How to Be Human in a Warming World

Under the Sky We Make

KIMBERLY NICHOLAS, PHD

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Introduction

Science Won't Save Us

In the half lifetime since we met in college, I've had many adventures with my friend Colty. Together we've seen the sun rise through towering pines after dancing all night on the shores of Fallen Leaf Lake; buoyed each other through heartbreak and celebrated when we both found true love; sobbed through a funeral where our tears loosened the glue of the fake mustaches we wore to honor our dead friend's iconoclastic spirit.

Colty and I have always been able to talk about anything and everything, but I was surprised by the conversation we had a few years ago, when I called to congratulate him on the birth of his second child. I was expecting to hear intimate stories of adjusting to new family routines, but his daughter's arrival had raised Colty's sights much higher.

"Kimmy, I want to talk about climate change," he said. "I feel like all these red flags are going up around me, saying, 'Wake up!' But I'm overwhelmed. Where do I start?"

For decades, I've spent my professional life researching, teaching, and communicating about climate change. But until recently, my climate work hasn't been something I talked about with my

closest friends. For my research, I spent long, sweaty days of field-work in the mountains and grasslands and vineyards of California, documenting sagebrush marching uphill and Pinot Noir grapes around my hometown of Sonoma losing their color as the world warmed around them. All this felt like a separate world from the time I spent with my friends, where we talked and joked about our families, careers, and love lives; went for hikes through the redwoods and to the beach; and shared good meals and wine.

Through my years of avoiding talking about the climate elephant in the room, I was like most Americans, who know climate change is happening and are worried about it. (Only 10 percent don't believe the unequivocal fact that humans are warming the climate.) But still, unlike the vocal climate dismissives, most of the climate-concerned majority stays silent, reporting they almost never talk about climate change with friends and family. Many feel like it's someone else's problem: polar bears, perhaps, or politicians, or people unlucky enough to be born somewhere poorer or sometime later than they were.

Once you do start talking about it, you can't avoid scientific truths with overwhelming, existential implications. Human climate pollution and destruction of nature are putting at risk both human civilization and life on Earth as we know it. Gulp. In the face of this enormity, no wonder so many feel helpless (that you're powerless and don't matter) and hopeless (that no one can help and therefore nothing matters). I understand those feelings. I have them myself.

Over the course of my career, climate change has transmogrified from something only experts could see—reading clues trapped in icy air bubbles or statistical patterns in long-term data sets—to something everyone on Earth is living through. For me, climate change has gone from being something I study to a way that I see the world and experience my life. It's one thing to publish a study

on the hypothetical impacts of temperature increase on California's people and ecosystems; it's another to feel my stomach gripped by fear as my parents flee a catastrophic California wildfire cranked up by longer, hotter, drier summers. It's one thing to measure declining color pigments in Pinot Noir grapes due to increasing temperatures; it's another to viscerally mourn the loss of the taste of my favorite wine as it passes from this Earth.

By the time Colty and I finally talked about climate, it had gone from a measurable change to a prevailing crisis to a screaming emergency. Climate change was already rewriting the stories we read, reshaping our everyday lives, affecting everything and everyone we love. Climate was already woven through everything else we talked and cared about.

Colty and I had a series of climate counseling sessions, where we talked about the core values he hoped to pass on to his kids, his hopes and fears for the future, what inspired him and kept him going. In our conversations, I translated the science of an enormous global problem to a personal and human scale. I wanted to help my friend see the power he *already* had to be a force for climate and social good and to live a better life more in line with his values along the way.

These sessions were a version of the conversation I've been having over and over again, for years—with strangers at parties and on trains, in my talks with business leaders, festivalgoers, protesters, knitting grandmas, and everyone else who will listen. From these conversations, I know firsthand that there are many smart, concerned people out there who are deeply invested in the future of humankind and who don't need further proof that climate change is a real and urgent threat. Those of us who want to help are the majority; if even a fraction of us can mobilize and take action, we are more than enough to stabilize the climate.

That's why I'm writing this book.

Science Won't Save Us

Here's some good news for everyone who's been avoiding science since you had to memorize the periodic table in high school: We don't really need more science to solve the climate crisis. Saving the planet for humanity (and the rest of nature) is no longer a matter of understanding anything we don't, or developing a ton of technology we haven't. Science has carried our collective knowledge about as far as it can in the time we have. Luckily, it's enough.

The science of climate change is firmly settled, and has been for a very long time. It boils down to just five key facts, which I've been teaching since 2011: It's warming. It's us. We're sure. It's bad. But! We can fix it: Humans have the capacity to stop dangerously destabilizing the climate.

Basically, the climate problem has been solved on paper many times over by now. We know what we have to do and how to do it. Further tech breakthroughs could make it even faster and cheaper, but essentially we have the tech we need in hand.

Okay, then fixing climate change is a political problem, right? Well, yes and no. Changes in goals, policies, and laws are crucial. And you need to understand some power politics to get why humans find ourselves threatening to unplug our own life-support system in the first place. But the basic political framework to solve the climate crisis is also in place. To paraphrase three decades of negotiation-speak: The world has agreed that stopping climate warming is in the shared interest of humanity. The 2015 Paris Agreement says each and every country (and therefore, each and every industry and city, and ultimately each person) must do their fair share to stop climate heating before it exceeds intolerable limits. That bounces the ball right back to us.

So yes, we need technical and social transformations, informed

by science, to be put into practice to solve the climate crisis. We need political processes to do this fairly, citizens informed by fact-based climate education at all levels, and media coverage that explains how climate shapes nearly every story. Preferably all at once.

But what will really make or break the climate, globally and forever, is what ordinary people do in the next decade. The climate hinges on what people vote for, with our ballots and time and money and careers, with our leisure and travel and consumption and production, with our relationships and conversations and aspirations and memes and everything else that adds up to culture.

Science or experts or technology isn't enough to save us from climate catastrophe. We as humanity, a groundswell of people alive today around the world, have to save ourselves, through what we think and feel and ultimately what we do. This means we need people with the courage and compassion and imagination to transform themselves, and society, in the ways that science tells us are necessary to maintain conditions for life on Earth to be able to thrive. Each of us can become that sort of person; more and more are every day.

The climate especially hangs on what Americans do in the next decade. In 2010 I moved from California to Sweden, where I'm a professor of sustainability science at Lund University. Looking at the United States from abroad, it's acutely clear how much the climate hinges on what happens in the world's largest economy and largest historical climate polluter (USA! We're number one!). For practical reasons, Americans starting to take climate responsibility at scale would be an enormously powerful accelerator of climate action worldwide.

But there's a deeper cultural element too: For generations, the world has aspired to an American model of consumption that is widening inequality, making us sick and unhappy, and destroying

the workings and wonders of the natural world. Americans need to reinvent our dream toward one worth striving for and spreading: a good life for *all*, within a budget the planet and future generations can afford.

That means the climate *really* needs people like me and Colty to step up, because our privilege translates into disproportionate power and responsibility in many realms—and the climate is no exception. With our incomes in the top 10 percent globally, we're part of the group that consumes the majority of the world's resources and therefore creates most of the world's problems when it comes to heating the climate and destroying nature. (If your income is more than $38,000 per year, you're in the top 10 percent of the global income camp too.) Those of us with even more climate privilege, who are higher up the income ladder, are having an even more outsize impact. We need to take a long, hard look at our climate legacy—in terms of both our personal lifestyles and the political, economic, and cultural systems we help create, support, and empower—to see if it's really the mark we want to leave on the world.

It's Us

This book is a guide to how to live through what I think is the most riveting, challenging, terrifying, important, and meaningful time to be alive. The most essential lesson I take away from the thousands of scientific studies I've read, and the fifty-plus I've written, is that people alive right now are living through the decade that will define the future for both humanity and life on Earth. We are setting the global thermostat and therefore the boundaries and possibilities for human development, as well as the living con-

ditions for all life on this planet, for the rest of our lives . . . and affecting millennia to come.

The goal is for humanity as a whole, and I hope you and me personally, to get through the warming decades ahead together; to live to see a time where the climate is stabilizing, nature is recovering, human well-being is flourishing, and equality is increasing. To get there, we will have to draw on the best of ourselves and bring out the best in one another.

How can we stop climate breakdown in time to protect the only home we have, which we share with almost 8 billion fellow humans and about 8 million other species? In my opinion, we need to put the human values we hold most dear at the core of this work, because ultimately preserving the legacy of these human values is what is at stake. Nothing short of transformative change is going to be enough.

As you may have guessed by now, this is a different kind of climate book, one that's not only about the science.

Sure, I draw from my expertise as a scientist, with a reverence for evidence (hence all those endnotes) and analytical rigor. But my mission is to use this science to draw lessons about how to be human in our warming world. I aim to give the science a human face, by sharing stories from my own journey and from people who inspire me. By sharing these stories, I am acknowledging something that was initially hard for this scientist to admit: It is not just facts that we need to solve climate change; it is also tapping into the strength of our feelings about what we most fear, grieve, and love. It is the people and places and things I love—relationships, family folklore, beloved landscapes, wine—that motivate and sustain my work. Only by looking at climate change as humans, bringing all our humanity and empathy to bear, can we start to head toward the solutions at the speed and the scale needed.

Breaking Up with Exploitation

As a nerd steeped in sophisticated analyses, when I look for the root cause of humanity's current woes, I'm embarrassed by the naivety of my diagnosis. But here it is anyway:

Right now, too many people have a mindset of exploitation of nature and other people. This Exploitation Mindset is not fact. It's not based on any fundamental truths about nature or human nature. Instead, it's a story we're telling ourselves about who we are and the way we live in middle-class, industrialized societies, until it's become as invisible and taken for granted as the air we breathe.

This story is changeable, even though it feels like it isn't. There's a better way to live. We must find it.

Our task as humans in this warming decade and beyond is taking the science and using it as a lens to change not just our systems but also ourselves, from the inside out. By clarifying our values and shifting our mindsets and actions, we can start to change the world.

We need a new mindset to have a good future for life on Earth. We can and must change the story of exploitation, by identifying all the ways this mindset is baked into our current society, eradicating it, and replacing it with a better one.

My suggestion for a better story is what I call the Regeneration Mindset, which is focused on working *with* rather than *against* nature and bringing out the best of ourselves and one another. I've boiled down the Regeneration Mindset to three ideas that could be embroidered on your grandma's throw pillow or pasted in construction paper on your kindergartener's classroom wall: Respect life. Stop harming life. Strengthen life. Sounds pretty basic, but as I hope to illustrate in this book, I think these principles are flexible enough to guide action across diverse circumstances. Ac-

tually putting them into practice would be profoundly transformative.

The Path Ahead

This book is structured in three parts, which roughly correspond to the brain, the heart, and the hands, or thinking, feeling, and doing. In general, the book progresses from diagnosing problems to offering solutions, and from the global and abstract to the personal and tangible.

In Part 1, I tell stories of my family history and the history of life on Earth, to illustrate how humans and nature are tied up together (it's warming; it's us) and show the legacy humans are leaving in the sky and across the living world. I tell these stories because I believe understanding the science—truly understanding what the workings of the material world we share mean for humanity and our civilization, and how acute our predicament is right now—offers a kind of awakening. I hope coming to terms with the sobering power humankind wields at this moment helps us converge on the urgent need to lay down the weapons of the Exploitation Mindset and pick up the tools of Regeneration instead. The point of Part 1 is to empower you to orient your goals by asking the questions and having the conversations about how your everyday life and everything you love are inextricably connected to the climate and the living world, which are under urgent threat.

Well, *that* was all a bit heavy, now, wasn't it?! If Part 1 is about facts, Part 2 is about feelings, drawn from my own journey of slowly learning to acknowledge all the uncomfortable emotions of being a climate expert with a brain, and a human being with a heart, in a warming world. I share what losing a dear friend to cancer taught me about grieving climate losses (it's bad), how

facing my climate fears with my community gives me strength to carry on, and my enraging experiences of being a scientist in a world that sometimes doesn't want to hear the truth (we're sure). To see a pathway out of our climate and ecological crises, I had to stop looking to science for all the answers and start changing myself, using the climate crisis as a crucible to create meaning by clarifying my values and putting them into practice. The goal of Part 2 is to help you find your climate calling: to identify and nurture what really matters to you and to cultivate and strengthen the personal and community resilience essential to make your way in this warming world with kindness and purpose.

After we've made it through All the Climate Feels in Part 2, we're ready to roll up our sleeves and get to work. Part 3 is all about how We Can Fix It: envisioning and creating a future we want through both personal and system change. Here's where "climate action" goes from a hollow hashtag to concrete steps for who can do what to zero out climate pollution while strengthening people and nature. This part is about putting the Regeneration Mindset into practice within the day-to-day life you already lead, and how it scales to policies. It's also about expanding your vision of your sphere of power, to help extend the reach of what humans make possible. In line with my focus on what matters most, I emphasize what research and my personal experience show are the most effective ways to spend your limited time and energy for maximum impact. The goal of Part 3 is to help you find ways to use your unique gifts with agency, urgency, and joy to start bending our story from a legacy of harm to one of care.

Simply put: This is a climate scientist's book about the apocalyptic urgency of prioritizing not just the planet but also our humanity. I want to tell the story of our Earth's past, our world's present, and humankind's future—under the sky we make.

Part I

It’s Warming. It’s Us.

How We Got Here

Chapter 1

Carbon Is Forever

Understanding the Urgency of the Task Ahead

My mother's mother's mother, Clara, fled what is now Ukraine in 1904, when she was twenty-two. She had sewn her filigreed platinum engagement ring into her jacket to avoid detection as a deserter. If the authorities caught you leaving with your husband, they knew you were escaping for good. Her immigration record from Ellis Island lists her port of departure as Bremen. She and her husband, my great-grandfather Mark, lived in a damp tenement near Coney Island before they eventually settled in Denver, where they ran a women's clothing shop and raised my grandmother Lillian and her brother.

I've seen only one photograph of Mark, wearing a fedora, and Clara, with dark wavy hair. It was taken on a suburban Denver street with my mother, a serious five-year-old, and her sister Judy, already a great beauty at nine: old-world grandparents who loved borscht, posing with their wholly American grandchildren who thought the smell of beets and cabbage cooking was just awful. Clara made her life in a new country in her twenties, as I did in my thirties when I crossed the ocean to live in Sweden.

I never met Clara, but she touches my daily life in two ways.

First, her diamond sparkles on my left ring finger. Second, carbon from the coal that powered her escape, across first a continent and then an ocean, is still warming the atmosphere I share today with nearly 8 billion people. Because when your individual actions are powered by fossil fuels, some of the carbon from those actions stays in the air for thousands of years. Your story doesn't end with your death; its contrails unfurl in the physical world for millennia.

Clara lived to be eighty-two—a good, long life. Her grandchildren—my mother and her two siblings—are the last generation of my family to have known her. They're now grandparents themselves. Once they're gone, living memory of Clara will wane and eventually the stories they shared of her will disappear too. Clara's life, as real and as vivid and important as mine or anyone else's, will fade into the background of the human tapestry. But her carbon will outlast us all.

I don't know the name of Clara's mother's mother's mother. She would have been born in black-soil country sometime around 1800, so I can guess that she was part of a big family, all of whom worked hard on the farm. I like to imagine them playing music around the fire at night. But here's one thing I know for sure: A portion of the carbon sent skyward from the wood they burned to stay warm—and the carbon they released plowing the rich black soil—is still in our air today, and it will be for at least the next *three hundred* generations.

I don't know what Clara was thinking when she decided to risk the perilous journey to a new land and leave behind everything she knew. I don't know how much thought she gave to her potential descendants and the life they would have as a result of her choice, or how much she was motivated by her own more immediate desires. Nevertheless, she set in motion a chain of events that shaped my life, giving me more choices, more freedoms, more privilege. I'm deeply grateful to her as a good ancestor.

Everyone alive today is skywriting the most important legacy of their lives in atmospheric carbon. Long after our names and faces and deeds have faded from living memory, long after any genetic or creative or physical or digital traces of us are gone, this carbon legacy will define us in the minds and stories of our distant descendants. It will literally define the terms of their lives: where they can live, how they can make a living, what kind of civilization and nature surround them. We will be remembered for our carbon legacy by far more people than we'll ever share a meal with or know by name.

Carbon Is Forever

"A diamond is forever." That De Beers cliché, in use since 1947, is to a certain extent true. Diamonds are composed of pure carbon. Carbon is the building block of life, found in all known life-forms. Living bodies, from plants to humans, are first and foremost water, which helps regulate temperature, circulate nutrients, and flush waste. But this temporary and variable internal lake drains away to join a new river when we die. What remains is largely carbon. The same carbon atoms have been circulating in a marvelous cycle between air, rocks, soil, water, and living creatures for about half a billion years, since land plants figured out how to turn sunlight and air into humble mosses, then towering trees, greening the earth with the magic of photosynthesis.

How much carbon is in which stage of the cycle largely controls the climate and therefore the habitability of planet Earth. Climate is the long-term average of weather in a particular place. As the saying goes, climate is what you expect; weather is what you get. Carbon in the atmosphere acts like a thermostat. It is the atmospheric level of carbon that primarily determines the

temperature to which the planet will eventually heat. When humans burn plants, we put the carbon those plants drew from the air to build their leaves and trunks back in the atmosphere. In the chemical reaction of burning, two oxygen atoms glom on to one carbon atom, forming carbon dioxide. CO_2 represents 75 percent of heat-trapping emissions; methane and nitrous oxide make up most of the rest.* These greenhouse gases trap heat near the Earth's surface instead of letting it escape into space. This extra heat warms the air and land and upper oceans.

Looking back over time, across the world, continents and oceans sing a coherent chorus: It's warming! The evidence for warming is found in decades of satellite and ocean buoy records; centuries of land thermometer and written records, like Thoreau's Concord journal, from which we know that plants now flower earlier in warmer springs than they did in his time; and millennia of environmental records quietly curated in the bodies of trees and corals and in the pollen lining lake beds. From these ancient records, we know the climate has been relatively stable for the last ten thousand years. Not coincidentally, human civilization was founded and flourished during this benign climate.

Humans have now markedly warmed the world, by approximately 1°C† above its pre-industrial average. Compared with his-

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*A note on nomenclature for the sticklers: Throughout this book, I use "carbon" to refer to carbon dioxide emissions. "Climate pollution" or "greenhouse gas emissions" refer to the sum of all human emissions warming the climate. Note that "carbon footprint" includes all greenhouse gas emissions, expressed in carbon dioxide equivalents.

†A note for American readers: All temperatures in this book are given in degrees Celsius, a very sensible temperature scale where water freezes at 0°C and boils at 100°C. All scientific studies and every country in the world save five (the Bahamas, Belize, the Cayman Islands, Liberia, and the United States) use Celsius to measure temperature.

Every mention of temperature in this book is about relative temperature, comparing the difference between temperatures (generally an increase from the pre-industrial global average temperature to a current or projected future temperature).

tory, today's warming is shockingly fast. A new color scheme, purple, had to be introduced in maps of Australia and the globe to show how much warming has *already* occurred above the previous end of the scale, red.

We know that today's warming is caused by humans through a combination of observations, theory, and models. Observed measurements show that CO_2 has increased 40 percent in the air; enough carbonic acid has been formed from CO_2 dissolving in the oceans to increase their acidity 26 percent. Atmospheric measurements sensitive enough to distinguish tiny variations in the global concentration of CO_2 pinpoint the source of this carbon from cities and factories. The warming observed is greater over land than over oceans, at higher latitudes, in the upper oceans, and lower in the atmosphere: all consistent with what physics predicts from humans burning carbon on land. Humans have likely caused *more than 100 percent* of warming to date, because natural trends alone (from variations in the sun and volcanic outputs) would have caused a slight cooling. In short: It's us.

For millennia, essentially the only carbon humans added to the atmosphere came from cutting and sometimes burning plants that grew within their lifetimes ("green" carbon), and from plowing and cultivating soil (a huge library of organic carbon built by generation after generation of decomposed plant roots and leaves). About 30 percent of the cumulative carbon humans have emitted to the atmosphere comes from centuries of transformation of land, clearing vegetation and disturbing soil to raise livestock, grow crops, and harvest timber. Human exploitation of land still causes about a quarter of our total climate pollution, including most methane and nitrous oxide emissions, as I'll cover in Chapter 10.

But the lion's share of greenhouse gas emissions today,

Each 1°C temperature change is equal to 1.8°F. So a temperature increase of 1.5°C is 2.7°F warmer; an increase of 4°C is 7.2°F warmer. Okay, no more footnotes!

including 86 percent of the carbon emitted over the last decade, is created by our burning of *ancient* plants. This fossil carbon is the 300-million-year-old remnants of lush swamps and sludgy seabeds (*not* dinosaurs!), transformed by heat and pressure from the Earth into fossil fuels like coal, oil, and gas. When we burn coal and gas to make electricity and energy to power and heat our homes, and oil to move our cars and planes, that long-buried carbon is transferred from the Earth to the atmosphere. It carries a telltale isotopic signature that definitively identifies it as fossil carbon. And we currently burn a metric shit-ton of prehistoric carbon: 36.8 billion tons of fossil CO_2 in 2019, to be exact.

Currently, nature cleans up a bit over half of humanity's carbon mess for free. Slightly more than a quarter of our carbon dioxide becomes plant food for photosynthesis on land. The oceans take up a bit less than a quarter of our carbon, but with a consequence much worse than more trees. Ocean acidification opposes the chemical reaction that the tiny creatures at the foundation of marine food webs use to build their shells out of basic calcium carbonate. The science writer Elizabeth Kolbert likens it to "trying to build a house when someone keeps stealing your bricks." There is a threshold beyond which it is physically impossible for calcium-based shells to form. Reaching it would be disastrous for life in the oceans.

After the land and oceans absorb their share, much of humanity's carbon pollution remains in the atmosphere, driving warming essentially forever. Up to a quarter of the carbon released into the atmosphere today will remain there *ten thousand years later,* a birthday Stonehenge is slightly more than halfway to reaching, and the Great Pyramids slightly less. Its route out of the atmosphere happens at the unimaginably subtle rate at which raindrops flatten granite mountains, or at which tectonic plates cross oceans, moving about as fast as your fingernails grow. Over millions of years,

most of this carbon will end up at the bottom of the ocean, some to eventually be returned to the sky when carbon-rich seafloors push under continental plates, melt to magma, and release their carbon back to the atmosphere when they erupt out of volcanoes.

Before humans showed up, the carbon slowly leaking from rocks to sky via the oceans and volcanoes was balanced by the carbon dissolving from sky to rocks in rainwater. Today, our factories, cars, and other industrial activities emit more carbon in three days than all volcanoes do in a year.

Humans are now adding carbon to the atmosphere hundreds of thousands of times faster than geology can remove it, hence our skyrocketing concentration of airborne carbon. The concentration was around 280 parts per million (ppm) back in the pre-industrial days. It passed 300 ppm for the first time in at least eight hundred thousand years in the early twentieth century, then started rising rapidly after 1950. In 2019, it averaged 411 ppm, rising about 2.3 ppm per year.

The "safe" level is 350 ppm, which we blew past in 1987. Oops.

All this carbon buildup has consequences: Every kilogram added to the atmosphere pushes us toward more dangerous climate change. The carbon math is brutally simple: the more emissions, the more warming, the more harm and suffering.

The Science and Politics of Danger

While the sluggish politics have always lagged far behind the urgent science, stopping warming in time to avoid dangerous climate change has been the central purpose of international climate negotiations for three decades. The objective of the world's first international climate agreement, the 1992 United Nations Framework Convention on Climate Change, and all subsequent

ones, including the Paris Agreement, is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-caused] interference with the climate system." Danger is defined in terms of three critical priorities that must be protected: healthy ecosystems, food production, and sustainable development. Seems reasonable enough. But of course, nothing is ever easy when it comes to international politics.

A long political process established the temperature goals meant to achieve the purpose of climate stabilization in time to avoid dangerous climate change. In the historic 2015 Paris Agreement, the nations of the world agreed to hold the increase in global average temperatures "well below 2°C above pre-industrial levels . . . pursuing efforts to limit the temperature increase to 1.5°C."

The definition of dangerous climate change enshrined in international agreements boils down to a simple affirmation that humans should maintain a climate compatible with life and prosperity. Avoiding dangerous climate change means we stabilize the climate in time to "allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner." These sound like pretty darn good ideas. I want to live on a planet where we maintain conditions where nature can survive, humans can grow food, and all people have the opportunity for a good life.

Unfortunately, humans have *already* caused warming of about 1°C, and this warming is *already* undermining each of the three priorities that define a safe climate. I'm sorry to tell you that this means we already live in a world of dangerous climate change.

First, the climate is already changing faster than ecosystems can naturally adapt. The current human-caused increase in CO_2 is more than *one hundred times* faster than the natural variation that happened in the past. Picture strolling along a NASCAR

racetrack and trying to keep up with the cars zooming by; keeping up with climate is an even bigger challenge. Some species are running out of options. Gorgeous birds in Hawai'i, including honeycreepers that exist only there, live in the remaining high-elevation forests, where cooler temperatures protect them from mosquitoes and the malaria they carry. As warming brings the shrill whine of the mosquitoes steadily higher, the birds are getting squeezed off the mountaintops toward extinction. Scientists are making desperate attempts at "assisted colonization" to relocate some species and create an "insurance population" to buy more time, but no one thinks this approach will save unraveling ecosystems. Camille Parmesan, who has studied ecosystems under climate change for decades, has found that half of all species studied have had to move in space (range shifts) and two-thirds have moved in time (for example, flowers blooming and birds migrating earlier in the spring) to chase after their niche in a rapidly warming world. These large responses to "only" 1°C so far are deeply worrying for what's in store under more warming.

As for the second component of danger, climate change is already threatening food production. According to a 2019 study led by Deepak Ray, climate change has been stealing 1 percent of consumable calories across ten major staple crops since 1974 (losing enough food to feed 50 million people each year). Earlier work by David Lobell and colleagues looked at decades of yields for four crops that provide 75 percent of human calories, finding they declined in warmer years at a rate of about 10 percent for each 1°C of warming experienced. Land degradation is further stressing food production; it has already reduced crop productivity in almost a quarter of global land area.

And climate change is already slowing economic development and increasing inequalities, undercutting human progress and the physical security on which it rests. A global analysis by Stanford

colleagues showed that human-caused warming has already increased the income gap between rich and poor countries by 25 percent, disproportionately slowing economic growth in poorer countries, which tend to be warmer.

Focusing on a broader set of impacts beyond this UN definition of danger, a review of 3,280 research papers on current impacts concluded that "greenhouse gas emissions pose a broad threat to humanity," and the few nonharmful impacts they found could not counterbalance any of the harms "related to the loss of human lives, basic supplies such as food and water, and undesired states for human welfare such as access to jobs, revenue and security." Climate change is already bad, and it's poised to get worse.

The Carbon Bathtub Is Almost Full

Climate action needs to be massively accelerated to meet the Paris temperature goals, because current climate policies are "blatantly inadequate" to do so (more on that shortly). To understand what humanity has to do to stabilize the climate, imagine for a moment that our atmosphere is like a bathtub, one in which you are a happily floating rubber ducky. The volume of the bathtub is its capacity to store a set amount of water. The water level represents the concentration of carbon in the atmosphere. From the faucet pours the carbon humans burn and unlock from ecosystems, raising the level. In my lifetime so far, we have kept opening the tap wider, transferring ever more carbon from Earth to sky, well after the science of the dangers of climate change was clearly established.

Out the drain flows the half of our carbon pollution that nature is currently absorbing on land and at sea. (Worryingly, warming is constricting the size of the drain, because overheated and over-

sions more to clean up your mess, or you have to physically remove carbon from the atmosphere. While the Exploitation Mindset favors a range of "pollute now, pay later" schemes to keep burning carbon, carbon removal is a ginormous, expensive, and risky undertaking. There is low confidence that it will actually work. The definitive climate authority is the Intergovernmental Panel on Climate Change (IPCC), a huge team of scientists who synthesize the latest evidence in massive reports after exhaustive scientific and governmental review. The latest IPCC assessment warns that carbon removal schemes would need to be deployed at large scale for at least one hundred years to have a two out of three chance to "significantly reduce" CO_2 concentrations in the atmosphere. While some carbon removal may be necessary to reach net zero, *in addition* to stopping emissions, clearly it's not Plan A—rapidly stopping fossil fuel use is!

What's Ahead?

Yikes, we already live in a world made more dangerous by human-caused warming, and to stop warming we have to completely stop adding carbon to the atmosphere.

Until we do, what's in store for the world we know over the twenty-first century?

To help orient your thinking to the scale of a century, please do some quick morbid mental math to estimate how much more of this century you and your loved ones can expect to live through. To help you calculate: Life expectancy more than doubled in the twentieth century and is now over seventy globally and over eighty in industrialized countries. (Personally, I expect to retire around 2050 and live into the 2060s; if I live as long as my father's

grandmother, I will die in 2079.) Even if you don't count on having many more years on this planet, please keep in mind that more than 40 percent of the world's population in 2020 is under the age of twenty-five, hopefully including many people you love; these young people have a good chance of living to see the year 2100.

Do you have in mind where you and your loved ones will be in 2030, 2050, and beyond? Good, let's look at the warming that could happen this century.

How much warming our planet experiences depends on the total, cumulative amount of carbon in the atmosphere. The faster we stop adding more carbon, the sooner the planet's temperature will stabilize.

Looking at the coming decade, I've got bad news for the instant-gratification wired among us. Some further warming, and thus worse impacts, is unavoidable at this point, already baked into the system; it is going to get worse before it gets better. That's because the next few decades are the era of committed climate change, where the global climate system will keep warming as long as humans are adding any carbon to the atmosphere. We will not start to see climate stabilization for decades, even if we throw ourselves at this problem with the urgency it demands and zero out emissions quickly, because each and every car and factory and power plant still belching out carbon will cause added warming. There will be additional, unnecessary human suffering and serious ecosystem destruction, compared to a world where we had stopped emitting carbon earlier. Even at "only" 1.5°C of warming, and even taking all available adaptation measures, the IPCC warns that extreme events will be more frequent and deadlier, air will be harder to breathe, diseases will spread faster and wider, and mental health and violence will be worse.

Some inevitable warming is certainly bad news, but that doesn't mean we should give up. To the contrary, our actions to

cut emissions now are critical. How much *more* warming our planet will experience beyond 1.5°C depends mostly on how much carbon humans keep adding to the atmosphere; that is, what we do now, and soon.

Looking further out, let's consider a possible range of warming from 1.5°C to 4°C. To put these numbers in context, it's helpful to know that an Ice Age is about 4°C colder than pre-industrial temperatures. A 4°C temperature change produces a different planet than the one we grew up on. During the last Ice Age, ice covered a third of the planet (instead of a tenth today). Boston was buried under nearly a mile of ice.

Consider that the planet's temperature is usually as stable as the human body's. As climate scientist Katharine Hayhoe points out, a body temperature one degree above normal is a fever; with a fever of two degrees above normal we would see a doctor, and at three or four degrees warmer, we'd go to the hospital. And please don't forget, if the world warms 4°C, the planet will already have suffered the impacts from warming 2°C degrees, then 3°C, just a few decades earlier.

Of course, what matters most is not what the thermometer reads, but how nature and humanity fare in a warming world. It's easier to predict biophysics than human beings; what ice or photosynthesis will do in response to a given temperature change can be tested experimentally, while the response of human institutions and societies under completely novel conditions cannot.

Some of the best-studied places are the wealthiest. Please keep in mind that impacts are much worse for the people who can least afford them, like the 2.5 billion smallholder farmers who rely on their farm labor and income to feed themselves and their families.

Fair warning: Climate heating is bad. It ranges from really bad to unimaginably, catastrophically bad.

Every Fraction of a Degree Matters

Humanity is not currently remotely on track to succeed in limiting temperature increase to 1.5°C, the aspirational goal of the Paris Agreement; at current emissions rates, we'll warm past this limit as soon as 2030. Stabilizing temperatures around 1.5°C would require enormous, heroic, sweeping transformations across sectors and societies, plus some luck (more on that shortly). Reaching a 1.5°C world would be an epic victory for humans and nature. It would help keep low-lying cities and even countries on the map ("One point five to stay alive" was a rallying cry from small island nations in Paris). Compared with a 2°C world, it would provide three times as much habitat for insects (the basis of many food chains) and twice as much for plants (the basis of nearly all food chains) and vertebrates (picture your favorite stuffed animal as a kid). And in a 1.5°C world, cleaner air would massively improve public health: clean energy would be widely accessible to help lift people out of poverty without increasing pollution.

Even so, for living creatures, a 1.5°C world is no picnic. Warming is already stressing sensitive ecosystems, and further warming will cause some unavoidable loss and damage compared with today. One of the most unique and threatened systems is coral reefs. Warming ocean temperatures are causing repeated and increasing bleaching worldwide, killing the tiny creatures that give dead coral skeletons their vibrant living skin. Bleached corals first become ghostly white before they're overgrown by a slimy blanket of algae.

My colleague Kim Cobb, a climate scientist at Georgia Tech, describes her research dive in 2016 through the dead coral reefs of Christmas Island in the remote Pacific as her "wake-up call that we are simply out of time." It was on this dive that she realized

that the impact from tropical ocean warming "we thought was maybe a couple decades out . . . was actually at our doorstep. In fact it had actually come in and sat on the sofa, and made itself at home. . . . These reefs . . . would take 40 to 50 years to recover . . . [they're] not going to have that kind of time. This is happening much faster than I thought it was going to. I'm devastated at the loss of this very fragile and vulnerable ecosystem. But we're going to be next." Even if we succeed at limiting warming to 1.5°C, only 10 to 30 percent of coral reefs will remain alive.

That's a lot better, though, than the virtual elimination of coral reefs worldwide expected under 2°C, a threshold we expect to pass by 2060 under current climate policies (on the way to 3°C-plus). Nearly half the world's current population, 3.6 billion people, will be exposed to water stress under 2°C of warming. A 2019 study found that with 2°C warming, US residents would feel as if their hometown had moved an average of about three hundred miles (five hundred kilometers) south. For example, Minneapolis would feel like Iowa City; Boston like a suburb of Baltimore; and New York City like DC. Residents of Tampa would experience temperatures similar to those in a suburb of Mexico City. Unsurprisingly, considering how much half an Ice-Age worth of warming would redistribute climates over the globe, my research with colleagues found that more than half of today's wine regions would no longer be suitable to grow their traditional grape varieties under 2°C of warming. Much more disturbingly, basic food production would also be both tenuous and variable, which is a bigger worry, as I hear it is possible to survive without wine; still, I would prefer not to have to try.

Existing policies are expected to lead to warming of about 3.5°C by 2100, after warming to about 3°C by 2070 under no policy. A 2020 study led by Chi Xu found that under *global* warming of 3°C, the average human would experience more than twice

to break it down. But a bit more warming could bring these frozen soils to life and release millennia of stored carbon to the atmosphere over a few years, driving more warming, which will release even more carbon.

The 2018 IPCC report assigned a "high" risk to tipping points around 1.5°C warming, which the world is likely to see in the next decade or so. This is something I lose sleep over.

Distinguished scientists led by Tim Lenton of the University of Exeter wrote a comment in November 2019 that basically screamed from the pages of *Nature,* the most prestigious journal in science: "Consideration of tipping points helps to define that we are in a climate emergency . . . both the risk and urgency of the situation are acute." They acknowledged that the science of tipping points is not settled but concluded imperfect knowledge was no excuse for inaction: "Given its huge impact and irreversible nature . . . to err on the side of danger is not a responsible option. . . . Warming must be limited to 1.5°C. This requires an emergency response."

In my line of work, I read a great many scary climate studies, but the ones I have the hardest time getting through, that I have to steel myself for the most, are about catastrophic sea level rise, which could be triggered by passing ice-sheet tipping points. It fills my stomach with lead to imagine drowned beachfront homes and whole coastal cities and even low-lying island nations being wiped off the map.

Sea level rise illustrates both the steady and dramatic dangers of climate change. On the slow and steady side, warming expands water already in the oceans (thermal expansion) and melts ice on land into water that eventually flows to the ocean. Sea level has already risen in the twentieth century, driving higher and more frequent coastal flooding. Parts of New Orleans are already being abandoned to rising seas; Miami is not far behind. More sea level rise is already baked into the system; a further twenty- to thirty-

centimeter rise by 2050 is broadly agreed. The IPCC concludes that it is "*virtually certain* that global mean sea level rise will continue beyond 2100, with sea level rise due to thermal expansion to continue for centuries to millennia" (it takes a long time for the heat in the slow-moving oceans to catch up with what's added to the faster-mixed atmosphere).

If humanity fails to prevent major sea level rise, coastal cities will be profoundly changed, to the extent that they may have to be abandoned. Authors of a 2019 sea level study conclude that "even in the US, sea-level rise this century may induce large-scale migration away from unprotected coastlines, redistributing population density across the country and putting greater pressure on inland areas."

The National Oceanic and Atmospheric Administration has an online sea level rise map linked to local plans; the scale runs to ten feet of sea level rise, which is too low to capture some of the "extreme" scenario results. Under their lowest scenarios, by 2100, San Francisco is planning for one and a half feet of sea level rise; New York City expects two feet. The changes under this amount of sea level rise are barely visible on NOAA's map.

But you can't miss the difference between today and the second-highest (though short of the highest, "extreme") scenario, where San Francisco expects more than eight-feet-higher water. This would drown city icons including Fisherman's Wharf and Pier 39, the Ferry Building, the baseball stadium, and many of the tech headquarters, coffee shops, and craft breweries around the Caltrain station.

Under their second-highest scenario, New York City expects nine feet of sea level rise, which would bury much of Lower Manhattan, Battery Park, and the East River shore in Manhattan; all the piers; and basically all of Red Hook and the Navy Yard, in Brooklyn.

If we fail to stop climate breakdown in time, I worry that the slow erosion of Earth's life-support systems, overlaid with ever-escalating climate catastrophes, will cause the increasing failure of human institutions stretched beyond their breaking points. After running out of food and water and other basic needs, how long can goodwill and democracy last? There is a limit to the planetary warming that human civilization can tolerate and retain our humanity. It's impossible to predict with precision what that limit is, but it's possible we will exceed it on our current emissions trajectory. I don't want to find out. I don't want to witness the reversal of the long arc of history bending toward justice and watch it bend toward material and ecological impoverishment instead. I don't want to have to look today's young people in the eyes and tell them to their face that, even knowing the stakes and the urgency, we chose, both explicitly and through willful ignorance, to fail them.

What is at stake under the different degrees of warming we face right now is nothing less than the progress of the whole human endeavor. There is much more work to do until humanity succeeds in providing equality and sufficient opportunity for everyone. Still, enormous social and human progress in health and education and equality have been advancing through hard-won struggles. Global warming in my lifetime has the potential not only to undo much of the last century's progress but also to permanently extinguish the very idea of human progress. It is not reasonable to expect or hope that things generally will be better for our children than they were for us if they live on a dying planet.

Welcome to Club Climate Alarmed

Time for a deep breath. In this chapter, I've given you an insider's tour of the terrifying gauntlet that is humanity's potential near-

term climate future. You're probably freaking out. Welcome to the club: None of the scientists I've privately asked about their Climate Freakout Level from one to ten rated themselves lower than a seven. This is really hard news to take in, but we have to recognize the severity of the mess we're in before we can start responding to it appropriately.

But so far, I've only told half the story. We've covered the damage that the Exploitation Mindset is doing to the climate, but now we need to lower our sights down to Earth and take a look at how we're treating our land and oceans and the creatures who live there. This too will not be pretty. But please hang with me for just one more super-depressing chapter. Once we are up to speed on the facts, I promise, we will start to run toward responses and solutions as if our lives depend on it, which they do.

assemble their armor. Precipitation in the Sierra Nevada is falling more as rain and less as snow in warmer winters. Reduced snowpack makes my hard-earned mountaintop vistas more monotonous, and it also means California farmers, who grow nearly two-thirds of the fruits and nuts in the United States, have less water to get through the longer, hotter growing season.

I care about stopping climate change because I care about the landscapes and nature I grew up with, and the traditions, culture, and way of life of my hometown and community. These are the tangible ways that climate change affects my lived experience, my identity, and my relationships with the people and places I love. I only know who I am in the context of the climate that shaped and underlaid all my experiences, that made my choices possible. When climate changes the planet, my existence and identity are at stake too.

My specific concerns reveal my personal passions and the privileges I've had to enjoy beautiful beaches and mountains, where I feel most alive. But these examples are part of a much bigger story. Whatever it is that you care about, wherever your Gualala is, the people and other species who live there are already being harmed by all the pressures degrading and destroying life on land and at sea and heating our climate. This is a personal tragedy for your favorite holiday spots, but it's also a deep problem for humanity, because ultimately, nature is not a luxury or a nice-to-have. Nature is life itself, and the means needed to sustain it. There is no substitute for the fundamental building blocks of life. To meet our most basic human needs, we are utterly reliant on nature. The Exploitation Mindset is putting lives at grave risk of more harm, because without enough healthy nature to support and sustain us, people will suffer and die. (I told you this chapter wouldn't be pretty!)

Today's "Normal" Isn't Normal

A beautiful and tragic thing about being human is that each generation meets the world fresh. For each of us, the world is what we were born into and grow up with. Everything we learn comes either from our direct experiences with and observations of that world or from what someone else (a parent, a teacher, a book) tells us about it. This renewing of collective consciousness can be wonderful, as fresh minds question limiting assumptions or expand past old prejudices.

But this collective innocence can also be devastating, because each generation perceives the degraded condition of nature as the normal condition. It can be hard to comprehend how staggeringly people have hobbled life on Earth, because our baseline for comparison is constantly shifting toward the increasingly impoverished world we live in. We think it's normal that humans are driving species to extinction at a rate *one thousand times* faster than natural; it is not. No one born after 1985 has lived through a normal year on planet Earth; every year of their lives has been warmer than the twentieth-century average. But a study led by Frances Moore at the University of California, Davis, showed that people just stop remarking on warmer weather after about five years. Although extreme temperatures still made people miserable, they stopped talking about it, seeming to accept it as the "new normal" even if there is nothing normal about it. People quickly forget what normal is, what the true baseline should be.

To go beyond our own personal experience and put our human lives in the context of the tapestry of life on Earth, at the geologic scale of the planet itself, we need to rethink our relationship with nature and the physical world. This means we need a different