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PLANETARY SCARCITY

On Christmas Eve 1968, astronaut Bill Anders photographed the earth as it appeared on the horizon of the moon. Then, Anders and fellow astronauts Frank Borman and Jim Lovell took turns reading the first ten verses of Genesis in a broadcast heard by millions back on earth. They finished with a blessing for the season: "good night, good luck, a Merry Christmas, and God bless all of you—all of you on the good earth."[1] Though the astronauts of Apollo 8 did not read beyond the tenth verse, many in their audience would have been familiar with the rest of the book of Genesis: On the fifth day, God made Man in his image and likeness to exercise dominion over all living things. This bond between the Creator and humanity would persist even after Adam and Eve were expelled from the Garden of Eden and God sent a deluge to drown the world. Carried aloft by a combination of kerosene and liquid oxygen, Anders, Borman, and Lovell were the spacefaring descendants of Adam and Noah, blessed by God to carry Man's dominion from the earth to a new world.

Yet such confidence in Christian cosmology did not entirely shield the astronauts from another, far more unsettling discovery. In the live

***Earthrise,* December 24, 1968.** Bill Anders's photograph encapsulated the clash of two opposing ideologies, expressing at the same time a celebration of human power over nature and a growing concern about the fragility of the biosphere. *Credit:* NASA.

broadcast to earth, Jim Lovell spoke of the "awe-inspiring" effect of watching the dance of the celestial bodies. "It makes you realize," he mused, "just what you have back there on Earth." Still thinking of the Old Testament perhaps, he conjured up an image of water and verdure in the desert: "The Earth from here is a grand oasis to the big vastness of space." Reflecting on the same void, Anders felt his faith waver: "We are like ants on a log. . . . How could any earth-centered religious ritual know what God's truth is?"[2] This startled sense of wonder was even more apparent in Anders's photograph of earth rising on the moon's horizon: a tiny blue island in a sea of nothingness. The image revealed the concrete and indissoluble unity of the Earth's biosphere; within its razor-thin atmosphere, blue

oceans, white clouds, and glimpses of land appeared, but no political boundaries or social divisions. Over the coming decades, Anders's "Earthrise" photograph would become an icon of environmental consciousness, encapsulating the fragility of life and the need for planetary stewardship. In parallel with this political movement, the new interdisciplinary field of earth system science began to map how the planet functioned as an integrated system. Humans were not lords and masters of creation but utterly dependent on the life support of the biosphere. The view from orbit drove home how little of the earth system humans actually understood, much less controlled.[3]

These conflicting impulses of the Apollo mission—technological dominion and environmental fragility—brought to the surface a deep contradiction of late-twentieth-century society. After the carnage of World War II, the advanced economies of the world entered a period of unprecedented economic growth powered by new technology, cheap energy, and mass consumption. At the same time, human impacts on the environment escalated, setting the planet on the path toward multiple dangerous tipping points. The quickening pace of economic growth in the postwar era was the outcome of several closely connected forces. Competition between the West and the Soviet bloc created a strong incentive to maximize growth through technological change. The American contribution was crucial, of course, but equally important was the parallel development of Soviet industrialization. In both cases, intensifying energy use went hand in hand with economic expansion and new kinds of consumption. Fossil fuels—coal, oil, and natural gas—provided the bulk of the cheap energy required to power an unprecedented pace of urbanization, crowned by the proliferation of megacities after 1950. Fossil fuels were also critical to industrial agriculture, which saw very high inputs of energy for every calorie produced.[4]

Latter-day scholars have christened this phenomenon "the Great Acceleration." In scientific terms, the concept captures the systemic and interrelated impacts of economic development on the biosphere that began around 1950 and are still continuing to the present. It is closely connected to the concept of Planetary Boundaries put forward in 2009 by environmental scientists Johan Rockström and Will Steffen (as we discussed in the Introduction). Vital socioeconomic and environmental indicators show steep growth curves in world population, real GDP, primary

energy use, transportation, water use, and tropical forest loss. A vertiginous rise in greenhouse gases marked the most ominous of these changes. Atmospheric concentration of carbon dioxide had surpassed the Holocene pattern of natural variability for the first time at the end of the nineteenth century, but after World War II carbon emissions increased much more rapidly, from a global mean of 311 ppm in 1950 to 331 in 1975, reaching 417 by 2022. In the first decades of the postwar era, most emissions came from Europe and North America. After 1980, China, India, and other developing economies contributed increasing shares.[5]

Politicians and economists greeted the Great Acceleration with open arms. For most members of the economics profession, the trajectory of sustained growth between 1950 and 1970 seemed to vindicate the basic optimism of the discipline about the truth and universality of Neoclassical Scarcity. Apparently, utility-maximizing consumers and profit-maximizing firms had spontaneously settled on the optimal resource allocation. Innovation, substitution, and growing efficiency seemed capable of averting the threat of depletion in nonrenewable resources like copper, tin, iron ore, and petroleum. The new aggregate measure of Gross Domestic Product made abstract growth easy to fathom and celebrate. In liberal democracies, the holy grail of sustained growth became the foundation of electoral politics in these giddy decades. Economists achieved newfound prominence as the guardians of future progress, and students flooded economics departments.[6]

Yet with the Great Acceleration came increasing disquiet among a vocal minority of social critics and scientists. Eminent philosophers warned about the corrosive effects of growth-oriented culture on human values and institutions. Rapid population growth revived Malthusian worries about the physical limits to the economy. Ecologists grew increasingly concerned about the effects of man-made toxins on the biosphere. Scientists and computer modelers began to map out the interactions within the earth system, exploring the circulation of carbon and other cycles. By the 1980s, the depletion of the ozone layer and the increase of greenhouse gases in the atmosphere indicated that the biosphere was much closer to disruption than earlier generations had imagined. In 2000, Paul Crutzen and his colleague Eugene Stoermer proposed that humanity had left the relatively stable and benign climate of the Holocene to enter a

new dangerous epoch, which they named the Anthropocene. This presented a visceral challenge to the mental universe of neoclassical economics. Insatiable wants and endless growth were on a collision course with the earth system itself. The world of Neoclassical Scarcity now confronted a rising consciousness of the condition we call Planetary Scarcity.[7]

This turn to Planetary Scarcity was centered on the unsettling discovery that runaway extraction and consumption produced pollution on such a great scale that human waste was overwhelming the cycles that kept the planet habitable and hospitable to complex societies. Even the oceans and the atmosphere were filling up with human contamination. What had once seemed a noble mission to conquer nature now looked increasingly misguided and dangerous, rife with unintended consequences and delusions of grandeur. In contrast with Malthusian fears about the pressure of population on the finite supply of land and mineral stock, Planetary Scarcity brought attention to the burden of overconsumption on the physical sinks of the earth.

This chapter traces the intellectual emergence of the concept of Planetary Scarcity across the era of the Great Acceleration. Already in the late 1950s and early 1960s, critics like Hannah Arendt and Rachel Carson warned that humans were overwhelming the earth with new kinds of nuclear pollution and chemical toxins. Cold War scientists played a critical role in supplying evidence about disturbances in the oceans, the atmosphere, and other natural systems. A new science of carbon exchange was developed for the atmosphere and the ocean from the 1950s onward using a language of sinks and reservoirs. In the 1980s, scientists awakened the public to the planetary threats of greenhouse gas emissions and ozone depletion. The problem of protecting planetary sinks from industrial pollution became a serious political issue. Such worries have only grown deeper in recent decades.

Yet the idea of Planetary Scarcity has also spurred a positive expression—a search for alternative ways of understanding nature and the economy. This movement was underway already at the start of the Great Acceleration. A dawning awareness of ecological risk quickly seeped into postwar social theory. This chapter therefore weaves two histories together: the story of Planetary Scarcity's emergence and the parallel history of postwar critiques of consumer society, including important

new movements in ecofeminism, ecological economics, and economic anthropology.

The Philosopher in the Great Acceleration

The Great Acceleration did not go unnoticed by philosophers. One of the earliest sustained treatments of the phenomenon came from the German-American thinker Hannah Arendt (1906–1975). Born in Hanover to a middle-class Jewish family, Arendt led a life that encapsulated the cataclysms of the twentieth century. After completing her studies with Martin Heidegger and Karl Jaspers, she became a stateless refugee from the Nazi regime. She made her name in American academia with her dazzling dissection of fascist politics, *The Origins of Totalitarianism* (1951). Arendt's next major work, *The Human Condition* (1958), mined the tradition of classical political philosophy to deliver a piercing attack on the modern cult of prosperity and progress. The book opened with the launch of Sputnik in the fall of 1957—the first satellite to orbit earth. For Arendt, Sputnik was a world-changing event, even more significant than the splitting of the atom, not because the Soviets had beaten the Americans into space, but because the dream of escaping the bounds of the earth now seemed within reach. Modern science with its godlike powers finally seemed to have fulfilled the Cornucopian promise of Bacon and Hartlib. But this was not an unmitigated blessing. Science had brought into the human realm *cosmic forces* (by which Arendt meant nuclear energy) that threatened to overwhelm the natural and social world. Arendt's observations on technology were more prescient than she could have known at the time. The ascent of Sputnik coincided with the first attempt to map greenhouse gas emissions during the International Geophysical Year (1957–1958). Unbeknownst to Arendt, the scientist Charles Keeling had begun to measure the buildup of carbon dioxide in the earth's atmosphere a few months after Sputnik was launched. Over the next decades, rocket technology made it possible to establish a network of satellites to monitor weather on a planetary scale. Sputnik thus marked the beginning of a global infrastructure of information gathering, which in turn ushered in the emergence of modern climate science.[8]

Although Arendt's political theory was not directly ecological in inspiration, she shared with Rachel Carson and other environmental

writers the recognition that the deep structure of human praxis and thought depended on the planet itself. "The earth," Arendt observed, was "the very quintessence of the human condition." Though humans had set themselves apart from animals through the power of artifice, they shared with animals and all other life the same dependence on the support system of the biosphere. Earth provided "human beings with a habitat in which they can move and breathe without effort and without artifice." From the natural order of the planet flowed the basic order of human communities: birth, life, and death.[9] At the same time, Arendt observed that the human endeavor required a separation between the natural and artificial sphere—as she called it, "the time-honored protective dividing line between nature and the human world." Artifice was a form of violence that wrested from the meaningless cycles of nature a durable world of objectivity and meaning. Arendt subdivided the active life of humans on earth into three "basic conditions."[10] *Labor* was the realm of necessity governed by the biological rhythms of the body. *Work* was the domain of the artist and the artisan who created durable things and made the earth into a dwelling fit for human beings. *Action* was the realm of choice—the arena where courageous individuals made history through political contestation.

What worried Arendt most about the state of modern society was the threat that unrestrained consumerism posed to the earthly balance of labor, work, and action. Technoscience and capitalism had elevated labor to the point of being the only worthwhile human activity. The first step in this process occurred when industrial labor replaced craftsmanship during the Industrial Revolution. By the middle of the twentieth century, modern science had achieved such power that it could channel natural forces directly into society. In giving free rein to human "needs and wants," automated production undermined the stability and meaning of the man-made world, replacing it with a consumer order oriented toward endless obsolescence:

> For a society of laborers, the world of machines has become a substitute for the real world, even though this pseudo world cannot fulfill the most important task of the human artifice, which is to offer mortals a dwelling place more permanent and stable than themselves.[11]

The expansion of the modern economy now covered the entire globe, with no apparent limit in sight: "every end is transformed into a means."[12]

By enshrining endless desire and the mastery of nature—the basic tendency of Neoclassical Scarcity—modern society produced a "waste economy, in which things must be almost as quickly devoured and discarded as they have appeared in the world." Labor and consumption formed "ever-recurring cycles" that eroded the durability of the world, depriving humans of a home on earth.[13] At the same time, the triumph of *Animal Laborans* stripped human experience down to "empty processes of reckoning" until the "only contents left in the mind were appetites and desires, the senseless urges of the body."[14] Though the capacities for art and action still persisted in such a society, they now became superfluous and marginal to human experience. The population sank into a state of "automatic functioning" characterized by a "dazed, 'tranquilized,' functional type of behavior."[15] Whenever laborers gained spare time, it was "never spent in anything but consumption, and the more time left to him, the greedier and more craving his appetites." The end result was a world where consumption consumed all things: "no object of the world will be safe from consumption and annihilation through consumption."[16] In this condition of excessive affluence, the "capacity for action" became the "exclusive prerogative of the scientists" who had little interest in the web of human society.[17] To counter these dangerous tendencies, Arendt argued that labor must be subordinated to work and action. Rampant consumerism must give way to a new ethic centered on "building, preserving and caring for a world that can survive us."[18]

Arendt was hardly alone in calling for an alternative to consumer society. Herbert Marcuse's *One-Dimensional Man* (1964) became a counterculture bestseller and a dorm room bible for the New Left. Marcuse (1898–1979), too, was a former student of Heidegger and, like Arendt, a Jewish refugee from Nazi Germany who found sanctuary from oppression in American academia. Haunted by his experience as a citizen of the short-lived Weimar republic, Marcuse saw postwar American affluence through the lens of his European past. Modern technology had created conditions in advanced industrial society under which all needs could be satisfied. But in both the West and the Soviet Bloc, the promise of freedom from want turned out to be a poisoned chalice. Advanced industrial society was "destructive of the free development of human needs and

faculties."[19] In both its capitalist and socialist guise, this technocratic regime suppressed true freedom, by seducing the "vast majority of the population" with "a rising standard of living."[20] Marcuse genuinely believed that modern technology could deliver people from want, but he also saw this new affluence as a terrifying tool of mental oppression. Citizens on both sides of the Iron Curtain lived in a state of false freedom. "Social controls" produced a regime of "false needs."[21]

There was more than a passing resemblance between Marcuse's pacifying and narcotic version of creature comforts and Arendt's vision of dazed and tranquilized automatic life in the society of labor. They differed principally in how they imagined a reconstructed order of genuine freedom: Marcuse's aim was to transcend the currently dominant technological rationality and engage in the liberatory process of critical theory, or what he called "negative thinking," while Arendt looked to ancient philosophy for a path to resurrect political action. For Marcuse, the insatiable desires underlying Neoclassical Scarcity were inauthentic products of capital that entrapped consumers in a state of social subjugation. For Arendt, the trap lay in "mass culture"—and its "universal demand for happiness." According to her, "neither the craftsman nor the man of action has ever demanded to be 'happy' or thought that mortal men could be happy."[22] By artificially accelerating and expanding the rhythms of consumption and production, consumer society eradicated the space for political action and art.

Yet another philosophical critique of consumer society emerged in the writings of their teacher Martin Heidegger (1889–1976). Unlike Arendt and Marcuse, Heidegger eschewed questions of freedom and politics in favor a phenomenological and poetic exploration of how modern technology had come to colonize ordinary life. Heidegger's greatest philosophical contribution was his investigation of the pre-theoretical and social basis of human knowledge, elucidated through the method of transcendental hermeneutic phenomenology in his masterpiece *Being and Time* (1927). In later life, he developed a mystical approach to the problem of Being, which revived and revitalized Romantic Scarcity with a strongly conservative bent.[23]

In "The Question Concerning Technology" (1954), Heidegger tried to show that the system of modern technology at the most foundational level constituted an interpretation of reality—what he called the "enframing" of

being. Technology reduced the natural world to something to be measured and manipulated, a "standing-reserve."[24] By contrast, farmers in traditional societies depended on the soil to deliver the harvest and the wind to grind the grain in the mill. They relied on natural processes without forcing them. In *Being and Time,* Heidegger had set forth a novel understanding of human involvement in the world through the model of the craftsman. Instead of following the dualistic conception of the active human and objectified natural world in Bacon and Descartes, Heidegger wanted to understand how practices and skills enabled people to dwell in the *Umwelt*—a term he used to describe the occupations that characterized common life.

In Heidegger's later works, the legacy of seventeenth-century Cornucopian Scarcity, with its focus on technology as the instrument of infinite growth, came into sharp focus. In modern society, technology had transformed the entire world into a storehouse of resources with an aim to extract "the maximum yield at . . . minimum expense."[25] Modern technology isolated the functional dimension of things—their role as natural resources—while covering up their essence. In the process, technology took on a momentum of its own, independent of human intentions. The force of technology altered and reframed the essence of human life so that instrumental use pervaded all action and perception. For example, the construction of a hydropower dam on the Rhine reduced the river into a mere storehouse for energy. Even though the landscape of the river had not been entirely obliterated, the spirit of technology inevitably degraded and deformed perceptions of the natural world. In this sense, modern tourism replicated the attitude of the engineer: the beauty and grandeur of the Rhine had become nothing more than "an object on call for inspection by a tour group ordered by the vacation industry."[26]

Another 1954 essay by Heidegger entitled "Building, Dwelling, Thinking" offered a poetic solution to the problem of modern technology by reviving the Romantic notion of living a simple life rooted in the earth. Since time immemorial, humans had sought shelter from predators and other threats. This search for protection involved care for other living beings, including livestock and food plants. Yet genuine dwelling required more than simply building houses. For Heidegger the durable structures erected by humans in the landscape were "things" in the ancient sense of

assemblies. They gathered together the fourfold forces of the world and remained at peace with them: "The fundamental character of dwelling is this sparing and preserving." Heidegger continued, "Real sparing is something positive and takes place when we leave something beforehand in its own nature, when we return it specifically to its being."[27] Heidegger spoke of a bridge joining two sides of a river as a dwelling in so far as it gathered "the earth as landscape around the stream." It "lets the stream run its course and at the same time grants their way to mortals so that they may come and go from shore to shore."[28] Poetry provided the crucial medium by which to recover the world of dwelling. For Heidegger this meant above all the works of Friedrich Hölderlin, a contemporary of William Wordsworth and John Clare. He closed the essay by describing how a historical example of dwelling—a simple farmhouse in the Black Forest—existed in harmony with the earth and sky and made room for generations to "journey through time"—an idea that harkened back to Rousseau's Edenic islands and Alpine villages.[29] Heidegger seems to have wanted to awaken in the public a sense of urgency about living *with* the earth. Our plight, he noted, lies in the problem that "mortals ever search anew for the nature of dwelling, that they must ever learn to dwell."[30] His defense of dwelling perhaps most closely anticipated the so-called Deep Ecology movement, with its rejection of Cartesian dualism in favor of a quasi-mystical subordination of the individual to the community of nature.[31]

Spaceship Economics

The existential and ecological problem of dwelling with the earth was articulated in a different way by Rachel Carson (1907–1964) in her ecological critique of consumer society. A marine biologist by training, Carson entered government service in the US Fish and Wildlife Division while pursuing a parallel career as a naturalist writer. In a trilogy of works about ocean life, she developed a lyrical sensibility of great power. Her interest in marine biology also stirred an early awareness of the effects of synthetic chemicals on human health and wildlife diversity. These concerns centered on the pesticide Dichlorodiphenyltrichloroethane (DDT), which had come into wide use to fight malaria during World War II. Though DDT was greeted as a marvelous breakthrough at the time and its inventor Paul

Muller received the Nobel Prize in Medicine in 1948, American government scientists soon sounded the alarm about the unintended consequences of the pesticide. Carson's critique of pesticide use in *Silent Spring* (1962) caused a public sensation and made her a figurehead of a new kind of conservationism.[32]

Silent Spring opened with the image of an ordinary American town, seemingly "in harmony with its surroundings." Yet underneath the surface of bucolic peace, there were signs of disturbance. Local vegetation and wildlife began to succumb to "mysterious maladies."[33] Chicken, sheep and cattle sickened. Unexplained deaths occurred among farming families. Even the birds fell silent and vanished. Modern chemistry had inadvertently unleashed a nightmare threat into the midst of everyday life. At the time, DDT was virtually omnipresent in American households and agriculture. Just as the second wave of feminism declared the private political, Carson showed that environmental risk also began at home. Her main lesson was that the toxins used to kill kitchen bugs or farm pests could not be contained within a safe zone. The strategy of DDT spraying mistakenly assumed such poisons would target only specific species. But in reality, all species shared the same fundamental biology and therefore a vulnerability to synthetic compounds like DDT. The unintended consequences of pest spraying showed how human ambitions to master the environment actually endangered the web of life, exposing the hubris of chemistry and the willful ignorance of economics, which treated nature as a cost of production, or an externality at best.[34]

DDT was not simply a local risk. Carson helped popularize the word "environment" to capture how humans could disrupt and overwhelm natural systems. In June 1963, just months before Carson succumbed to metastasizing breast cancer, she testified before Congress about the need for urgent action to contain the threat of pollution. "Contamination of various kinds" she warned, "has now invaded all of the physical environment that supports us—water, soil, air, and vegetation." Toxic pollution affected not just wildlife but also the "internal environment" of the human organism, perhaps across multiple generations. Human pollution of different kinds—radiation, household waste, and pesticides—posed an insidious threat to the integrity of all life.[35] Moralists and physicians had warned about the dangers of consumption to the health of individuals and society in past centuries. Carson's book revealed how chemical compounds tied

to middle-class consumption could poison ecosystems across the earth. DDT accumulated through the food chain, striking top predators like birds of prey. Its menace was compounded by the uncertainty and delay involved in its long-term effects.

The scare about DDT was part of a broader set of worries about other ecological risks and toxins, from growth hormones to nuclear dumping.[36] Carson herself drew attention to the dangers of radioactive waste to marine ecosystems in the revised preface to her book *The Sea Around Us* in 1961. The ocean, like the atmosphere, was not an infinite dumping ground for pollution but a finite sink vulnerable to universal contamination. Waste deposited in one location could easily travel on the currents to pollute the whole marine system. Here and in *Silent Spring,* Carson helped pioneer the new environmental discourse we call Planetary Scarcity. Instead of worrying about the physical limits of finite stock, as Malthus had done more than a century before, Carson shifted attention to the problem of finite sinks for pollution, and to the interconnectedness of all life. The chemical menace of DDT and the nuclear contamination of the ocean thus anticipated the environmental horror stories of coming decades—first the threat of Chlorofluorocarbons to the ozone layer and then the danger of greenhouse gases to the climate of the Holocene.[37]

Concerns about the fragility of the environment were not an invention of the 1960s. It is possible to trace a long history of ideas about natural deterioration and catastrophe stretching into the early modern era. Even older is the tradition of conservation and resource stewardship. What did change in the postwar era was the pace and scale of economic and technological change, along with the emergence of new fields of science, including systems ecology and earth system science. These developments in turn spurred novel ways of grasping environmental vulnerability at the global level and over geological time scales and thus enabling an understanding of scarcity in a planetary frame. Carson's book marked the spread of such ideas into wider popular consciousness in the United States and beyond. However, her message did not always meet with a hospitable reception. Advocates for the chemical industry unsurprisingly defended their turf, often resorting to personal attacks to denigrate Carson's stature. Likewise, the great mass of professional economists also resisted Carson's pessimistic interpretation of technology, for all the reasons explored in the previous chapter. Only a tiny minority of prominent

economists took the warnings about environmental degradation as a genuine challenge to Neoclassical Scarcity. While they found themselves marginalized in their own discipline, their approach opened the door to a radical reorientation of economic analysis toward the biophysical context of production and exchange, which coalesced into the field of ecological economics in the 1980s.[38]

One of the first postwar economists to embrace ecological thinking was the British-American academic Kenneth Boulding (1910–1993). After receiving first-rate training in economics at Oxford and Chicago, Boulding seemed destined to climb to the top of the profession. In 1949, he won the John Clark Bates medal, one of the most coveted honors for young economists. Paul Samuelson had been the previous Bates winner and Milton Friedman would be the next. Yet Boulding soon strayed from the fold by insisting on a holistic approach that took in both the social and the natural sciences. By the middle of the 1960s, he had begun to incorporate ecological frames into his economic theory. Boulding also dared to question the primacy of mathematical modeling at the moment that it gained ascendancy. For Boulding, this meant jettisoning the basic assumptions of modern economics in favor of an evolutionary and nonequilibrium model. Economics should not imitate the celestial mechanics of the static solar system. Instead, economists should look to the "profound indeterminacy" of evolutionary biology to understand the critical place of the environment in economic change.[39] Boulding cast Adam Smith as the founder of evolutionary economics (perhaps not such an outrageous idea when we remember the centrality of agriculture in Smith's model of growth).

Thermodynamics inspired Boulding's classic challenge to Neoclassical Scarcity, "The Economics of the Coming Spaceship Earth" (1966). Here, Boulding contrasted two ways of thinking about scarcity: the open "cowboy economy" of the past and the closed "spaceship economy" of the future.[40] The roots of the "cowboy economy" went deep. Perhaps inspired by Christian theology, Boulding attributed it to a universal and permanent tendency in human nature. Yet he also left little doubt that modern science and technology hade greatly strengthened the impulse: "The extraordinary achievement of the last 200 years have given us certain delusions of grandeur and a certain feeling that man can accomplish anything if he only puts his mind to it." Communists took this belief to the greatest extreme with their faith in human "infallibility, omnipotence, and immortality."[41]

But they were far from alone. In the West, economists, politicians, and ordinary consumers happily rejected all notions of limits. "Economists, and indeed mankind generally, have tended to treat the economic system as if it could enter into continuous exchange with an infinite reservoir of nature." Yet this cornucopian belief was now growing untenable. Ecology had brought these "flights of omnipotent fancy . . . down to earth."[42]

Boulding imagined the closed system of the spaceship model in terms of a cyclical economy where all materials were recovered (though energy remained subject to entropy). The aim was to minimize throughput while maintaining stock. There were "no mines and no sewers" in a spaceship.[43] In an astonishing reversal of basic economic dogma, Boulding proposed that the processes of "production and consumption" on the whole must be counted as "bad things" rather than essential measures of success in the economy.[44] In the spaceship economy, "consumption is no longer a virtue but a vice, and a mounting GNP is to be regarded with horror."[45] For Arendt, the event of space travel seemed to promise transcendence from earthly conditions, but for Boulding, the actual practice of space travel was necessarily an ecological problem. A voyage between the stars involved the task of preserving life within a closed space over many generations—maintaining a circular economy by drawing on a "very small stock" that "circulated constantly through the system."[46]

The turn toward spaceship economics also brought the rights and claims of future generations into focus. Boulding saw pollution as a pressing problem rather than an issue that could safely be adjourned for future engineers to resolve or internalize into the economist's cost function. He presciently noted that pollution in the atmosphere might become a "major problem in another generation." Indeed, "even today it is clear that oceans and the atmosphere are by no means inexhaustible reservoirs."[47] In parallel with Hannah Arendt and Rachel Carson, Boulding was articulating a new idea of Planetary Scarcity. With eerie accuracy, Boulding suggested that it would be "fatally easy" for people to "change the composition" of the ocean or the atmosphere "in such a way that the earth will pass some watershed point—for instance, through something like the greenhouse effect of the accumulating carbon dioxide in the atmosphere—which will destroy the existing equilibrium which may be much less desirable for man."[48] These tipping points were fundamentally connected with demographic pressure as well as growing consumption. A skyrocketing

world population increased the "chance of man's activities seriously interfering with the whole balance of the planet."[49] Before the Industrial Revolution, when only a few hundred million humans inhabited the earth, there had been space for most other species to thrive, but the rapid acceleration of mankind in the twentieth century made this balance increasingly precarious. The world population had increased from two billion in 1930 to three billion in 1960, and would reach four billion in 1975. Boulding predicted that the "insatiable pressure for food supplies" would cause a mass extinction of animals and plants in the next century.[50]

From the perspective of the "spaceship economy," the concept of scarcity took on a radically new meaning. Rejecting the fungible world of neoclassical economics, with its infinite substitutability, Boulding saw the economy as a subset of a planetary system defined by biophysical feedback and evolutionary change. He replaced the present-centric time scale of Neoclassical Scarcity with a cosmic outlook defined by the forces of evolutionary and geological change. The "technical achievements of the last 200 years," Boulding noted, had largely been made possible through the depletion of "geological capital."[51] This gigantic consumption of iron ore and fossil fuels was a one-time event, never to be repeated (on a human time scale). The question was how best to take advantage of such a gift while moving toward a circular economy after the end of fossil fuel. Paradoxically, the future was at the same time ascetic and cornucopian, Boulding seemed to think. Welfare would come to depend not on the speed and scale of throughput but on "the richness and variety of . . . capital stock, including of course . . . human capital."[52] When conservation and durability became primary duties and virtues, a new kind of affluent society would emerge:

> A space ship society does not preclude . . . a certain affluence, in the sense that man will be able to maintain a physical state and environment which will involve good health, creative activity, beautiful surroundings, love and joy, art, the pursuit of the life of the spirit, and so on. This affluence, however, will have to be combined with a curious parsimony. Far from scarcity disappearing, it will be the most dominant aspect of the society. Every grain of sand will have to be treasured, and the waste and profligacy of our own day will seem so horrible

> that our descendants will hardly be able to bear to think about us, for we will appear as monsters in their eyes.[53]

Because Boulding had so little to say about the psychological drives and rewards of consumption, it is difficult to tell precisely what he meant by affluence and parsimony in relation to human welfare. What we do know is that he resisted crude generalizations about self-interest and material gratification. In neoclassical economics, the ideal subject engaged in self-indulgent processes of utility maximization, in which there were no moral constraints on their hedonism. By contrast, Boulding insisted on the human capacity for selfless sacrifice and savaged utilitarian ideas of preference. Note his gleeful use of Wordsworth's quip: "High Heaven rejects the Lore of Nicely calculated Less or More."[54] As a practicing Quaker, Boulding believed that economic behavior was embedded in a larger "integrative system" extending to values such as "status, respect, love, honor, community, identity, legitimacy, and so on."[55] Without this cultural envelope, economic relations could never have evolved in the first place. Even the most basic form of exchange demanded "trust and credibility."[56] Such norms defined the boundaries of markets as well by demarcating what could be bought and sold. In the "cowboy economy," commodification would proceed endlessly outward. In the "spaceship economy," there was a limit beyond which markets could not extend.

Resource Panics and Counterculture

The photograph "Earthrise" became an icon of earthly fragility at a moment when Malthusian Scarcity once again was gaining force. In early 1968, two American biologists—Paul and Anne Ehrlich—published a chart-topping prediction of famine entitled *The Population Bomb*. The book was written in part to influence the presidential election that year by warning the public about the danger of demographic overshoot. Echoing the mathematical confidence of Malthus, the Ehrlichs painted a terrifying picture of near future calamity, insisting that the "battle to feed all of humanity is over." In the next decade, they argued, the world would undergo massive famines, which would kill hundreds of millions of people. For the Ehrlichs, any real solution to the problem required population control: "The first move must be to convince everybody to think of the earth as a

space ship that can carry only so much cargo." When their prophecy proved false, the fiasco gave a boost to counterarguments about the dangers of Malthusian pessimism. Critics pointed to the success of the Green Revolution in increasing agricultural productivity across the Global South. Even so, Ehrlich's Neo-Malthusian position remained a potent influence on the environmental movement.[57]

The year of Apollo 8 also saw the founding of the Club of Rome, an international network devoted to investigating pressing contemporary problems. At the suggestion of the American computer engineer Jay Wright Forrester, the group decided to focus on growth as the underlying cause of global crisis. In 1972, the Club of Rome issued its first report based on groundbreaking computer simulations of future trends in population growth, resource consumption, and pollution. Like Paul and Anne Ehrlich, they predicted overshoot in the near future. The Club of Rome's report, *The Limits to Growth* (1972), popularized a systems approach to environmental problems, stressing multiple variables and conflicting rates of exponential change.[58] It made use of scenarios to model different futures, including a world of overshoot as well as a future of ecological equilibrium. When US oil prices rose 400 percent in response to the OPEC embargo of October 1973, the crisis seemed to deliver grim confirmation of the precarious nature of modern growth. Though the cause of the supply shock was political rather than a matter of material exhaustion, policy responses to the oil crisis aligned with broader narratives about environmental risk and the need for a transition to renewables.[59]

One of the most radical reactions to the age of "Earthrise" came from feminist thinkers. They argued that the instrumental approach to the environment underpinning Neoclassical Scarcity and postwar capitalism was a disastrous mistake. In her landmark book *The Death of Nature: Women, Ecology and the Scientific Revolution* (1980), environmental historian Carolyn Merchant (1936–) traced the source of this error back to the mechanization of science in the seventeenth century. Trained as an early modern historian of science at the University of Wisconsin Madison in the 1960s, Merchant found crucial inspiration in second-wave feminism, counterculture social protests, and the environmentalist writings of Rachel Carson and Paul Ehrlich. At the center, *The Death of Nature* was a startling reinterpretation of the origins of Cornucopianism. By rejecting the idea of nature as a nurturing mother and replacing it with a machine,

philosophers like Francis Bacon and René Descartes had invented a new ideology of mastery that rested on a false separation between mind and body, male and female, human society and nonhuman environment.[60]

Along with other ecofeminists like Susan Griffin and Val Plumwood, Merchant demonstrated that this kind of dualistic thinking extended into the gendered spheres of work and household. Only male labor was valued in the capitalist economy, while the creative sphere of reproduction in the household was ignored and relegated to insignificance. The formal analysis of market exchange and marginal utility ignored the profound reliance of capitalist production on unpaid work in the household. It also turned a blind eye to the dependence of human enterprise on the ecological productivity of the natural world. In her later writings, Merchant articulated a new ethic of care and partnership with nature. Nature was not a machine to be mastered but an active partner in the web of life. Humans and nonhuman communities must be treated with equal moral consideration in "their mutual living interdependence." The new partnership ethic simultaneously fulfilled "humanity's vital needs and nature's needs by restraining human hubris."[61]

The same moment that gave rise to ecofeminism also saw major new work on the psychological dimension of scarcity. For a long time, mainstream economists had bracketed the problem of mental states in favor of the black box of formal preferences. What mattered was not how consumers actually felt but that their preferences were revealed in consumer behavior.[62] In the early 1970s, this formal understanding of scarcity came under fire on multiple fronts. Major critiques included Marshall Sahlins's *Stone Age Economics* (1972), Richard Easterlin's comparative study "Does Economic Growth Improve the Human Lot?" (1974), and E. F. Schumacher's *Small is Beautiful* (1973). Although vastly different in their scope and disciplinary aim, these critics all addressed an essential question left unanswered by the economists: What defines the true nature of satisfaction?

Stone Age Economics doubled as an investigation of hunter-gatherer society and an ecological critique of neoclassical economics. In the first chapter of the book, Sahlins (1930–2021) took aim directly at Lionel Robbins's idea of scarcity and his assumption of an insurmountable tension between "unlimited wants" and "insufficient means." Economic anthropology revealed an alternative "Zen road to affluence where human material wants were finite and few." In such societies, quite

simple technology paired with ecological knowledge sufficed to provide adequate sustenance for all. The possibility of "affluent society" was as old as humanity.[63]

At first glance, Sahlins's critique seemed to rehearse ideas launched two hundred years earlier in the pages of *The Discourse on Inequality*. Rousseau had argued that natural man had no knowledge of the future and therefore no reason to yearn for things; the condition of the household in the primitive state was insular and self-sufficient. While Sahlins's optimistic view of Paleolithic foragers bore a certain resemblance to Rousseau's conception of scarcity, it relied on a new language of quantitative social science that measured nutritional demands and hours of work. For Rousseau, "savage" man was a figure lost in time whose existence could only be imagined through philosophical conjecture. By contrast, Sahlins argued that Paleolithic people could be studied in the flesh in the present. He built his case in part on the quantitative ethnographic fieldwork of Richard Lee amongst the !Kung people of the Kalahari desert in southern Africa. What this research showed was that nomadic foragers lived in a state of relative material plenty. Other investigations of Aboriginal people foraging in Arnhem Land in Australia's Northern Territory demonstrated that adults worked on average no more than five hours per day to collect and prepare food. Their labor provided more than adequate sustenance for the group. In cultural terms, hunter-gatherers put a premium on leisure over additional consumption, making time for relaxing, visiting, entertaining, and other pursuits. Sahlins's analysis rested on an ecological basis. Only by knowing the land intimately could foragers sustain their way of life.

Paleolithic "affluence" admittedly came at a certain cost. Effective foraging required constant movement. Possessions had to be kept a minimum. More disturbingly, people unable to move were left behind. Infanticide and senicide kept population size low. Diminishing returns in foraging made "Malthusian practices" necessary.[64] Yet whatever the price of mobility, Sahlins insisted that it held privation at bay. Lest readers dismiss the Paleolithic system as a special case, Sahlins enlisted hunter-gatherers on the side of substantivist theory against market-oriented explanations. The activities of the !Kung should not be judged by the standards of utility-maximizing consumers and profit-maximizing firms. Like his teacher Karl Polanyi, Sahlins believed that economic activity outside market societies was best understood as a provisioning system embedded in

social institutions and normative discourses. Anthropology, archeology, history, and ecology revealed a great tapestry of alternative social systems outside the narrow path of Western capitalism. If anything, the mystery to be explained was not the rationality of Paleolithic foraging but the widespread acceptance of Neoclassical Scarcity. Sahlins ended the chapter on the original affluent society with a satirical swipe at modern economics: "it was not until culture neared the height of its material achievements that it erected a shrine to the Unattainable: Infinite Needs."[65]

Another penetrating criticism of Neoclassical Scarcity came from within the profession. American economist and demographer Richard Easterlin (1926–) brought together survey data from nineteen countries, split between industrialized nations and countries in the developing world, along with a detailed national time series of attitudes about happiness in the United States between 1946 and 1970. Easterlin's findings seemed to contradict a basic assumption of economic progress that a constant rise in GDP should yield a commensurate rise in life satisfaction. Despite significant material improvements in living standards, consumers in the United States reported little subjective change. Subsequent scholarship described a threshold effect for happiness: evidence of subjective happiness increased up to a certain point but then stagnated and remained stubbornly flat despite respectable GDP growth. While Easterlin did not frame his research in an ecological context, these findings found a receptive audience among environmental critics looking to rethink the aims of growth in the face of planetary crisis. Why should economies go on producing more goods and thus destroy the environment when additional consumption could not make affluent people any happier?[66]

In the same moment, German-British economist Ernst Schumacher (1911–1977) became an unlikely prophet of Green counterculture with his wildly popular book *Small is Beautiful: Economics as if People Mattered,* first published in English in 1973 and translated into fifteen languages afterwards. Schumacher was a refugee from Nazi Germany who had served as an economic planner of German reconstruction before becoming a statistician for the British National Coal Board. Side by side with these professional commitments, Schumacher grew interested in questions facing underdeveloped nations, guided in no small part by his spiritual devotion to Buddhism. Visits to Burma and India made a deep impression on

Schumacher. In *Small is Beautiful,* he gathered these experiences into an alternative theory of development that he called Buddhist economics.[67]

Where Western economists put the material standard of living at the center of economic life—ever more goods at lower prices—Buddhist economics instead focused on the twin goals of meaningful work and liberation from desire. Since consumption provided "merely the means to human well-being," the aim "should be to obtain the maximum of well-being with the minimum of consumption."[68] An economy devoted to the endless growth of wants went against the most basic dictum of wisdom: "simplicity and nonviolence."[69] The impetus for Buddhist economics came in part from Schumacher's interest in the problem of securing local livelihood at the level of the Indian village economy. What kinds of investment, technologies, and energy sources were most appropriate to support such communities? The other influence on Buddhist economics came from ecological, romantic, and anarchist thought. Like Mill and Ruskin before him, Schumacher endorsed growth "towards a limited objective" but rejected "unlimited, generalized growth" for its own sake.[70] The appeal to Buddhism tapped into a wider fashion for eastern spirituality in Western counterculture though Schumacher himself had actually converted to the Roman Catholic faith in 1971. His own stance was explicitly ecumenical and pragmatic: all the great spiritual traditions of the East and West, he intimated, served the same purpose as safeguards against the nihilism and folly of materialist economics.

Global Environmentalism

By the early 1970s environmental concerns garnered increasing support around the world. Millions gathered in the United States for the first Earth Day event in April 1970. New organizations such a Greenpeace and Friends of the Earth attracted attention with innovative protest tactics. Environmentalist priorities also began to shape national and international politics. Green Parties emerged across the West, first at the local level and then on the national scene. In the United States, the Nixon administration established the Environmental Protection Agency in 1970. One of its first achievements was to ban DDT in 1972, ten years after *Silent Spring.* Environmentalist politics was not just a concern of the Western middle class. In the Himalayas, local villagers united into the Chipko movement to de-

fend use rights and forest preserves. Over the following decades, environmentalist values went from fringe concerns to mainstream priorities in public opinion and governance across the globe. Yet this pattern at the same time produced an apparent contradiction. The success of counterculture values and the spread of environmental consciousness did very little to dent the basic trends of the Great Acceleration. Indeed, the condition of the earth system began to show serious strain *after* the globalization of environmentalism.

The simple explanation for this apparent contradiction is that environmentalist values and policies often served as excuses to justify continued consumerism. After all, the most common slogan of sustainable development explicitly set out to reconcile economic growth with environmental stewardship. The concept became fashionable thanks to the 1987 UN report *Our Common Future* chaired by Norwegian prime minister and leader of the Labor party Gro Harlem Brundtland (1939–). At the heart of the text was a multigenerational vision of equitable growth: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."[71] Essential human needs included "food, clothing, shelter, jobs" as well as an aspiration "for an improved quality of life."[72] Beyond the most elementary definition, the authors made little effort to establish particular quantitative or qualitative parameters of needs and well-being. Brundtland's report instead focused on the long-term challenges to global and intergenerational equity, including deforestation, desertification, fossil fuel exhaustion, climate change, population pressure, and decline in biodiversity. Yet despite this catalogue of risks, the UN commission suggested that economic growth and environmental stewardship remained compatible goals. Brundtland and her colleagues proposed that rising standards of living could be achieved without serious ecological strain.

That sanguine outlook was very much in evidence in a talk on energy policy Brundtland gave at Harvard University in the fall the same year. The North Sea oil supply, she told her audience, represented a precious intergenerational heritage to be husbanded wisely for the long term. Sustainable stewardship entailed a "moderate depletion policy" informed by "mature behavior" with a thirty-year horizon.[73] Brundtland ended her talk by commenting on the work of the 1987 Commission:

> The Commission is sounding an alarm, but it does not paint a gloomy picture of the future. Quite to the contrary: we believe that human resources and ingenuity, our capacity to address the issues in a responsible concerted manner, have never been greater and that we can indeed solve both energy and environmental problems in a new era of economic growth—an era in which economy and ecology are merged at all levels of decision-making and where there is a more equitable distribution of wealth within and among nations.[74]

Brundtland's celebration of ingenuity and fossil fuel had much in common with the anti-Malthusian critique of environmentalism fashionable among economists in the United States during the Reagan years. It was a direct rebuke to the melancholy predictions of Paul and Anne Ehrlich and the Club of Rome. Instead of an era of mass famine or mineral exhaustion, Brundtland cast the coming environmental crisis as an opportunity for universal growth.

Conclusion

A year later, on a blisteringly hot day in late June of 1988, James Hansen, the physicist and director of the NASA Goddard Institute for Space Studies, appeared before the United States Senate Committee on Energy and Natural Resources. He testified that the earth was currently warmer than it had been at any time across a century of measurement. The past twenty-five years had seen the highest temperatures on record, and the four warmest years had all occurred in the 1980s. In all likelihood, Hansen explained, such a disturbing trend would continue into the future. This 1988 Congressional testimony marked a milestone in the history of climate awareness. While the science of the greenhouse effect reached back to the nineteenth century, and continuous collection of carbon dioxide data had started with Charles Keeling's measurements at Mauna Loa in 1958, it was only in the 1980s that natural scientists began to put together a definitive picture of the climate system and its sensitivity to greenhouse gases. At a conference in Villach in 1985, a general consensus crystallized that carbon dioxide levels might double by the middle of the twenty-first century. The climate system of the Holocene no longer appeared to be stable. What

Hansen did was to raise public awareness of these scientific apprehensions and to turn the topic of global warming into a political issue during the 1988 American presidential election. The same year also saw the establishment of the Intergovernmental Panel on Climate Change (IPCC), which soon became the most important institutional force in building a scientific consensus about the causes and effects of global warming.[75]

In the 1990s and early 2000s, scientists and activists began to experiment with new modes of representation to make climate change and other kinds of planetary degradation visible and compelling to the public. Mathis Wackernagel and William Rees pioneered the concept of the ecological footprint in 1996. This accounting tool highlighted how much land or biocapacity was needed to sustain a specific level of consumption. In 2000, Paul Crutzen and Eugene Stoermer coined the term *Anthropocene* to bring home the dramatic scale of change in the earth system. Around 2005–2006, a variety of experts and institutions began to promote the carbon footprint formula to measure the carbon dioxide emissions caused by particular economic activities. Parallel to this work, the British Department for Environment, Food, and Rural Affairs developed the concept of the social cost of carbon. This formula estimated the net present value of the damage of one additional ton of carbon to the world over the next century. At the same time, a research network led by environmental scientist Johan Rockström and Will Steffen incorporated the Anthropocene idea into a quantitative model of biophysical limits to development. Called the Planetary Boundaries framework, the model described nine major tipping points that would take earth out of its Holocene state (see Figure I.1). Climate change was only one of many possible disruptions to the safe functioning of the earth system.[76]

These new approaches sought to visualize and quantify the planetary impact of the Great Acceleration by tracking its ecological consequences across different scales. Each model encouraged a novel scalar imagination, which situated the individual and the economy inside the biogeochemical processes that maintained the earth system. Each model also involved prescriptions for slowing or limiting dangerous forms of growth—by reorienting energy use, for example, or reinforcing protections to preserve biodiversity. Yet the deeper our knowledge of the earth system, the more grave the challenge appeared. Because carbon emissions permeated the entire economy, the need for constraints and limits necessarily extended to every kind of economic activity.

The political discovery of anthropogenic climate change pushed the discourse of natural limits and environmental degradation in a new direction. From the age of Malthus onward, pessimists had worried about the physical limits to growth imposed by the finite supply of land and nonrenewable mineral stock—the condition we have called Malthusian Scarcity. But with global warming, the threat shifted decisively from a problem of finite stock to a dearth of sinks. Simply put, there was too much coal, petroleum, and natural gas in relation to the earth system's capacity to absorb the waste products of fossil fuel. The ancient symbol of infinite space—the boundless ocean and endless atmosphere—turned out to be all too finite. Rachel Carson and Kenneth Boulding had anticipated the idea of Planetary Scarcity with their warnings about oceanic and atmospheric pollution in the 1960s; Jim Hansen and the IPCC showed that planetary sinks were already in the process of filling up. The discovery of anthropogenic climate change also sharpened the rift between human history and evolutionary time that Rachel Carson had explored in *Silent Spring*. For Carson, pesticides imperiled a biological system calibrated to adapt on an evolutionary time scale. With climate change, fossil-burning humans acted as a geological force in the earth system. Carbon emissions from fossil-fuel growth threatened to disrupt the planetary carbon cycle and the relative stability of the Holocene climate.

Climate change involved social and spatial disjunctures as well as temporal lags. Developing countries were more vulnerable to climate change than affluent nations. Class, gender, and race played a role in shaping the geographies of risk. In addition to such spatial inequalities, the delayed effects of climate change created a temporal divide, as future generations would suffer the consequences of consumption patterns in the present. Carbon emissions eluded easy management since they were the product of myriad interrelated processes in the fossil fuel economy, including not just industrial production and transport but also agriculture, construction, and energy-intensive services. The planetary scale of the phenomenon transcended conventional forms of environmental activism. Even as certainty grew about environmental change and social impacts, powerful political headwinds thwarted effective action, reducing the chance of successful mitigation.

Despite the warnings of the climate scientists, mitigation policy fell far behind the carbon curve. Economists and politicians across the fossil-

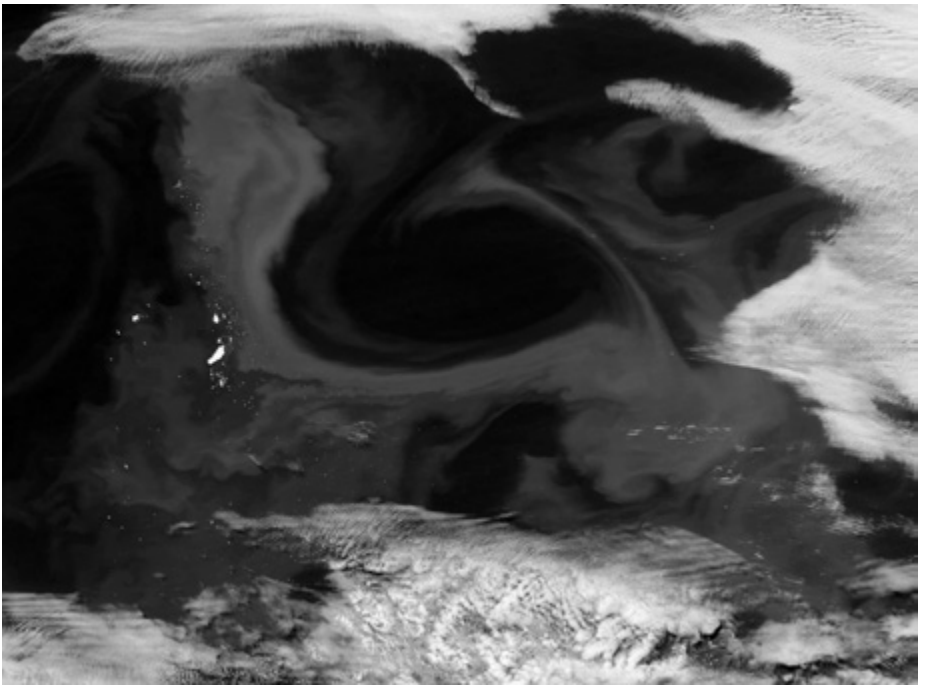
fuel economies tended to downplay the risks of climate change and the urgency to act. Some even went so far as to deny the reality of global warming. Meanwhile, carbon levels continued to climb upward. An increasing portion of these emissions came from the developing countries, including the new manufacturing powerhouses of China and India. In his 2016 essay *The Great Derangement,* the Indian novelist and social critic Amitav Ghosh (1956–) observes that the rise of the industrial economies in the Global South exposes the cruel truth about fossil-fuel development. By driving up worldwide demand for energy and resources while at the same time increasing the amount of waste and pollution in the system, globalization pushes the planet ever closer to calamitous degradation.[77]

Ghosh's paradox (the promise of global economic growth will produce planetary catastrophe) captures something essential about the relation between Neoclassical and Planetary Scarcity in the Great Acceleration. The more that developing nations seek to emulate the fossil path of the affluent countries, the greater the disruption of the carbon cycle. As emissions have mounted, it has become evident that the promise of the Great Acceleration cannot be universalized without deepening danger to the biosphere. Where Neoclassical Scarcity sees history as the confluence of insatiable, ever-expanding desires and technological progress, Planetary Scarcity reveals the limits of human ingenuity, the power of unintended consequences, and the fragility of all earthly things.

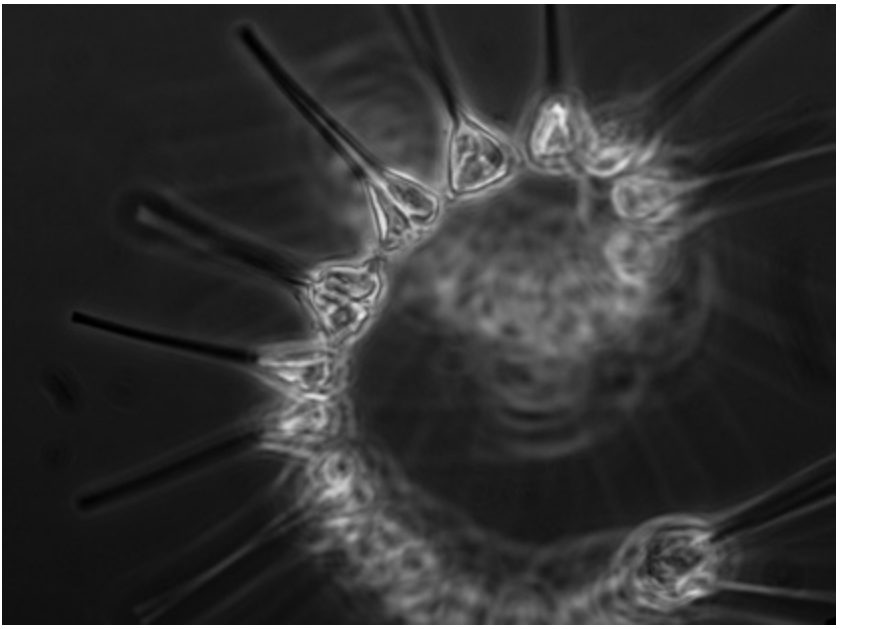
CONCLUSION

Toward an Age of Repair?

In the upper layers of earth's oceans, single-cell organisms collectively known as phytoplankton thrive in great numbers, drifting along the currents. Although microscopic in size, they add up to a biological force that shapes the conditions of life on the planet to an extraordinary degree. Decomposing phytoplankton yield a crucial ingredient in the formation of shale and petroleum over geological time and therefore a major portion of fossil fuel consumption in the present. As converters of solar energy into organic materials, phytoplankton also have a central place in the food chains of the sea. By transforming carbon dioxide and water into oxygen and carbohydrates through photosynthesis, phytoplankton offer a sink for human pollution while at the same time making the atmosphere breathable to other life forms. They absorb about forty-five to fifty gigatons of inorganic carbon each year and produce half of the oxygen in the atmosphere. Nearly 40 percent of carbon dioxide emissions from humans have been taken up by the ocean. Even though they comprise less than 1 percent of the biomass on the planet, phytoplankton are as important to the earth system and the carbon cycle as the rain forests and other terrestrial sinks.[1]



Phytoplankton bloom in the Southern Ocean. *Credit:* Lawrence Berkeley National Science Laboratory.



Phytoplankton (microscopic). Microscopic in size, phytoplankton play an extraordinary role in the maintenance of the earth system. *Credit:* NOAA MESA project, 1973.

The science of phytoplankton is a belated achievement. Only recently have scientists begun to grasp the significance of these organisms in the earth system. Such knowledge has already sparked hopes of harnessing the species for economic purposes. Some scientists want to make renewable fuel out of phytoplankton genes, by mimicking and accelerating natural processes. Others want to fertilize phytoplankton by dumping iron into the seas to increase the ocean's capacity to act as a sink. However, these ambitions to engineer phytoplankton and incorporate them into the capitalist economy fail to reckon fully with the fragility and complexity of ocean life. Iron fertilization might trigger ecological perturbations of a harmful kind. At the same time, climate change threatens marine biodiversity. Warmer surface waters contain fewer nutrients for phytoplankton, slowing down its growth. Warming waters also fail to mix with colder layers of the ocean, turning off the pump that sequesters carbon in the depths. What will happen to the carbon cycle and the oxygen supply if phytoplankton drastically shrink in numbers? It is probably better if we never have to face this possibility in reality.[2]

For millennia, humans have ignored the depths of the oceans, imagining that the sea was infinite and impervious to human influence. Now we are beginning to appreciate just how vulnerable marine ecosystems are and how much they do to keep the world habitable. The capitalist economy has brought about rapid and massive changes that threaten to overwhelm the earth system. The science of phytoplankton resembles in this regard the discovery of anthropogenic climate change. Both reveal critical material boundaries for human flourishing. Both suggest how little we know about the natural world and how dangerous the current economic ideology has been for the stable functioning of the earth system. Rather than press ahead with further exploitation, a better strategy would be to repair the damage done and then back off to preserve marine ecosystems from further disturbances.

This need to repair becomes even more urgent once we recognize that the threat to the earth system extends to many more domains beyond marine life and carbon emissions. In the Planetary Boundaries model, environmental scientists warn about irreversible and nonlinear changes to the earth system in nine areas: land system change, biodiversity loss, climate change, oceanic acidification, the supply of freshwater, aerosol loading, ozone depletion, nitrogen / phosphorus, and "novel entities." Planetary

Boundaries represent approximate quantitative values for thresholds of environmental risks beyond which we can expect irrevocable change on a continental or global level.

Most prominently, climate scientists have warned that atmospheric CO_2 concentrations above 350 parts per million (ppm) take us out of "the safe operating space" provided by a "Holocene-like state."[3] Beyond the 350 boundary, drastic changes await: glaciers and ice caps will melt, sea levels rise, forest and brush fires become more extensive and destructive, and hurricanes gather force from warmer oceans. If the average temperature rises above two degrees Celsius, coastal cities around the world, including New York City, Miami, Venice, Stockholm, Tokyo, Mumbai, and Hong Kong, might face a sea level rise of between 1 and 2 meters by 2100. Traditional food growing areas would risk losing their capacity to sustain large harvests, triggering subsistence crises in the hottest part of the world, including South Asia and Sub-Saharan Africa. Scientists expect mass mortality events as combined heat and humidity reach wet bulb temperature of 35°C, which is beyond the physiological limit of human endurance. Heat, water, fire, and dearth might put in motion a mass-migration of destitute people, the size of which will make the migration sparked by the civil war in Syria look trivial. The UN predicts that there will be 200 million climate refugees by 2050. This will test the capacity of the political and social systems of the Global North in ways that seem likely to intensify xenophobia and racism, judging by past experience.[4]

To confront these emerging threats, the idea of Planetary Scarcity invites us to reorient and reimagine the purpose of the economy by embracing caution and constraint. Our confidence in mastering the environment has relied all along on a radically incomplete understanding of the natural world. Earth system science undermines this self-assurance by demonstrating how the ideology of maximum efficiency, infinite substitutability, and infinite growth threaten the very processes that keep the planet habitable. This discovery alters our sense of the past as well as the future. The Industrial Revolution produced environmental risks that have only become fully known after more than two centuries of growth. The marginalist economists simply assumed that industrialization could be carried out without dangerous consequences to the natural world, yet unbeknownst to them, carbon emissions from the new global economy had already departed from the pattern of Holocene variability by the last quarter

of the nineteenth century. This divergence of neoclassical economics from physical reality only increased in the twentieth century. Lionel Robbins and Paul Samuelson produced their canonical definition of the idea of Neoclassical Scarcity right at the outset of the Great Acceleration. As such, we might think of the persistence of Neoclassical Scarcity as a relic of the Holocene epoch. In the midst of the ongoing rupture of the earth system, neoclassical economics clings to an ideology of human mastery increasingly out of tune with the predicament of the planet. The Industrial Revolution was not a conclusive triumph over nature, but a temporary reprieve bought with fossil fuel energy and a Pandora's box of unintended consequences.

One lesson of the science of greenhouse emissions is that we might not know the extent of future dangers that could be unleashed by present technologies until it is almost too late. What if our technical fixes produce problems even greater than the ones they seek to solve?[5] At this moment in time, one option is to continue embracing Cornucopian optimism, which has been a dominant force in Western economic thought for the last three hundred years. Yet a countermovement is also gaining force, fueled by alarming signs of earth system change. People across the globe are realizing that radical change is needed. Will the new generation refuse the theories handed down to them and instead commit to the formulation of Finitarian ideas, policies, and praxis?

The Holocene Hangover

The need for a novel way to think about the relationship between nature and the economy has yet to make much of an impact on mainstream economists who "are inclined to believe" that market forces "will go a long way toward solving any environmental problems."[6] In the case of resources, such as oil or rain forests, becoming scarce, economists predict that the resulting price increase will lower demand for the goods produced with these natural resources as inputs and will spark greater investments in research and development that will ultimately yield substitutes. They believe that by reducing demand and incentivizing the development of alternatives, the market dynamic, when combined with scientific and technological development, has the capacity to resolve the problem of resource exhaustion. While often optimistic about this dynamic, economists admit

that it will take some time, but that there is plenty of historical evidence suggesting that the market will be able to work its magic over and over again. In their bestseller *Abundance: The Future is Better than You Think,* Peter Diamandis and Steven Kotler argue that humanity lacks sufficient patience and optimism.[7] Indeed, they suggest that people suffer from what the Nobel laureate economist Daniel Kahneman calls an "anchoring problem." Because humans extrapolate and linearly project on the basis of their immediate experiences, they tend to be anchored in the present, failing to imagine future solutions. This "negativity bias," Diamandis and Kotler insist, makes people overly nervous about ominous prognostications such as those made by Paul Ehrlich in *The Population Bomb* and the Club of Rome in *The Limits to Growth.* While Diamandis and Kotler do acknowledge remaining challenges, they refuse to believe these cannot be handled by the miracle of the market and the wonders of science.[8] According to them, accelerating scientific breakthroughs in "computational systems, networks and sensors, artificial intelligence, robotics, biotechnology, bioinformatics, 3-D printing, nanotechnology, human-machine interfaces, and biomedical engineering" have the capacity to create a world in which "the vast majority of humanity" will be in a position to "experience what only the affluent have access to today," and to do so without destroying the environment.[9] Scarcity is thus the mother of invention; what was once scarce will become abundant in the future. This fervent belief in markets and science recalls the exuberant visions of progress dreamt up by the seventeenth-century alchemists.

The problem with the consumption of fossil fuels, according to modern economists, is that prices are not accurately capturing the cost that oil, coal, and natural gas impose on the environment and ultimately on humanity. Producers are not paying for the cost of externalities, which means that consumers are not charged enough and therefore consume in too great a quantity. The solution, many economists maintain, is to force firms to internalize these costs either by making them pay taxes on their use of fossil fuels or by creating a system of cap and trade, both of which require the government to step in. Some carbon taxes have already been implemented, but they have been far too low to make a real difference. One economist proposes the solution that the government should adjust the rate in proportion to global temperature increases. In the case of cap and trade, the government sets a cap on how much emission is allowed and then

issues tradeable carbon emission rights. This gives firms an incentive to use more energy-efficient technologies, so that they can sell their pollution permits to others, a strategy the carmaker Tesla has successfully employed recently. While the Environmental Defense Fund credits cap and trade for the reduction of sulfur dioxide in the atmosphere, which led to a drastic decline in acid rain, many economists acknowledge that because of intense lobbying by the oil, gas, and coal sectors, governments around the globe have allowed for too many exceptions and loopholes.[10] The International Monetary Fund suggests that, to reach net-zero emission by 2050, along with the implementation of state-financed carbon capture technologies, it is necessary to price carbon at a level that reduces emissions by 80 percent.[11] It proposes that prices be increased by 7 percent each year. This would yield relatively modest price increases in the first few years, but after a decade prices would start becoming quite prohibitive and would therefore have the intended effects of lowering demand and making other energy sources more affordable.

Many economists also remain unconvinced that the threat of global climate change is as great as environmental scientists insist. A former chief economist for the OECD, David Henderson, for example, argues that the IPCC is institutionally biased toward pessimism and lacks the proper expertise to estimate the economic costs of climate change. Also reluctant to accept the findings and suggestions of climate scientists, Nobel laureate William Nordhaus challenges the methods and assumptions employed in key environmental reports. Cambridge economist Diane Coyle further argues that the IPCC, although backed by almost all climate scientists, "is not sufficiently transparent, has not engaged effectively with critics, and lacks political legitimacy."[12] The most common complaint, however, lodged by economists against environmental scientists is that they do not properly consider the power of substitutability.

Belatedly, a few economists have begun to recognize the severity of the threat that economic growth poses to the ecosystem and the role that economics have historically played in promoting maximum exploitation of natural resources and infinite economic growth. They recognize that the projections made by environmental scientists in the past, instead of being too pessimistic, have not been dire enough. In a 2021 publication, *The Economics of Biodiversity,* Cambridge economist Partha Dasgupta addresses the economists' tradition of treating the biosphere as external to

the human economy, despite the fact that humanity has always been embedded in nature.[13] At the heart of his critique is the widespread use of GDP to judge economic performance. GDP measures the total market dollars of output per year, but it does not take into account the depreciation of assets—human, capital, and nature. As a result of GDP bolstering the focus on quantitative economic growth, it is a singularly inappropriate device to assess the goal of sustainable economic growth. In its place, Dasgupta suggests that economists ought to use the concept of "inclusive wealth," which captures all of the economy's assets, including produced capital, human capital, and natural capital.[14] The latter category, defined to be as expansive as possible, includes everything from soils, plants, pollinators, and ocean currents to the global climate. Dasgupta correctly focuses the attention not on the scarcity of specific resources but on the capacity of the biosphere to regenerate itself. Without the hydrological, carbon, and nitrogen cycles, life on earth would be impossible, and without sufficient biodiversity the ecological system would lose its resilience. When an investment project is assessed within Dasgupta's proposed framework, the criterion is not whether it adds to economic growth (that is, GDP), but rather whether it advances inclusive wealth. If it is estimated that a project will add to produced capital, but at the same time impose significant damage on the environment, the net effect is negative and the project is therefore not undertaken.

Dasgupta offers plenty of specific advice on how to tackle the looming crisis. He calls for restructuring consumption and production, massively reducing waste, increasing efficiency with various technological advances, ending subsidies that encourage overextraction and overharvesting of the biosphere, implementing pollution taxes, charging resource extraction fees, establishing protected areas, rewilding natural environments, encouraging socially responsible consumption, nudging people toward more sustainable behavior, and developing carbon-capture technology. These efforts, he correctly argues, cannot be undertaken on the margin, but must involve colossal endeavors on the scale of the Marshall Plan. Together with a rethinking of the purpose of the economy, these transformations can go a long way toward creating a sustainable economy. The key, Dasgupta insists, is to recognize that the human economy is intrinsically bounded and that, regardless of how ingenious humanity may be, there are limits to how much of nature can be transformed into goods

and services. The cornucopian dream of infinite substitutability that economists have held on to for so long must be recognized for what it truly is: a fantasy.

While Dasgupta's approach is not perfect, as he himself acknowledges, it constitutes a much more rigorous and responsible approach to economic development than the traditional pursuit of ever higher GDP. Dasgupta recognizes that there are massive challenges associated with accurately measuring the stock of natural capital and the damages incurred from economic activities. Such problems notwithstanding, it is far better to work with rough figures, he argues, than simply "ignore whole swathes of capital goods by pretending they do not exist."[15] Dasgupta also acknowledges that his entire approach to the economics of biodiversity is conducted in anthropocentric terms. He justifies this by arguing that nature should be "protected and promoted even when valued solely for its uses to us."[16] But once we consider that nature also has an intrinsic right to exist that extends far beyond human use, we gain even more robust reasons for protecting it. The problem is that economic reasoning has been detached from nature for too long and that it has facilitated a perception that humans are external to nature and that rich societies are independent of their poorer counterparts. But this does not imply that economics is necessarily fundamentally flawed, he argues. The problem is not with economics per se, but with how economists "have chosen to practise it."[17]

Dasgupta's revisionist approach is a crucial step toward reforming mainstream economics, but whether his views will gain traction within the profession as well as in the halls of power is an open question.

The Uses of the Past

Climate scientists warn that we now have only radical options before us: either fossil fuel growth remains dominant with dire consequences for the habitability of the earth or we reorient the economy and politics toward a new social order that will keep us within the safe operating space of the earth system. Business as usual will bring disaster. With the stakes so high, some readers might well wonder about the wisdom of our historical approach. Facing such an unprecedented and serious situation, why look to the past for explanatory frameworks or alternative values? Why not simply jettison entirely all the baggage of history and start anew?

Although it is easy to sympathize with the anger and grief that drive some people to a wholesale rejection of the past, erasing all that came before would be a catastrophic mistake, depriving us of critical knowledge while actually exacerbating the problem of Planetary Scarcity. Without the benefit of historical perspective, people are far more likely to mistake an ideological position for a universal and timeless truth. In the case at hand, the idea of Neoclassical Scarcity insists that the human condition is permanently caught between insatiable wants and limited means, with infinite substitutability providing the source of endless economic growth. Yet, far from reflecting some universal or natural truth, this notion arose from a peculiar understanding of nature, psychology, and the economy. Through some historical detective work, we have traced the emergence and descent of this idea back from present-day neoclassical economics to the marginalists of the late nineteenth century and before them the Enlightenment *philosophes,* all the way back to the defense of insatiable desire and godlike mastery of nature among seventeenth-century natural philosophers and alchemists. In this sense, our book offers a genealogical approach to historical knowledge. We show how a widely accepted normative principle came into being in a specific historical process marked by contest and conflict rather than the rational discovery of universal truth. By uncovering the hidden history of scarcity, we also begin to understand how this idea constrains our vision of the future and obscures alternative ways of seeing the economy.[18] Only by recognizing the historical specificity of Neoclassical Scarcity can we begin the search in earnest for theoretical frameworks that are better suited to guide us as we tackle the challenges brought on by the Anthropocene.

Yet our argument is not confined to a purely negative and critical approach whose sole aim is to purge destructive ideas from scholarship. Historical investigation can enrich the social sciences in far more profound ways, by letting us escape the tyranny of the present and by broadening the horizon of intellectual and political possibility. Thinking historically, we also become more adept at dealing with a complex and contingent future. In tracing the history of scarcity, we have uncovered a family tree of alternative interpretations of the relationship between nature and economy. By investigating the concepts and aims that have guided past thinkers, from David Hume to Rachel Carson, we have sought to expand and enrich the horizons of social analysis. In reconstructing the historical

debates that accompanied the making of the modern world, we also uncover paths not taken. In this sense, the past forms a storehouse of lost ideas and forgotten questions.[19] Beneath surface appearances of variation and complexity, we can detect underlying patterns that persist across time. Such archeological excavation uncovers continuities that reach all the way forward to the present moment. For example, one of the main findings of our book is the deep and growing influence of cornucopian thought from the seventeenth century to the present. Yet, our analysis also reveals countermovements and positions of resistance. For example, the legacy of romantic thought has remained a potent influence on the opponents of cornucopianism from the late eighteenth century to the present. Likewise, socialist critiques of capitalism, with roots dating back at least to Thomas More's *Utopia* in the sixteenth century, have shown remarkable vitality and perseverance.

We should not be surprised then to see how the storehouse of the past shapes the current moment. In searching for alternatives to how neoclassical economics theorizes the nature-economy nexus, thinkers from across the political spectrum have turned to a wide range of past ideas and ideologies for inspiration. Some critics have eschewed European intellectual traditions altogether in favor of non-Western systems of thought, but many still look to the concepts we have excavated in this book. Pope Francis's encyclical *Laudato si,* a devastating critique of modern consumerism and environmental degradation, revives the Christian ideal of curbing desire and living within limits. The American environmentalist Bill McKibben, founder of the 350 Movement, embraces notions of self-sufficiency and degrowth that harken back to Rousseau and the Romantics. On the secular left, a new generation of scholar-activists looks to Marx and the other socialists and their critique of capitalism for a deeper understanding of the origins of climate change. Some Neo-Marxists put their hope in transformative technology like geoengineering and carbon removal while others explore forms of flourishing that reconcile human welfare with ecological limits and Planetary Boundaries. By drawing on both recent and distant traditions, these competing movements have forged a range of creative responses to Planetary Scarcity. It is worth noting that none of these efforts are simply reactionary or nostalgic; all seek to adapt and transform the worlds of the past to the problems of the present. Such rival responses in turn mirror the fractured condition of humanity. Per-

sistent geopolitical divisions, ideological polarization, and cultural differences appear to preclude the possibility of a single dominant understanding of the Anthropocene.[20]

We have simplified the findings of this book by grouping the various approaches to scarcity under two umbrella terms. The first kind involves a family of ideas that endorses an active mastery of nature together with a dynamic and expansive notion of desire: Cornucopian Scarcity, Enclosure Scarcity, Enlightened Scarcity, Capitalist Scarcity, and Neoclassical Scarcity. This tradition of *Cornucopian* ideology first emerged in the seventeenth century and eventually reached a dominant position by the end of the nineteenth century. A second cluster of ideas in our history revolves around limits to human power over nature and the need for constraint and moderation of human desires. This was a *Finitarian* ideology of bounded economies rather than open frontiers. It was the dominant worldview of sixteenth-century Neo-Aristotelian Scarcity. Later expressions of Finitarianism have included Utopian Scarcity, Romantic Scarcity, Malthusian Scarcity, and Socialist Scarcity.

The conflict between Cornucopianism and Finitarianism is still playing out in the current moment, yet there is also growing recognition that we simply cannot afford to rehash the same old rivalry. This duel cannot go on forever. While Cornucopians have had the upper hand until recently, the accelerating pace of growth and scale of extraction in the global economy has ended up creating environmental problems of unprecedented gravity at the level of the earth system, such as climate change, oceanic acidification, and nitrogen overloading. At this point, the long struggle between Finitarians and Cornucopians seems to have reached a new stage. Cornucopian ideology may well persist for a long time to come, but the planet itself now seems to weigh in on the side of the Finitarians.

Our excavation of Finitarian scarcities presents a map of possible paths to guide new ways of thinking about the economy and nature. Early modern Christian and Utopian thinkers conceived of the economy as circular. They imagined the economic activity of the nation and kingdom as an orderly and bounded sphere—along the lines of an idealized family household—embedded in the divine order of the natural world. Desire was harnessed toward moral and spiritual ends, not insatiable consumption. This hierarchical conception of the economy was not just expressed in religious tenets and moral maxims but also entrenched in legal restrictions

and popular tradition, including sumptuary laws to regulate consumer desire, poor laws to provide parish welfare, and customary use rights to access common land. In the early modern traditional social order, long-term growth was neither a political objective nor a moral imperative. The purpose of human desire was not to stimulate endless new forms of consumption. While this Christian cosmology fell apart in the seventeenth and eighteenth centuries, it left a legacy that was never wholly eradicated. Liberal economic thinkers reworked the question of limits to desire by suggesting that human needs would become saturated over time. David Hume argued that needs and wants would undergo gradual refinement, in effect decoupling pleasure and enjoyment from their material basis. Over time, as minds were polished and refined, people would opt for higher pleasures, such as conversation, poetry, and art. Indeed, even Alfred Marshall held out the possibility for such a development. Expanding on the same theme, John Stuart Mill and John Maynard Keynes hoped that humans would eventually liberate themselves from material needs and occupy themselves instead with the pursuit of what they called the "Art of Life."

Among the critics of commercial society, the concept of a bounded economy provided an essential alternative to liberal notions of expansion and growth. Thomas More and Gerrard Winstanley wanted to restore a need-based social order. Jean-Jacques Rousseau and John Ruskin drew on the model of the household to imagine convivial stationary states. In the twentieth century, the image of the circular economy gained new life, inspired by the science of thermodynamics and systems ecology as well as feminist theories of the household. The ecological economist Kenneth Boulding imagined a blend of affluence and austerity in the closed spaceship economy. Ecofeminists saw in the maintenance of the household the true locus of human welfare, recentering the economy toward care work and reproduction. Coming full circle back to the early moderns, the feminist theorist and environmental historian Carolyn Merchant recovered ancient cosmologies of the nurturing principle of nature (a theological variation on the care principle of the household) to attack the mechanistic and patriarchal origins of cornucopianism.

Such a reorientation requires a new scalar imagination: we need to think on the scale of the earth system *while* taking a long-term approach to the economy in the name of intergenerational equity. As we have seen, Cornucopian and Finitarian approaches differ markedly in how they view the

future. The idea of insatiable desire presumes a specific conception of time and temporality. Cornucopian philosophers and agricultural improvers of the seventeenth century imagined a rapid transition toward earthly abundance—what they called the Great Instauration—achieved through the deciphering of nature's source code, designed by God, the Creator. Later versions of cornucopianism retained this profound optimism, but grew more circumspect about the precise content of the future. When traditional Christian cosmology began to lose ground in the Enlightenment, the future became the territory of competing political and social interpretations. Paradoxically, such faith in future progress often precluded actual long-term thinking. While the advocates of neoclassical growth theory expect a dynamic future, predicated on continuous technical innovation, they show little interest in questions of intergenerational solidarity or long-term social developments. The future takes the form of investment decisions big and small. Prudential firms and individuals weigh present cost and future benefit with an eye to the discount rate. We find a parallel reticence about the future in Marx, whose vision of socialism promised a total rupture with the capitalist system but offered little in the way of a blueprint for the political and social order after the Revolution.

In contrast, Finitarian forms of scarcity have produced more specific recipes for long-term thinking. We can understand the circular economy of early modern Christian and Utopian thought as a strategy to preserve enduring stability and encourage spiritual rather than material wants—what Roman Krznaic terms "cathedral thinking."[21] Such forms of thought did not become extinct in modern times. For example, John Ruskin saw the exhaustion of coal as a source of hope and renewal, necessitating a return to skilled labor and a circular economy. Ruskin drew on medieval architecture and art to imagine the possibility of intergenerational flourishing after fossil fuel. John Stuart Mill also looked forward to a future steady state during which the social strife intrinsic to the growth phase was eliminated and people could peacefully pursue the quest for the good life. Fourier had an even more ambitious vision of the future. He described in great detail how people might go about fundamentally redirecting their desires, away from excessive consumption toward libidinal and libertine pleasures. Such concerns about future possibilities continued to surface in the twentieth century. For Keynes, advancements in the science and technology raised the possibility of a fundamental shift in the economy:

How should people plan for the end of work and the coming of abundance? In Arendt's critique of affluent society, the acceleration and multiplication of consumer wants was a corrosive force, wearing down the space for political action and reducing citizens into drones. She, too, looked to art and architecture to defend the significance of the long term. Without the persistence of a durable world of art and action, humans became trapped in a myopic present, captive to their own desires.

The central theme of this book has been to explore the manifold ways in which humans have imagined their relation with nature. Neoclassical Scarcity rests on the idea of humans as intelligent artificers—*Homo faber*—capable of remaking the world in their image. This dualistic and mechanistic worldview attributes intelligence only to humans who give form to matter by mastering the passive and inert resources of the world on the basis of mechanistic principles. While this kind of dualism has been crucial in sustaining Cornucopian ideology since the seventeenth century, it has never been entirely dominant. A major alternative idea of nature relies not on mechanistic science but the respectful mimicry of organic processes. From this perspective, humans learn from nature how to make useful tools, without assuming absolute mastery. In fact, this approach tends to endow nature with an intrinsic force and complexity that humans may emulate to some degree, but where nature takes the lead and people simply follow. We find a variation on this theme already in eighteenth-century vitalist philosophy and physiocracy, which saw power over nature not in terms of absolute mastery but a collaborative partnership. Here, human labor contributed some part of the overall value of the product together with the work of nature.

This notion of partnership was common among the classical political economists, including the Physiocrats and Smith. There was an echo of it also in Marx, though his theory was almost entirely devoted to the human component of the partnership rather than its ecological foundation. However, with the marginalist economists, the partnership of man and nature lost ground to a fundamentally anthropocentric notion of value. As agricultural production grew in efficiency, nature forfeited its central place in the economy and the theories of economists. Yet in the same historical moment, the idea of partnership received a dramatic new expression in natural science. For Darwin, the human power of breeding (what he called "artificial" or "methodical" selection) amounted to a pale

imitation of the superior ingenuity and rationality of natural selection. In the twentieth century, this pessimistic view of human capacity became the foundation for a new ecological critique of capitalism. Rachel Carson argued that humans were meddling like clumsy children in systems they could manipulate but not fully understand. Where Darwin had seen little reason to worry about human intervention, Carson thought the unintended consequences of interference might destroy the web of life. Humans behaved like lords of all creation, yet in practice they had become a destructive parasite on the life process. As we have seen, this threat has only grown in scope since Carson's death. The Great Acceleration now disturbs the basic biogeochemical processes that keep the earth hospitable to complex societies.

New approaches to Planetary Scarcity also require us to confront the problem of distribution and equality from the perspective of the earth system. Modern economics assumes that perpetual growth can legitimate the social order even if relative inequality persists. Poor countries and lower classes might lag behind the rich, but as long as technological innovation proceeds apace, living standards across the globe will continue to improve. What will happen to the global order if this promise of rising standards turns out to be false? The new science of Planetary Scarcity underscores the finite capacity of the earth to absorb the waste products of the global economy. It also insists that a stable climate and biodiversity provide the biophysical foundation for all economic activity. We are at a moment when globalization is putting increasing pressure on sinks, resources, and biodiversity. Since business as usual will drive the global economy toward multiple tipping points, one might reasonably conclude that the promise of perpetual growth cannot be made a universal standard for the whole human population. Imagine the effect on world politics if this discovery became common knowledge. At the moment, earth system science does not look like a vehicle for radical social change. And yet, we may one day look back at climate science and the ecology of biodiversity as the catalysts that led to the transcendence of the economic order of the twentieth century.[22]

The end of the idea of perpetual growth would challenge not just Neoclassical Scarcity but also Socialist Scarcity. In Marx's framework, the prospect of socialism was explicitly tied to the pursuit of large-scale industry and agriculture, fueled by steam and coal. While some socialists have

aspired for an ecological understanding of justice, much of the movement still celebrates growth and mastery as preconditions of equality. Yet as Rousseau reminds us, egalitarianism can be defended on different grounds, beginning with material simplicity and republican liberty rather than Promethean industrial technology. This alternative conception of the good life might make it possible to imagine a process of global convergence around new standards of human flourishing. The effort to raise material standards in the Global South would have to be accompanied by a concomitant reduction of the ecological footprint for the affluent countries. Such convergence would require a new model of development, which favored material growth only up to a certain universal income threshold. Growth in one region or class would have to be balanced by degrowth or a lower rate of material growth in another.[23]

Slowing down the Great Acceleration will require immense effort and creativity in cultural and technological terms. The complex challenge of Planetary Scarcity rules out a strategy that focuses *only* on restraint and withdrawal. Humanity faces threats so dangerous that extensive technological intervention and cultural change have become necessary. To back off, we first need to repair what has been damaged. The Great Deceleration is not a moment for technophobia or apocalyptic pessimism. Our best bet may be to exorcise Cornucopianism from culture and ideology and replace it with a new politics and technology of repair, oriented toward the goal of universal flourishing within planetary constraints.

This radical future of repair extends to many different domains. Fossil fuel economies must transition to renewable energy while at the same time removing carbon from the atmosphere. In technical terms, this might involve projects of carbon sequestration of different kinds, through the constructing of artificial sinks by means of underground storage or the enhancement of the ocean's capacity to absorb carbon. Such carbon removal industries could provide employment and livelihoods in places where meaningful work is hard to come by. Yet, at the moment carbon sequestration technologies are very expensive and energy intensive. Repair might also take the political form of debt payment where the affluent countries pledge to clean up the mess they have made while assisting goals of just development in the Global South. By halting land use change and repairing ecosystems, humans might regenerate and even expand the natural carbon sinks of the earth. Some critics imagine a planetwide project

of rewilding to this effect. This would make room for functional and genetic biodiversity by setting aside sufficient space where nonhuman life forms could thrive. Here again, political priorities will determine the shape of things to come—should a vegan diet become a global priority to save land for biodiversity?[24]

Curbs on land use would also prevent the spread of new pathogens. Forest logging, road construction, and other points of contact between humans and nonhuman species provide key pathways for the emergence of new infectious diseases. Virologists predict that the frequency of epidemics will only increase as commodity frontiers expand. Here, an ethos of ecological repair would not only preserve the integrity of the natural world but also help restore the health and welfare of human beings, especially in those social classes and minority populations most vulnerable to epidemics. In part, this is a question of balancing local livelihoods with conservation aims in the Global South; in part, it is a problem of limiting or reorienting consumption in affluent countries.

Without a doubt, the ethos of repair will require a profound psychological shift across the planet. Cornucopian ideology has usurped universal aspirations of equality, freedom, and creative fulfillment. Any viable alternative to the present order needs to come to terms with the human desire for self-determination and find means to channel it in new directions. Repair does not rule out an element of dynamism. Circular economies can still foster individual and collective forms of creativity, pleasure, and play, channeled through science and art as well as everyday living. But whatever direction freedom takes in the Great Deceleration, human desire will be bounded by the new condition of Planetary Scarcity.