched as it seems. Since the mid-nineteen-sixties, Israel has forested tens of thousands of acres of the Negev Desert, using simple irrigation systems to collect and distribute the rainfall. In Kenya, the Green Belt Movement founded by the late Wangari Maathai, who won the Nobel Peace Prize in 2004, has planted more than forty-five million trees. And the Chinese have outdone everyone. Since 1982, they have planted more than forty billion trees, many of them in a nearly three-thousand-mile strip along the southern edge of the Gobi Desert. Forests that were clear-cut for agriculture during the Great Leap Forward, fed into furnaces for the ironworks of the Cultural Revolution, or sawed up for housing and other needs (chopsticks alone consume nearly an acre of trees a day) have been replanted on an equally epic scale. By 2020, the Chinese plan to add another hundred million acres of trees—an area larger than Germany.

As global temperatures rise, reforestation schemes seem to grow ever more extravagant—fever dreams of the desert's future. One project, proposed three years ago by a group of British and Norwegian designers, would consist of long chains of greenhouses and orchards, running for miles across the Sahara. The trees and crops would subsist on seawater pumped from the coast and desalinated using heat and power from huge solar arrays. Another proposal, from the Swedish architect Magnus Larsson, would make use of an organism called *Bacillus pasteurii*, which can turn sand into sandstone. In Larsson's scheme, great masses of the bacteria would be injected into dunes across the breadth of the Sahara, creating

a bulwark against the sand and solid footing for a shelterbelt of trees. Water would collect in the sandstone's cool, porous substructure, sustaining the trees' roots and any settlers who wished to move inside. In Larsson's drawings, the underground rooms have the groovy, biomorphic look of an old Yes album cover.

George Taylor, a former agriculture and environment officer for U.S.A.I.D., remembers fielding a number of such proposals when he worked in Africa in the nineteen-eighties and nineties. "Delusional development," he calls them. Yet a variation on Larsson's idea has attracted substantial political and financial backing. The Great Green Wall, as it's known, was first proposed in the mid-eighties and finally approved by the African Union in 2007. The exact shape it will take is still a matter for debate, but the idea, in its original form, is thrillingly simple. To halt the spread of the Sahara, eleven African nations have agreed to erect a wall of trees across the dusty shoulders of the continent. It will stretch from the Atlantic coast of Senegal to the east coast of Djibouti, across sand and scrub and desiccated grassland, in a column nine miles wide and almost five thousand miles long. If and when it's completed, it will be the largest feat of horticulture in human history. "The desert is a spreading cancer," Abdoulaye Wade, the President of Senegal, declared

at a summit in Chad in 2010. "We must fight it. That is why we have decided to join in this titanic battle."

The Great Green Wall is a collective effort, which is to say, a patchwork affair. Each country along its path will reforest its segment after its own fashion, coordinated by a pan-African agency in Chad. The Global Environmental Facility has allocated a hundred and nineteen million dollars for the countries involved in the project, but that barely counts as seed money. A desert, once established, is hard to push back. African leaders have neither the means to mobilize a billion tree-planting farmers nor the money for irrigation systems like those in Israel. How can they grow a forest in the desert?

When I asked foresters and environmentalists that question, they tended to give conflicting answers: the solution lay in technology or grass-roots activism, they said, land reform or carbon-credit financing, drought-tolerant trees or water-retaining gels. And so, this past year, I went to Oman and then to sub-Saharan Africa to look at two of the most promising, albeit contradictory, approaches. Both of them, as it happened, were espoused by Dutchmen.

Hoff's invention, which he calls the Waterboxx, was inspired by a trip to Italy in 1994. He was driving past a barren mountain range near Naples, and he began to wonder what it would take to



"I want to be so successful that it ruins my life."

grow trees there. The local climate was fairly dry, but the problem was less a matter of moisture than of timing. Even deserts can get as much as twenty inches of rain a year, but it all comes down at once. The plants that survive tend to rely on condensation—"They drink from the air," as Hoff puts it. In Africa's Namib Desert, *Welwitschia* plants have been known to live for more than a thousand years on the dew that they absorb through their long, porous leaves. What if a device could be built on the same principle? Hoff thought. It could collect rain and dew, then release it to a seed or sapling one drop at a time.

Hoff had never lived in a desert. He didn't know much about tree planting or industrial design. But he did have a good business sense and a lifetime's experience with plants. Born in 1953, he grew up in a small farming village in West Friesland, the eldest of nine children. His father was a tulip and lily grower with a modernizing bent—he was one of the first farmers in northern Holland to own a tractor—and Pieter showed an early gift for breeding new varieties. (Most of his lilies were named after Santana songs: Moonflower, Black Magic Woman, and his best-seller, a canary-and-aubergine number called Festival.) In 1976, Hoff and two of his brothers bought the farm from their father and began to expand it. By 2003, when they sold the place, it was Holland's largest grower of lilies.

Hoff went on to devote most of his time and the greater part of his fortune—

some thirteen million dollars, at last count—to developing the Waterboxx. By the time I met him, he had spent five years shuttling from desert to desert, testing prototypes with local agronomists. That month alone, he'd been in Kenya, Kuwait, and Bahrain, with Spain and India still to come. "I always search for the most extreme places, where no one expects anything to grow," he said. All told, he had planted some sixty thousand trees in twenty countries, with a few vegetable patches and vineyards thrown in. (Robert Mondavi Winery was testing Waterboxxes in the Napa Valley.) Oman was his most challenging site yet. If he could grow trees there, Hoff figured, he could grow them anywhere.

On the morning before our trip to find the baobab, Hoff took Abdullatif and me to see his latest plantings, in the port city of Sohar. The site was a former camel racetrack, levelled to make way for an industrial park. The soil was gray and gravelly, compacted into hardpan by bulldozers and steamrollers. A viewing platform had been erected nearby—what exactly was on view wasn't clear—surrounded by a hurricane fence topped by razor wire. Beyond it, the land lay table flat in every direction, punctuated only by some container cranes along the coast and the distant flares of an oil refinery. Hoff knelt down and poured a handful of dust into his hand. "It's like the moon," he said.

The Waterboxxes were arrayed in a circle around the platform. There were

forty in all—a gift from Queen Beatrix of the Netherlands to Sultan Qaboos bin Sa'id, commemorating his forty years in power. Like most good tools, they weren't much to look at: a set of simple ideas combined to surprising effect. Each box had a round, four-gallon tank molded out of polypropylene, with an open-ended shaft in the middle where the seedlings grew. The lid was modelled on a lotus leaf, with radiating folds that collected the rain and the dew and sluiced them into a pair of drains. "If you have a rain shower of only four inches, then this is full," Hoff said. A wick at the bottom of the tank carried the water to the root at a rate of about four tablespoons a day—a single tank could sustain a seedling for about a year without a refill. The whole box functioned as a temperature regulator, Hoff said. The water absorbed heat by day and released it by night. The shaft was shaped to let in the morning and evening sun but throw shade over the seedling at midday.

Hoff reached down and pried the lid off one of the boxes. "Mother Nature plants trees differently than people do," he said. "We buy a very big plant and then we dig a hole for it. Mother Nature starts with a seed." Saplings from nurseries have well-developed secondary roots, which spread laterally through the ground. Short and densely woven, they draw maximum sustenance from the soil, but they need water right away and by the bucketful. A seed can afford to wait. Encased in dung from a passing bird or other animal, it can survive for months without rain. If the soil is dry, it can put all its energy into sending a single taproot in search of groundwater.

Hoff liked to collect pictures of trees in improbable places: ponderosa pines sprouting from boulders in the Sierras, holly oaks clinging to ledges of Extremadura granite in Spain. A taproot is one of nature's astonishments, he said. It can worm itself into the tiniest crack, then expand a few cells at a time, generating pressures of up to seven hundred and twenty-five pounds per square inch—enough to split paving stones or punch holes through brick walls.

The Waterboxx is designed to encourage such persistence. Like nature, it begins with a seed, then gives it just enough sustenance to survive until it finds water. After a year, when the root reaches wetter soil, the box can be lifted away and reused. "See these young leaves?"



"Come on, baby—just this once! It's been forever since we got stoned and went out carolling!"

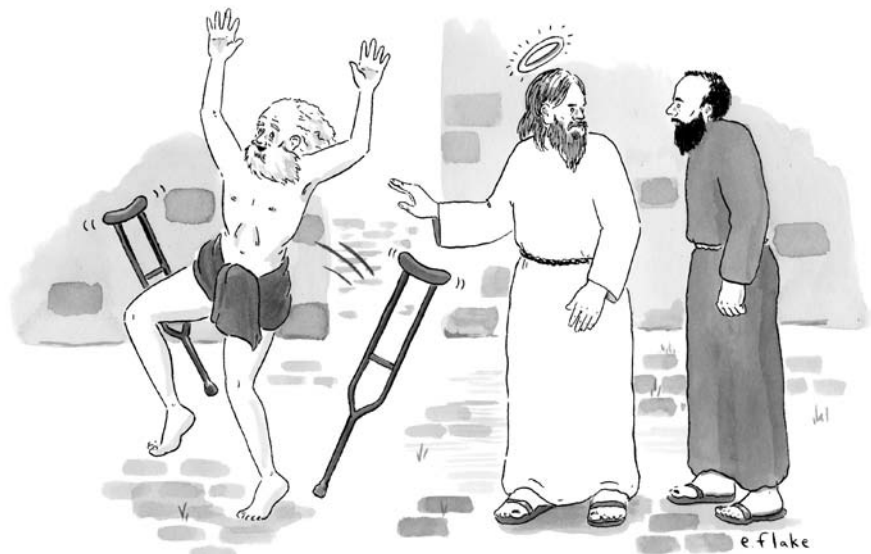
Hoff said, pointing to a cluster of heart-shaped buds, bright green against the darkened soil. "They show that the root is already tapping deeper."

This was a Moringa seedling—one of a number of species that Hoff thought might do well here and in Africa. In its native India, it was known as the drumstick tree for its bulbous seedpods, but a generation of tree-planting N.G.O.s had given it a new name: the Miracle Tree. Moringas are among the world's most nutritious plants. Their leaves can be eaten raw, cooked, or ground into baby formula. They contain four times the calcium of milk, three times the potassium of bananas, four times the Vitamin A of carrots, seven times the Vitamin C of oranges, and about half again the protein of soybeans. The seeds can be pressed for an unsaturated fat like olive oil or crushed into a powder that purifies water: its electrolytes attract impurities and precipitate them out of the fluid. Best of all, Moringas are fast-growing and extremely drought-tolerant. "They will not die," Abdullatif said. "A Moringa you cannot kill."

When Hoff planted these seedlings a month earlier, he'd watered the soil and filled the tanks. Now they had to fend for themselves. Soon the heat would rise above a hundred and twenty degrees, with no rain for six months. Yet Hoff could count on close to ninety per cent of his seedlings surviving into their second year. (A few months earlier, *Popular Science* had named the Waterboxx its Innovation of the Year.) All of these Moringas were alive, as were about half the tamarisks that he'd planted in other boxes. Since he'd planted the seedlings in pairs, most of the boxes held at least one living tree. "Next year, it will be one and a half metres," he said, pointing to a survivor.

He stood up and swept his gaze around the site. If this project succeeded, he hoped to plant six thousand more trees in Sohar, and still more in the surrounding desert—a forest of Moringas surging up from the sand, marching west across the Arab Peninsula toward Africa. "Within forty years, if the world wants it, everywhere is covered with trees again," he said.

The Great Green Wall alone could require five billion seedlings or more, not counting those which would die along the way. But Hoff wasn't intimidated. "My country has sixty thousand miles of canals," he said. "We made them over the



"Yeah, but good luck getting it peer-reviewed."

last two thousand years, all by hand. We have eight thousand miles of dikes, all made by hand. That is one and a half times the length of the Chinese Wall. If tomorrow there is no electricity, we are beneath the water. That is Holland. It's not a country; it's the largest art work in the world. That is why I tell people, if we really want to replant five billion acres, we can do it. It is a matter of determined will."

The cost of planting trees is hard to gauge, given the wildly varying results. The Chinese spend less than fifty cents a tree—just enough to plant a seedling and pray that it will live. The Israelis invest closer to forty dollars, with a success rate of around ninety per cent. Hoff is somewhere in between. Until recently, he gave his Waterboxxes away, chalking them up as a research expense. But, as his costs have mounted, his strategy has changed. "I have to live," he told me. "And you can't reforest deserts if there is no moneymaking business model." Depending on the size of the order, he now sells his boxes for around fifteen to twenty-five dollars. In a project like the Great Green Wall, he says, the box could be reused up to ten times, bringing the final cost down to as little as a dollar-fifty a tree.

The one thing missing from this equation is local people. When Hoff talks about the world wanting to reforest five billion acres, he mostly means West-

ern donors and environmentalists. But even if he can persuade them to send a billion Waterboxxes to Africa, the seedlings will have to be planted and cared for by local farmers. And they'll have to be convinced that it's worth it.

China is a cautionary example. Most of its reforestation has been done involuntarily, by villagers obliged to meet national quotas. "If you add up all the acres, more trees have probably been planted there than anywhere else," Nick Menzies, the executive director of the Asia Institute at U.C.L.A., told me. "But the survival rates have been dismal." Farmers have set seedlings in the poorest soil, to keep their crops and pastures clear, or planted them upside down, to spite the authorities. They've laid them in identical grids, regardless of the terrain, and never bothered to water or thin them out. They've plowed up tenacious old prairies, where trees rarely grew, then left the seedlings and the topsoil to blow away. Decades after the reforestation along the Gobi began, the desert still claims more than a thousand square miles of land annually. "Every year, we plant trees," one popular saying goes. "But we never see a forest."

The Great Green Wall will face even tougher conditions. The Sahara is an ungovernable landscape—more than three million square miles of sand and stone, advancing and retreating with every change in the weather. Between 1980 and 1984,

the desert's southern border moved a hundred and forty-five miles south; by 1990, it had shifted sixty-six miles north. Even if the Great Green Wall survives, the land to the south of it can still turn to desert from drought or overgrazing. The Sahara is bordered by a semi-arid savanna known as the Sahel. (In Arabic, *sahel* means "edge of the desert.") To the north, it gets as little as eight inches of rain a year. To the south, rainfall rises, but so do demands on farmers. In the past sixty years, populations in the Sahel have more than quintupled.

"The idea that there will be an uninterrupted green wall from Dakar to Djibouti—I think it's a dream," Chris Reij, an agroforestry specialist at the Free University of Amsterdam, told me. "If you want to maximize your difficulties, go there." Reij, who is sixty-two, has worked in the Sahel for more than half his life, first for Oxfam International, then for the Centre for International Cooperation, based at his university. Like Hoff, he grew up in Holland and speaks impeccable English—the crisp, almost jaunty sort common among northern Europeans. But if Hoff is a businessman turned environmentalist, as trusting of the free market as he is of photosynthesis, Reij is a radical at heart. He was brought up as a devout Calvinist and studied in Amsterdam in the nineteen-sixties. While Hoff was breeding lilies on his father's farm, Reij protested the war in Vietnam and debated the Club of Rome's limits to growth. "You develop a certain sense about the world and what needs to be done," he told me. "I had a nice picture of Che Guevara in my room."

Reij and Hoff have never met, though not for lack of trying on Hoff's part. Reij's long history in the Sahel, and his ties to academia and to private foundations, have made him one of the gatekeepers for funding in the region. Last year, a Dutch businessman sent Reij an e-mail on Hoff's behalf. "He was suggesting a meeting to discuss the large-scale inclusion of the Waterboxx in the Great Green Wall," Reij told me. "My reaction was that I had no intention whatsoever to participate." The Waterboxx is much too costly for most farmers, Reij told me, and it fails to address the fundamental issue of desertification: what sort of agriculture makes sense in this place? "Tree planting is bloody difficult in dry lands," he said. "When I come across people who say it's possible to

re-green two billion hectares, I start observing the clouds."

And yet Reij's own vision is no less ambitious than Hoff's. For the past two years, Reij and Tony Rinaudo, an Australian agronomist and former missionary, have organized what they call the African Re-Greening Initiatives. Instead of trying to erect a wall of trees across the Sahara, Reij told me, African leaders should look fifty miles south, where a green revolution is already under way. In the past twenty-five years, farmers in Burkina Faso, Mali, and Niger have reforested vast stretches of the Sahel. They've done so with little money and no modern equipment, in some of the world's most politically volatile regions. Theirs may be the greatest environmental success in African history, Reij said, and it violates almost every rule of reforestation.

Burkina Faso lies just above the equator, between the sands of Mali to the north and the tropical forests of Ghana and Ivory Coast to the south. When I met Reij there in the spring, it was the middle of the dry season. The noonday sun could send temperatures soaring to a hundred and fifteen degrees and a hot harmattan wind blew down from the

HORSE PIANO

The idea is to get a horse, a Central Park workhorse.

A horse who lives in a city, over in the hell part of Hell's Kitchen, in a big metal tent.

You have to get one who is dying.

Maybe you get his last day on the job, his owner, his tourists.

You get his walk back home at the end of the day, some flies, some drool. You get his deathbed, maybe.

And then, post mortem, still warm, you get the vet or else the butcher

to take his three best legs. And then you get the taxidermist to stuff them

desert. On the drive north from the capital, Ouagadougou, a faint haze hung over the countryside, more dust than condensation. To either side of the road, the grasses were parched brittle and sere, the red soil baked hard beneath them. The only signs of life were a few Senegalese fire finches, darting like sparks among the shea trees.

"These are the really difficult months," Reij said. In the open country, the farmers and their livestock had retreated to their mud-brick compounds—miniature fortresses with low walls and circular towers—or to the mosques that spired above the treetops. But in the cities the escalating heat and rumors of distant revolution had begun to inflame local tempers. When we arrived in the city of Ouahigouya, we found most of its municipal buildings burned. A few days earlier, police officers in a nearby city had beaten a student to death, sparking a riot. "The officers are still in hiding," our driver said, pointing gleefully to the blackened shell of the police station. "They're afraid to come out!" Within days, soldiers would be rioting in the capital as well, looting the houses of government officials and injuring the mayor.

To keep tabs on the situation, Reij

heavy, with some alloy, steel, something.

Next day you go over to Christie's interiors sale and buy a baby-grand piano,

shabby condition but tony provenance, let's say it graced the entry hall

of some or other Vanderbilt's Gold Coast classic six.

And you ask the welder you know to carefully replace the piano legs

with the horse legs, and you put the horse/piano somewhere like a lobby,

and you hire a guy to play it on the hour, so that everybody will know

how much work it is to hold anything up in this world.

—Anna McDonald

chatted with local bartenders or with a Syrian family that owned his favorite hotel in town, but nothing seemed to faze him. Going from village to village in his S.U.V., he looked like a retired professor on holiday: floppy hat, comfortable belly, high domed forehead fringed with gray. An avid bird-watcher, he had a beautiful, warbling whistle with which he often accompanied himself as he drove. "I'm a born optimist," he said. Or perhaps he just had a longer memory than most.

When Reij first came to Burkina Faso with his wife, in 1978, he had been hired by Oxfam as a regional planner. It was hard to know where to begin. The Sahel was in the midst of a devastating long-term drought: close to a million people died of famine between 1972 and 1984, prompting huge shipments of Western aid. In Burkina Faso's Central Plateau, some villages lost as many as a quarter of their families, as they were driven into exile, and water levels fell between twenty and forty inches a year. "I was gripped by a certain fear," Reij recalled. "Am I going to work here? Am I going to live here?"

Much of the conservation work in the area was a disaster of good intentions. Two years before Reij arrived, Erik Eck-

holm, of the *Times*, had warned that the Sahel faced a desperate fuelwood shortage—"the other energy crisis," he called it. Almost every tree within forty miles of Ouagadougou had been cut down. To meet the demands of multiplying populations, one study estimated, reforestation would have to increase fiftyfold. "It was 'Oh, my God, the desert is expanding! Let's plant some trees!'" George Taylor, of U.S.A.I.D., recalled. "So they did these industrial-scale plantings in every country across the Sahel. Big Caterpillars bulldozing down what they thought was useless brush. And then putting in just huge fields of eucalyptus."

The Sahel had inherited from its French colonists a strictly compartmentalized approach to agriculture: crops over here, trees over there. Farmers were told to clear and plow their fields, enrich them with chemicals, and plant them with improved species. Foresters would



oversee the tree plantations. It was a tidy, seemingly scientific method, but it often failed miserably. Without trees to shelter the fields, the topsoil dried up and blew away. Without farmers to tend to the trees, the seedlings died. By the early eighties, crop yields were down to less than four hundred pounds per acre—in the United States, the average cornfield produced fourteen times that amount—and the fuelwood crisis was worse than ever.

In the spring of 1984, Reij drove across the border into southeastern Niger to design a soil-and-water-conservation project. He'd grown to love the Sahel by then—"It felt like a second mother country," he told me—but he despaired of its future. "It was a drought year, a very bad drought year," he said. "There was so much sand and dust in the air that you couldn't see a hundred metres. Even at noon, we had to drive with our headlights on. I thought Niger was being blown off the map." That same year, Reij recalled, the French environmentalist and former Presidential candidate René Dumont visited the region and reached the same conclusion. "Burkina Faso isn't a developing country," he declared. "It's a disappearing country."

Tony Rinaudo, Reij's future partner in the Re-Greening Initiatives, was working in the city of Maradi in those days, near Niger's southern border. He had come to the Sahel from Australia four years earlier with his wife and infant son (they would have three more children in Africa). He was in charge of organizing tree-planting and farming projects for a Christian aid group, Serving in Mission, but was soon doing famine-relief work as well. "I was in shock," he told me. "We had windstorms that would bury the seed or carry it away. We had a mouse plague. We had locust swarms—hatchlings moving across the ground like a carpet. We had crows who knew where the drill holes were. For a young agricultural adviser—I was born in 1957—it was just mind-boggling."

One afternoon, Rinaudo was driving into the country with a trailer-load of tree seedlings when his truck began to get mired in deep sand. He got out to let some air out of the tires, for better traction, and looked around at the barren scrub that encircled him. "I'm wasting

my time,” he remembers thinking. “It wouldn’t matter if I had millions of dollars and dozens of staff. I wouldn’t have a chance. The water table was forty to sixty metres deep. I’d plant the trees and watch them die.”

It was in that moment of surrender, he says, that an altogether different thought struck him. What if he had things backward? Every year, the villagers cleared the brush to make room for crops, and planted trees around them. And every year the plantings failed and the brush resprouted from its old rootstocks. What if they just let it grow? What if they cut back only a portion of the native trees, let the rest mature, and planted crops between them?

The idea went against conventional wisdom in almost every way. In temperate areas like Europe, the United States, and southeastern Australia, the growing season is short and sunlight is a limited resource. The best way to take advantage of it is to plant your crops beneath an open sky. Most of modern agriculture—its rolling plains and mechanized harvesters, monocultures and center-pivot irrigation systems—is predicated on that assumption. Nothing is allowed to block

the sun or get in the way of the equipment. And that means getting rid of the trees.

In the Sahel, the situation is reversed. The sun beats ceaselessly down. There’s too little water for irrigation, too little money for mechanized harvesting. The trick isn’t to maximize your crops’ exposure, Rinaudo realized, but to minimize it—to provide shelter and shade from the wind and the withering heat. It’s not enough to plant a row of trees around your field. You have to grow them side by side with your other plants, as a secondary crop. That way, you can harvest grains and vegetables on the ground, fruits and nuts in the trees.

Farmers in the tropics have been doing this since agriculture began, Dennis Garrity, of the World Agroforestry Centre, told me. But the tradition was largely quashed by colonization. In the French colonial system, trees were the property of the state—even those which grew on a farmer’s land. Pruning without a permit could earn you a fine; felling a tree could get you jail time. “The laws were put in place to protect the forests,” Garrity said. “They did the opposite.” Caught between agronomists who in-

sisted on cleared fields and foresters who claimed any new seedlings as state property, farmers in Niger had learned to avoid growing trees altogether. If a seedling sprouted in a field, the farmer dug it up before an *agent forestier* noticed. If an N.G.O. paid for a communal woodlot, it was dutifully planted, fenced in, and left to die. In most cases, the trees cut down to make the fences outnumbered the ones inside.

“So I went to the forestry department,” Rinaudo recalled. “And I said, ‘Look, what you’re doing isn’t working. You have a forest guard at the entrance to every city, but the wood comes in anyway. Would you let us try something? If you give people permission to harvest trees, we will teach them to take care of them.’” As it turned out, the foresters were easier to convince than the farmers. “We had ten or twelve in as many villages who agreed to try it out,” Rinaudo said. “They were ridiculed and laughed at. As soon as it looked like the idea was taking root, people would come in at night and cut the trees back down.” The real battle wasn’t against the Sahara, he discovered, but against people’s ideas. “If we could change their minds, we could change everything.”

In the end, the farmers were given an ultimatum: unless they protected their trees, they would get no food from Rinaudo’s famine-relief program. “A lot of them hated me,” he said. “They protected roughly half a million trees, but, when the famine was over, two-thirds of them chopped down their trees again.”

It was the other third that made all the difference.

Rinaudo and his family went home to Australia in 1999, but Reij continued to work on conservation projects in the Sahel. In 2001, he co-edited a book called “Farmer Innovation in Africa,” but most of what he described were small local changes. Nothing that could be called a movement. Then, in the summer of 2004, Reij returned to Niger for the first time in a decade. “There were villages that I used to be able to see at distances of several kilometres, the land was so barren,” he told me. “Now I couldn’t see them. There was too much vegetation. I thought, Huh. Something is happening here.”

A few days later, Reij sent a note to



“So then I said to myself, ‘Why should I make toys when I can make the deals to make the toys?’”

Gray Tappan, a geographer at the U.S. Geological Survey. Tappan had spent more than twenty years documenting land use and vegetation in the Sahel with satellite images and aerial photographs. Like Reij and Rinaudo, he had worked in the area during the terrible droughts of the early eighties, but he hadn't been back in years; and he hadn't heard any talk of reforestation. "A lot of the satellite images were medium or coarse resolution, where you couldn't see the trees," he told me. Even if you could, the area that Reij had seen was dominated by winter-thorn trees, which lose their leaves in the rainy season. In the satellite images, they didn't appear green. "The whole phenomenon flew under the radar," Tappan said.

Tappan promised Reij that he'd do an aerial survey. Then he began to dig into earlier records of the country's vegetation. Beginning in 1955, when Niger was still a colony, French cartographers had taken tens of thousands of aerial photographs. Tappan found copies of these at the official mapping agency in Niamey, then he compared them with his own survey results, as well as with photographs from 1975. "I was blown away," he told me. "I'd never seen something like that." There weren't just a few more trees along the roadsides. Entire stretches of the country had been reforested—more than twelve million acres in all. What's more, the most densely forested areas weren't in parks or nature preserves. They were on farms.

"Twelve million acres equals about two hundred million trees," Reij told me. "No other country in the Sahel, or even in Africa, has managed to do that." We were sitting in a bar in Ouahigouya, looking at aerial photographs on Reij's laptop. One set was from 1975, the other from 2005. In the older pictures, the skin of the continent lay pale and featureless below, creased only by a streambed or two and by the faint cross-hatchings of roads. Thirty years later, it was covered with trees. It's tempting to credit the climate, Reij said, since rainfall has increased somewhat in that same period. But rainy periods haven't had this effect on Niger in the past, or on its neighbors today. He pulled up a photograph of the border between Niger and Nigeria. "Same landscape, same people, same culture," he said. Yet Nigeria, which gets



"When I was your age, I had to hike ten miles through the ice and snow to a porno store when I wanted to look at dirty pictures."

more rain, was nearly barren. Niger, to the north, was cloaked in forests. "You can literally see the border from space," he said.

After Reij and Tappan made their discovery, they travelled through southern Niger together to try to figure out what had happened. "Of all the places for trees to return, why there?" Tappan wondered. It was the poorest country in the world, according to the United Nations Development Programme, and it barely had a rainy season. The two men eventually traced the story back to Rinaudo and his epiphany that day outside Maradi. Farmers who still had trees standing after the drought in 1984 found that their harvests increased. Women who used to spend an average of two and a half hours a day collecting wood now spent half an hour. And their neighbors, seeing this, began to protect seedlings on their own land. "The penny dropped," Rinaudo told me. "Trees stopped being a weed."

Until Reij called to give him Tappan's results, in 2004, Rinaudo had no idea how far things had come. But he has since returned to Niger three times as an

adviser for World Vision, a Christian relief and development organization. Since 2009, he has helped lead the African Re-Greening Initiatives. "I don't think that I'm creating a green movement or turning all these villagers into environmentalists," he told me. "The bottom line is just this: growing trees puts food on the table and money in your pocket."

To Reij, what he's seen has been a kind of regional awakening—an outpouring of new ideas from farmers and aid workers left with no other choice. Sometimes, he said, it takes a near-death experience for a person or a people to truly change their behavior—to pull themselves out of the sand by their own hair, as people in Mali like to say. "*Il faut reculer pour mieux sauter*," Reij said, quoting Montaigne. You have to step back in order to jump.

Worldwide, more than a billion acres of forests could be regenerated naturally, according to the World Resources Institute. But the re-greening of Niger won't always be easy to replicate. In some places, like Burkina Faso's Central Plateau, the rootstocks of native trees



"I cooked us a lovely dinner for two—you could at least do the dishes!"

died off long ago. The soil on the Central Plateau is lateritic—laced with aluminum and iron oxides, which give it its rusty red color. Mixed with water and baked in the sun, it hardens into a crust that's nearly impermeable to the rain. *Zipele*, the locals call it.

One morning, Reij took me to see Oussen Kindo, one of his favorite farmers in the area. Kindo owns eleven parched acres on a hillside north of Ouahigouya. Lean and grizzled, he wore a midnight-blue robe and a cream-colored prayer cap, and kept up a high-pitched patter as he showed us around. (He claimed to be fifty-four and brought out a birth certificate to prove it; when we pointed out that it said he was sixty-nine, he laughed and admitted that he couldn't read.) His compound was home to two wives, fourteen children, a pair of zebu cattle, and an unruly mob of sheep and goats. To keep the latter away from his seedlings, he carried a homemade sling-shot, armed with a sharp rock.

When Kindo first began farming, in 1985, the land was barren. In some spots, the topsoil had washed away, exposing the rock below. During the next twenty-five years, Kindo tried every trick he could to improve things—some picked up by trial and error, some from other farmers, some from N.G.O.s like

Oxfam. He made compost piles and girded the slopes with low stone ridges to prevent erosion; he set up termite colonies to churn the soil, and hung feeders to attract birds, for their droppings. On the neighbor's property, the soil was as hard and flat as a clay tennis court; on Kindo's side, it was dimpled with circular pits. This was an ancient technique called *zai* agriculture, Reij said—a kind of low-tech version of Hoff's Waterboxx. The pits, each about a foot wide, collected the rain and funnelled it toward the plants at the bottom. Kindo added a little dung to each one, to fertilize it and seed it with native species. The rest was up to natural selection. "If the seed dies, it doesn't cost you anything," Dennis Garrity, of the World Agroforestry Centre, told me. "If it survives, you know it'll be hardy."

Kindo's land had the scrubby look of savanna, yet every inch of it was cultivated. The trees came in dozens of species and were spaced about twenty feet apart, as in an arboretum. Their branches formed a canopy above the rows of millet, sorghum, cowpeas, and dryland rice at their feet. Some trees provided fruit: tamarind, marula, raisinier, custard apple. Others, like the winter thorns, fertilized the soil by fixing nitrogen with their roots. Shea seeds

could be pressed to make butter for cooking or skin care; neem leaves made an excellent mosquito repellent. And almost every tree had some medicinal value: marula bark for malaria and rheumatism; neem oil for acne and contraception; tamarind leaves for jaundice, boils, dysentery, and hemorrhoids.

Farming this way is hard work, Kindo admitted: "I'm always here, even during the dry season. Even if a baby is being baptized, I'm here." The *zais* had to be chopped out with a pickaxe or a hoe, the trees continually pruned and protected from goats and poachers. (The scarecrow on Kindo's farm wasn't meant for birds; it helped ward off local gold miners, who came scavenging for wood.) Still, if the Sahel has a surplus of anything, it's manual laborers. And agroforestry more than repays the effort. On average, *zais* increase yields between thirty and eighty per cent, Reij said—"It should really be a hundred, because the starting point is often *zipele*." The thirteen hundred pounds of grain that Kindo harvested per acre, and the food, fuel, fodder, and medicine that he got from his trees, had carried him from subsistence to surplus. "With my cowpeas alone," he said, "I can pay for food to keep my family for a year."

At the top of the hill, where Kindo's property ended, one of his neighbors came over to greet us. Small, gaunt, and well into his fifties, the man had lost his right arm in a car accident. His left arm was still strong enough to heft an axe, however, and he was busy digging a *zai*. Thirty-five years after Erik Eckholm warned of "the other energy crisis," farmers like these were turning his predictions upside down. Instead of stripping the land of forest, they'd added three-quarters of a million acres to the Central Plateau, and another million acres to southern Mali. "It's counterintuitive, but it's true," Garrity told me. "The more people, the more trees."

Within a generation or two, Reij believes, agroforestry could spread across the southern Sahel, forming a green zone many times wider than the Great Green Wall. If so, it will arrive just in time. Even if farmers manage to double their harvests, they'll barely be able to feed the doubling population. The current famine in Somalia, which could

affect twelve million people or more before it's over, has shown how precarious the situation is. "All those children between five and fifteen—bloody hell! What will they be living off in ten years?" Reij said. "We should act as if the Devil is knocking at the door—and he *is* knocking."

Reij's call to action can seem contradictory. The best way to help local farmers, recent history suggests, is to leave well enough alone. Yet groups like Oxfam and Rinaudo's Serving in Mission have played a crucial role in the re-greening—if only, at times, by undoing decades of bad advice from former colonists. Even in areas where forests can resprout naturally, there are wells to be dug, roads to be built, and land reforms to be encouraged. In parts of Niger, Mali, and Burkina Faso, the authorities now let farmers trim or cut down their trees as they see fit. But in most of the Sahel the old colonial system of government control continues.

Last January, Reij began a project with the World Wide Web Foundation to broadcast the latest innovations over cell phones and radio. But the Re-Greening Initiatives' most effective tactic, by far, has been much more direct: take the poorest farmers, pile them into a van, and show them what agroforestry has done for their neighbors. "This isn't a big project with a cloud of money," Reij said. "It's a movement with a bunch of people with their noses in the same direction."

Whether Reij can persuade others to join him remains to be seen. African leaders are loath to give up their literal vision of a Great Green Wall, the journalist Mark Hertsgaard recently wrote in *The Nation*. Yet most Western donors are convinced that this vision is doomed. Hertsgaard, who wrote about the re-greening of the Sahel in his 2011 book, "Hot: Living Through the Next Fifty Years on Earth," believes that the Global Environmental Facility will push for a grass-roots approach to the Wall, and that it's unlikely to fund any proposals that are scientifically suspect. But when I spoke to Mohamed Bakarr, a senior specialist with the G.E.F., he wasn't eager to force the issue. "It's the country's prerogative," he told me. "One cannot rule out the idea that some will want to have tree plantations. Those are things that we cannot control."

When it comes to planting trees in the desert, unfortunately, mad ambition is often its own reward. The more titanic the struggle, in the words of the Senegalese President Abdoulaye Wade, the greater the appeal. Wade turned eighty-five in May, and is said to think of the Great Green Wall as a valedictory gesture—an arboreal Arc de Triomphe. Last year, when an official promotional video for the Wall was released, it looked as if it could have been made three decades ago. It showed bulldozers clearing away brush in Senegal while happy volunteers and soldiers planted nursery seedlings all in a row. "When I saw that, I just started to tear my remaining hair out," Reij told me.

Near the end of our trip, Reij and I drove north into Mali, up a winding road that led to the cliffs of Bandiagara. The cliffs are the leading edge of a sandstone escarpment that juts a thousand feet above the Seno Plains. Centuries ago, people built mud-brick structures in the shadow of the rock, like those at Mesa Verde, that are still used as granaries by local villagers. "This is all farmland now," our guide told us, as we looked out from the top. "Twenty years ago, people left this place to go elsewhere. Now they are coming back." I could see the thatched roofs of a village tucked among some mango trees below. Beyond them, to the south and west, airy groves of winter thorn and acacia stretched to the horizon. The wind whipped across the plains so steady and sharp that it made my eyes water. But there was no sand in it. "If you come here on a clear day, you can see all the way to Bankass," the guide said. "Green! Green! Green!"

It was a spectacular view, but not so different, I thought, from the one that I'd seen a month earlier, with Pieter Hoff, in the Al Hajar Mountains. In both places, people were fighting to stave off an encroaching desert; they just had different means at their disposal. The Sahel had manpower but no money; Oman had money but little manpower. Hoff's twenty-dollar Waterboxx might not interest the subsistence farmers of Mali, but then Sultan Qaboos and his citizens weren't likely to pick up axes and dig *zais*. There is a place for technical ingenuity and epic reforestation schemes—for

turning the surface of the earth into an art work. It might be in Holland or Israel, southern Spain or someday, perhaps, the Sahel. But you have to start somewhere.

In Oman, on the evening that Hoff and Abdullatif went searching for the baobab, the light had begun to fail when we finally climbed back into the car. The road had narrowed to an old camel path and the dropoffs were more precipitous than ever, but we decided to forge ahead. "I will never forget this baobab," Abdullatif muttered. "But first I have to pass through this in one piece." Soon we were off-road entirely, the undercarriage of the S.U.V. clanging like a gong, a cloud of dust billowing around us. At one point, we stopped to ask directions from two small boys standing outside a mud hut. And then, suddenly, there it was, next to a small stream at the bottom of a hill: the great tree.

In the deepening dusk, it looked like an apparition out of "The Arabian Nights"—a fat caliph surrounded by his fan-fluttering harem. It was wider than our vehicle and at least forty feet tall, with knobby gray branches that hung low over the water. Its wrinkled hide was embedded with thousands of pebbles and nails—offerings, Abdullatif said, from villagers who hoped they would rid them of tooth decay. Like the Moringas in Sohar, this baobab had almost certainly come from someplace else. Half a millennium ago, perhaps, a settler from Zanzibar or East Africa had brought a seedpod here and planted it in a rare patch of wet soil. And then, for hundreds of years, his or her descendants had kept the water flowing past, chasing away goats and sheep and hungry cows until the tree's roots grew deep, its branches so strong and thick that they could fend for themselves.

"If we could plant a tree like this in Sohar, all of Oman would come to see it," Hoff said, gazing up at the branches. In the meadow behind him, Abdullatif and our guide were kneeling on the ground for their evening prayers, bowing low toward Mecca and the setting sun. Their voices came to us as a steady murmur mixed with the rustlings of leaves. When they were done, Hoff bent down and picked something off the ground, then walked contentedly back to the car. His pockets were full of seeds. ♦