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Environmental Times

Synchronizing Human-Earth Temporalities from *Annales* to Anthropocene, 1920s–2020s

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In recent years it has been proposed that the advent of the Anthropocene may profoundly affect the human sciences, including, perhaps most significantly the field of history and many of its subfields such as economic, environmental, world, and colonial history. The Anthropocene is a concept no older than this century, coined by atmospheric chemist and Nobel Laureate Paul Crutzen and ocean scientist Eugene Stoermer in 2000, followed by a far more widely circulating article by Crutzen in *Nature*.[1] It has quickly received a considerable following and critical reflexivity among social scientists and humanists. Since 2009 the International Stratigraphic Community has been preparing a proposal to the International Geological Union as to whether the Anthropocene should be considered an official geological epoch with a likely start at some point in the middle of the twentieth century.[2]

Although the Anthropocene idea was discussed by humanities scholars earlier, it was an essay in *Critical Inquiry* 2009 by Dipesh Chakrabarty, "The Climate of History," that in earnest raised interest among historians.[3] Chakrabarty argued that the writing of history will become deeply affected by the new Anthropocene condition, especially global climate change, and that our understanding of freedom and the entire metaphysics of time will need to be reconsidered. He also suggested that the divide between natural and social history must be breached and he advocated a new "negative" universalism that would construct a global "us," united by the "species" contributions that we humans make to the planetary change, regardless of class, gender, or nation. Chakrabarty did not have much to say, however, about *who* would write the new history or *how* it should be done, although it is clear from his later, recent work that he thinks knowledge from the sciences must inform a desired more total earth and species history. Such novel "human-earth historiography," as

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we may call it, would entail significantly new ways of looking at times and temporalities, beyond conventional structuring of time based on cultural and political chronologies and established archaeologies of the past.[4]

While acknowledging that there is a potential for change, perhaps even radical change of the social temporalities that can guide humanity and human societies in our troubled times my purpose with this chapter is rather to reexamine some of the historical and scientific contexts that can help us understand the current transformations of historiography. For some time now, times and temporalities in relation to earthly conditions, have emerged as just as important as more conventional preoccupations of historians such as periodization and social explanations.[5] The possible implications of this "temporal turn" of the environment is vast. If the concept of the Anthropocene becomes canonized not only as a geochronological idea but as a framing concept of "our times" on the global scale it will influence how we conceive of future directions for societies and perhaps even what it means to be human in this world.

Even without a full canonization of the Anthropocene by the geoscientific community, environmental times are bound to affect human societies more and more as societal and natural processes increasingly resonate and entangle. The temporalities of "natureculture" will affect politics, mentalities, and our perceptions of past, present, and future.[6] Or, in other words, how we temporally structure our thoughts, lives, and societies, what Reinhart Koselleck (1979) called *Erfahrungsrahm* and *Erwartungshorizont*, frame of experience and horizon of expectation.[7] What sort of temporalities do such concepts activate? Where do they come from? What kinds of knowledge are they based on? Who is providing the elements of these temporalities? Historians will typically play a role in the assemblage of temporalities, but other experts, many of them scientists and notably—as I shall return to—those who make up the Earth System Science community, have already appeared as candidates for the roles as environmental timekeepers of both the past and the future.

Time and Judgment in the Time of Numbers

Our times are numbered, and the Anthropocene is a quantified epoch. Its characteristics are the result of carefully measured and monitored geological, geophysical, and biological impacts of human activities on the earth, ultimately producing what has been called a "computational" or a "mediated" planet.[8] Biostratigraphy, chemostratigraphy, and lithostratigraphy have been studied for a long time but with a marked increase in the modern era, especially the period since 1950, which has been termed the Great Acceleration.[9] In this respect the concept comes out as typical of a long-standing trend in

the emergence of modern expertise on global change.[10] In a growing literature it has been demonstrated that the very notion of expertise is predominantly reserved for certain categories of knowledge. This literature tells us that expertise and evidence are concepts that tend to favor the quantifiable and formal.[11]

The reasons are many: one is that expertise is a sociologically determined category that reflects the relative proportions of educated people who have gradually shifted expertise to expanding fields such as science, engineering, and economics. Other reasons are based on popular assumptions and expectations. Numbers seem to many, *prima facie*, to carry more credibility and precision than what is expressed in words. Numbers are also portable. A widespread perception is that numbers are somehow more neutral and therefore more useful, as Theodore Porter described it in his analysis of nineteenth-century social and engineering projects.[12] These assumptions may be regrettably superficial, some even plain wrong, but they must nonetheless be considered as circumstances, well known from the history of statistics and social numbers.[13]

A central feature of the extended practice of time making that preceded the Anthropocene concept was "the environment." The word itself is old but used in this way, as a particular singular noun, it appeared in the twentieth century.[14] The concept entered into circulation gradually and its usage increased dramatically, especially after World War II. A characteristic feature was its integrative capacity. Once it became established that humans impacted nature on a massive scale, often with problematic effects, the idea of this kind of dynamic relationship between humans/societies and their "surroundings" could be applied to almost any activity and place, from agriculture to zoonosis, from indoor to outdoor, and from the smallest molecular features to the atmospheric scale and beyond.[15] It was integrative, mobilizing expertise first in the natural sciences of human-nature interaction (biology, ecology, hydrology, strands of medicine), then gradually expanding into the social sciences and humanities, a process that covered the entire second half of the previous century.

A core element of the environment was time. The concept itself was as much temporal as it was spatial. The basic idea was that the environment "out there" was not static but that it was vulnerable to human influence and that it changed as a result of it. The rate and direction of that change became important; one could even say that environment was "nature with velocity." The changes in velocity were contributed by humans, and they typically went beyond the rates of change that could be attributed to natural variability. So, *temporalities and nature were welded together in the concept of environment.* These "environmental times" were not uniform, they appeared in different shapes and guises and they also scaled in different ways. Impact could be immediate if a city expanded into a new area. Impacts could be slower if a

river was polluted by chemicals, and slower still, on time scales of generations and centuries, if humans were emitting carbon dioxide from fossil fuels. They could be essentially nonlinear and unpredictable if tropical rainforests were cut or burned and brought homeless animals closer to humans and, seemingly randomly caused viral epidemics to spread in human populations.[16] Environmental time could be any pace or scale of time, but whatever the time, it was closely interwoven with human timescales, from the processes of causation of change to the impacting phases of different duration, and to the temporalities of effect and long-term change. Since timescales were different, a major scientific and, later, policy change mounted: how do these times relate to each other and what does it mean for the effects of the environment, in part and *in toto*?

This chapter aims to address some temporal dimensions of the rise of the environment and of environmental discourse and to suggest some ideas for how we can regard the emergence of "environmental times" as an element of this historical process. Given the plethora of possible illustrations to the basic point of departure—that environmental times are a product of the twentieth century and that they have gradually become part of the structure of contemporary *Zeitlichkeit*, to use Koselleck's term[17]—I will have to limit myself to a stylized approach using a small number of examples from a subset of geological field sciences, glaciology, quaternary geology, and paleodisciplines which focused on materialities of time as represented by layers, strata, and archives and produced a rich variety of visual representations of local and distributed time records. I will juxtapose these with a more theoretically oriented, physics-based atmospheric science where temporalities were understood as more universal and became increasingly seen as parts of changes on a planetary scale, including the stabilizing orthodoxy on anthropogenic climate change during the latter decades of the twentieth century. I have previously drawn attention to how disciplines and fields of knowledge responded very differently to the new understanding of comprehensive anthropogenic environmental change.[18] The Anthropocene idea may serve as the epitome for irreversible human intervention on the planetary scale, but the main thrust of my argument here is rather that it should be seen as a late, and quite extreme case of environmental times that had by the early 2000s already grown over the course of a century. We may even wish to characterize the work conducted on interactions of environmental—and elemental—timescales during the twentieth century with the concept Proto-Anthropocene.[19]

The emergence of environmental times has led to profound alterations of how we (and here I mean large parts of humanity) experience our being in the world. Certainly, human deeds in the Christian tradition always had a relationship to Divine intervention and punishment, but the science-based hegemony of a dynamic, humanized nature that changes in problematic ways

over time and that was possible for humans to understand and assume responsibility for was very different.[20] Disasters, cataclysms, upheavals that used to be called "natural" or, indeed, "acts of God" have been gradually moving towards the realm of the human and the societal and should be seen not just as part of the *zeitlich*, or temporal, in Koselleck's sense, but also of the affective and existential, along the lines of what Raymond Williams called "structures of feeling," deep perceptions of the regulating features of social existence.[21]

The more-than-a-century-long process whereby this new environmental dimension of modern temporality has played out *qua* history—that is, not just as a phenomenon to be studied by natural science—should be a matter of more detailed historiography. I posit that, apart from a shifting notion of causation and scale, there would be certain formats of knowledge that play a role.[22] One would be "technologies of prediction," such as models, assemblages of data, and methods for processing these, and the institutions, i.e., the "technologies" whereby environmental changes were negotiated and defined and hence the size and level of human impact, theoretically underpinned by an increased mathematization of "rates of change," prominently by Alfred Lotka, in the early 1920s.[23] Another is "mediated expertise" which may refer to the visualization and communication of results (figures, images, keywords, etc.) and to manifestations of environmental change. These and other "environing technologies" are in turn connected to temporal tropes and scales in religion, ideology, social and historical theory, and also to activism in policy formation and advice.[24] In this respect it may be useful to regard environmental times as continuously intervening in and responding to other times, and therefore requiring active "synchronization"[25] with social, cultural, and political time scales and temporalities, in ways that reach beyond the scope of this chapter but that hold a lot of promise for future reflection.

Temporalizing the Environment—Febvrian Enthusiasm

Given the copious influence of the sciences for the formation of the environment and its multiple times, it is illustrative of the concept's complexity that we may meaningfully choose a work of the deep humanities as our starting point. It needs to be said at the outset: temporalization of the environment as a broad process encompassed numerous agencies, including both the sciences and the humanities, from the very early decades of the twentieth century. A unifying link between the two was the French historian Lucien Febvre, later founding father of the *Annales* school, and his book *La terre et l'évolution humaine* (1922), translated into English as *A Geographical Introduction to History* (1925).

Febvre articulated the modern anthropogenic "environment," his favored concept, against the backdrop of an earlier understanding of the word as a deterministic external force, working on humans and their entire societies and civilizations. Other words commonly used for this determining influence were "earth," "geography," or "climate," words found in the work of Friedrich Ratzel and Ellen Churchill Semple, whose key work *Influences of Geographic Environment* (1911) drew heavily on Ratzel, and in the work of Ellsworth Huntington, famous for his ideas of the strong influence of climate on human societies in *Civilization and Climate* (1915) and other books.[26] In acknowledging their intellectual diversity, it may be worth noting that they were primarily anchored in nonscience fields, with Huntington as a liminal figure, a metaphysical geographer of a kind not unusual in the first half of the twentieth century: a Griffith Taylor, a Vilhjalmur Stefansson.[27]

At about the same period, geographical factors such as populations, pests, harvests, and famines were adopted by French historians, later to become important for the *Annales*. The journal itself didn't start until 1929 but already in 1913 Febvre, then a rising star on the French historical firmament, had been commissioned by Henri Berr, the wide ranging and well-connected philosopher who started *Revue de synthèse*, to contribute a volume to his book series *L'histore de l'humanité*, or *The History of Civilization* in its English version. Its stated aim was to present in accessible form "a library of masterpieces," "results of modern research throughout the whole range of the Social Sciences," in the kind of synthesis vision that Berr had proposed as an ideal for history.

Febvre's *La Terre et l'Évolution Humaine* is a massive, repetitive, powerful, polemical, yet modest and polite, yet also brutal and pitiless rejection of the Ratzelian tradition. And not only that, it is in this volume, not published until 1922, after five years of a writing pause during World War I, that we envision the shift of direction of the concept of the environment. No longer is the environment only something "around" that influences "man" and human societies. On the contrary, the relationship is mutual, and, above all, the impacts run in the other direction as well, and according to Febvre this has been going on throughout human history.

Several features of the book point in the direction of a refashioning of historical temporalities: first of all, Febvre's acknowledgement of anthropogenic change. Febvre is remarkably sparse in his usage of the word "nature"—he prefers earth, geography, and, above all, environment, or *milieu*, in Febvre's French. Because, as he remarks, there is not much untouched nature, what humans relate to is mostly environment, that which is already transformed. This is also what Berr had commissioned him to do, as he writes in the foreword, entitled "The Effect of Environment on Man and Man's Exploitation

of the Earth."[28] In a series of repetitions throughout the volume Febvre juxtaposes "man" and "environment"—"two groups of obscure forces," as these were addressed in the deterministic tradition, going back not only to Ratzel, but also to Hippolyte Taine, who used environment to explain art and literature, and from Taine's professor in turn, Victor Cousin, an arch-determinist, to Montesquieu, whose understanding of environment Febvre ridicules as simplistic and superficial, and ultimately to Jean Bodin, whose circular way of reasoning is exposed in good-humored polemical irony.[29]

The chief concept that had linked "environment" to "man" in the Ratzelian tradition was "influence," which he rejects as a superstitious idea. How, Febvre asks, can soil and climate influence people and societies? How does temperature enter the minds of humans? How is it that cold and damp can make people slow, dull, and lacking, that warmth makes them spiritual and philosophical, according to Hippocratic tropes that had circulated since Antiquity? Febvre found such beliefs unfounded and therefore unscientific. What did exist were "relations" between the environment and humans and their societies, and these relations were empirical and should be researched as such.

That Febvre attacked a deterministic understanding was crucial, because it paved the way for a possibilist version of history which was also about environment and geographical factors but retained the essential property of human agency, crucial to most historians and a matter of epistemic life and death for Febvre. If Febvre's enemies were Ratzel, Semple, and Huntington, his hero was Paul Vidal de la Blache who had written seminal works on French regional history.[30] Vidal, just like Fernand Braudel some decades later, presented geographical factors as framing conditions which, essential for Febvre, humans constantly surpassed in their development of society, through knowledge, technology, social relations, that is, everyday life, and what Vidal and his followers called *genres de vie*.[31]

At the same time that Febvre refuted determinism as bad science (underpinning false and dangerous political ideas), he also embarked upon a completely new and complementary understanding of environment, namely as the object of human impacts and thus best studied with a broad range of approaches to these impacts. Humans acted consciously, historically, in time. In the final parts of his book he turned increasingly to anthropology, psychology, history, and other human sciences. It was necessary to widen the methodological arsenal, because, as he noted, "Between man and his natural environment, ideas are always creeping in and intervening."[32]

In turning the tide away from environmental determinism, which made humans smaller than the forces of nature, Febvre argued that humans played a mighty role in shaping the earth, essentially suggesting that change, and the times of change, in the environment were closely linked to human agency,

hence to historical time, and therefore to history. This becomes evident right at the beginning of the book in his description of Comte de Buffon—the optimistic aristocrat, polymath natural historian, and director of the Jardin du Roi in Paris—and from his description of the earth and life cosmography in Buffon's *Les Époques de la Nature* (1778).[33] "Buffon's man," Febvre says, "is no creature of putty to be shaped by nature. He is a doer. He is literally one of the forces of nature." In the following he cites Buffon at length: "The entire face of the earth bears today the imprint of man's power. . . ." Man is in this superior to all other species; "animals are, in many respects, productions of the earth; man is in every way the work of Heaven." Buffon had found anthropogenic climate change already demonstrated, especially in a densely populated and culturally vibrant city such as Paris, where temperatures grow thanks to conviviality and intimacy in *les salons*! That Febvre appreciated Buffon is beyond doubt. He was an eighteenth-century natural historian, but, akin with Vidal de la Blache, he "thinks like a modern." Furthermore, Buffon does not belong among the "'Church Fathers' of the theory of 'environment.'" Because, according to Febvre, "he marks the starting-point of another idea than theirs—the complete antithesis of their idea. The earth, fashioned, altered, adapted, humanized by man."[34]

Buffon, nowadays presented as the early Arch-saint of the Anthropocene—named as such in 1956 by Clarence Glacken and cited as an authority already by George Perkins Marsh 1864—was attractive to Febvre because Buffon did away with determinism and at the same time enhanced human agency.[35] In this he served as the perfect template for Febvre's own welding of environment, time, and agency. It is equally obvious why other social scientists and humanists, including many historians, have remained less convinced. Buffon's "man" is, after all, not very historical in the common sense, rather a singularity, like "humanity." He (most likely a he) pursues his pure agency universally in the world, transforming it as if "man" was just another natural force at play. So, paradoxically, from this agency follows a universalism that runs the risk of becoming both flat, one-eyed, and too powerful to realistically represent historical change, a standing trope in the recent humanist critique of the Anthropocene.[36]

Febvre launched a possibilist crusade against a geographically and biologically determined understanding of history. First and foremost, his work made the environment historical: he inscribed it with the potential of times and timescales that related to human agency, and he did so in ways that until then had not been attempted. The concept of environment before World War I was predominantly seen as variations on the Hippocratic theme.[37] Febvre's more dynamic outlook was brought to the *Annales*, the journal he founded, but only found its way slowly into *Annalistes* practice which did not release the full potential of Febvre's anthropogenic environmentalism.

Environment *Quasi Immobile*—Braudelian Stability

Even Fernand Braudel's *History of the Mediterranean* (1949), which begins with a huge 350 page "introduction" entitled "The Role of the Environment" (*La part du milieu*), managed to move the idea of anthropogenic environmental change into the background. This is, somewhat ironically, carried out through his famous tripartition of historical time: the *longue durée* as the backdrop to the faster events; *l'histoire événementielle*, a concept he had borrowed from François Simiand, on the shortest time scales up to decades; and *les conjonctures,* which encompassed several decades up to centuries.[38]

At first blush, Braudel's strong preference for long duration historical analysis where the environment plays a structuring role in the affairs of mankind, seems akin with Febvre's ideas in *La Terre*. But, on closer scrutiny, they are quite different. Febvre presented an immediate and comprehensive impact from human action, and one where human agency reached deeply into the heart of nature and its workings. The Mediterranean geography portrayed by Braudel—and hence the relationship of mankind to its environment—reflects rather an equilibrium-oriented natural world characterized by relative stability, in today's Earth System Science parlance perhaps to be likened with the postglacial "stability domain" of the Holocene. In the light of our current understanding of climate and geophysical change as rapid and dramatic it is remarkable how Braudel depicts the tranquil *longue durée* of the Mediterranean world, not only changing very slowly but hardly changing at all. He says in the preface, still repeated in the 1966 edition, and in the 1972 translation into English, that "I did not wish to overlook this facet of history, which exists almost out of time and tells the story of man's contact with the inanimate" (*quasi-immobile* is his word in French).[39]

In Braudel we have an author who is not aware of the Great Acceleration that started just as his book went to press, or of the canonization of *Man's Role in Changing the Face of the Earth*, the core idea (and title) of the influential, multidisciplinary Princeton conference in 1955 on humanity as geophysical agent, manifesting anthropogenic environmentalism in the sense that Febvre had suggested. Nor does he seem interested in the budding applications of the word "environment" as an integrative concept for the many dimensions of the natural world that were threatened by human expansion.[40] Braudel is, we can say, writing in a state of innocence and also disjoint from the most recent French debates since he did much of the actual work on *La Méditerranée* in a German prison camp in Lübeck. From our 2020s Anthropocene viewpoint, we can see Braudel balancing precisely on the moment of both knowing and not knowing, without knowing, as we do, that this was the case. He wrote about environment and time, but he did so before the increasing velocity of

environmental times had fully started to gain visibility and traction and the scale of anthropogenic influence had become known.

Braudelian historiography, this is the point here, stands in a special relation with non-historian actors, such as the community of earth system scientists that advocate adopting the Anthropocene as a new geological epoch in periodizing the past, comprehending the present, and projecting the future. One particular concept to consider in this regard is "crisis," discussed so vividly by Koselleck.[41] Crisis, according to Koselleck, can be comprehended as a time-compressing force in that it evokes urgency and a threatening instability that is the antithesis of long-term socioecological sustainability. Environmental and climate crises are, however too often taken as natural facts, without adequate reflection on the human agency behind the construction of the social concept of crisis. Within a prevailing crisis discourse, singular *events* (such as hurricanes or droughts) have been linked to climate change but must be managed in the moment, while societal *adaptation* is called for over the medium term, and deeper socioeconomic *transformation* is portrayed as humanity's only hope for long-term survival.

Koselleck's distinctions may seem reminiscent of Fernand Braudel's division of episodic (*événements*), social (*conjonctures*), and slow (*longue durée*) timescales. They are, however, very different: compressed by the acceleration of human environmental impact—as elaborated through concepts such as the Great Acceleration and the Anthropocene—on the one hand, and the perception of subsequent environmental and climate crisis on the other. Earth System Science studies extremely long durations, which, for a long time, few historians found useful to consider except as general background information. Those who did were often influenced by science, or working in close collaborations with scientists. Their results sometimes supported social interventions intended to elicit rapid societal change across short time horizons.[42] Institutions and individuals associated with the community of Earth System Science, including the supporting technological instruments, models, and visualizations, are hence key aspects of what might be regarded as a rising "crisisfication."[43]

Although there are similarities between Braudelian and Earth System Science in the tripartition of time scales, the differences are striking. Anthropocene nature is prone to dramatic change at unpredictable moments. These moments of crisis are directly or indirectly induced by human activities, but they are also "anthropocenic events" that in many respects require human science and technology (instruments, monitoring) to become perceivable. Climate change is the obvious case in point. Despite being visible at certain "truth spots" where glaciers are melting and islands are overtaken by the ocean, climate change typically needs careful monitoring and masses of

scientific data and theory to become comprehensible.[44] At the truth spots and through the instruments, there is thus also a repeating, or a perpetuating, of the human agency that initiated the change, thus building time into the environment as an essential factor of understanding.

Expanding Environmental Time

Seen from the vantage point of our contemporary situation a hundred years later, the attempts by the *Annalistes* to naturalize historiography seem too modest to capture the increasingly complex and entangled relationships between time scales of nature and culture. "The environment" had established the existence of a human-made version of the natural world where change is just as present and marked by human agency as it is in society or culture. That was the central message of Febvre's *La Terre*. However, it was at least partly overlooked, and it is clear that his student and protégé, Braudel, became a much larger presence in modern historiography than his mentor ever did. That does not mean that Febvre's book is unknown. It has been well cited for example in the literature about the background to environmental history that emerged as a field around 1970.[45] But it has not been used anywhere near as much as Braudel's work which has been regarded as the perhaps most important contribution by any historian in the twentieth century. Furthermore, Febvre's anti-determinist stance, which became a standard part of historical virtue was typically not derived from him but rather from R. G. Collingwood and typically adopted without the keen interest in the environment that Febvre advocated.[46] A result was the fact that environmental times, especially as they brought profound interaction with human agency, did not become a concern in the humanities and social sciences until fairly recently.

Further work on environmental times, after Febvre, instead occurred in the sciences while the humanities and social sciences opted to largely remain in the waiting room for several decades. That time was a critical factor in almost any natural process was of course well-known, and had been built into science and natural history since the Early Modern period. Geological strata and fossil records increased earthly times and Buffon himself famously created a proxy for the age of the once heated earth by heating iron balls on his estate and measuring the time it took them to cool; a bit more than 70,000 years.[47] Natural selection and evolution demanded far longer timescales to be realistic—Darwin famously suggested in *The Origin of Species* that the age since the dinosaurs alone would require at least three hundred million years.[48] Thomas Hunt Morgan's study of *Drosophila* flies made it apparent that a "generation" could mean anything from hours (in flies) to decades (in humans). Literally any dimension of the natural world expanded in time, down to the smallest

fraction of a second and up to the time of the universe itself that grew with millions, soon billions of years.[49] But these times were not yet environmental times—they lacked the presence of human agency.

At about the time when Febvre finished his book for Berr this started to change. Alfred Lotka's work on population dynamics in the 1920s demonstrated how oscillating fluctuations that he found in predator-prey distributions were extremely time sensitive. They could also affect the result of human interventions in lakes and other habitats that were soon to be called "ecosystems," Arthur Tansley's 1930s concept, "of the most various kind and sizes." Ecosystems as well were subject to temporalities: "those which can attain the most stable equilibrium survive the longest." Tansley had already taken a deep interest in the concept of "succession."[50] Much of the work on relations between populations and their external conditions hinged on models, abstractions of principles that could be tested statistically. Charles Elton built models of animal populations and used them to write his influential *Animal Ecology* (1927). The idea that external conditions were influential could be used equally well on human populations, as in the work of Alexander Carr-Saunders, who trained as a zoologist and worked under statistician Karl Pearson and together with him published *The Population Problem* (1922), the very same year Febvre published *La Terre*.[51] Demographers and zoologists were still not always "possibilists," they would rather see constraints than opportunities, but at least the focus had started to move away from separating humans from natural processes. They were increasingly seen as connected, and time was of the essence. Most of the functions had time on the x-axis, but what if time itself was a variable?

Early examples where this was the case occurred in the soil sciences. Already in the interwar years deserts and erosion became acknowledged concerns. The Dust Bowl of the American west turned into a national crisis and human neglect of soils became a political issue. Ecologist Paul Sears wrote *Deserts on the March* (1935), literally depicting a perfectly natural habitat, drylands with extremely limited vegetation, that had started to break away from modeled expectations, leaving their ordinary grounds and heading west with the winds. They were deserts on speed, and what usually took decades or centuries, or perhaps shouldn't happen at all, happened in days and weeks, once the protecting trees and grasses were eliminated to clear land for agriculture.[52] Erosion harried Russian and Ukrainian steppes, and American grasslands. It had happened in the past in the Roman Empire, the Nile Valley, India, Sudan. There were times when even the most stable of agricultural civilizations seemed to drive up the rate of change in landscapes to threatening levels.[53]

Issues such as these, only years later, right after the coming World War, would be called "environmental problems" and thus entered into a soon familiar vocabulary of the environment as a sensitive, yet opportunity driven

relationship between humans and their surrounding climate and life conditions. Climate itself became an issue where time was quickly going out of hand. Swedish chemist Svante Arrhenius had calculated the greenhouse effect in a paper published in 1896. His interest was not climate change as we now know it, on the contrary, he was keen to learn about the causes of ice ages.[54] But the principles were correct and after several decades of relative silence a British steam engineer, Guy Stewart Callendar returned to Arrhenius's paper and made a calculation to connect the observed, ongoing warming around the world and connected it to emissions of CO_2 from the combustion of fossil fuels.[55] Again, time was the most immediately affected variable. Natural variability that produced, and reduced, ice ages over time scales of thousands and tens of thousands of years could now be replaced by anthropogenic effects with temperatures growing tangibly and with dire consequences over timescales as short as (human) generations, decades, or even years.

These were not just times that were a-changin'—they were new, environmental times, produced by human societies, shifts in agriculture, principles of land distribution, changes in energy provision, and behind it all a growing demand for food and livelihoods and power to engines and industries in turn driven by increasing populations, and the greed and creative destruction of capitalism. They were environmental because they were produced in that critical zone of interaction where human societies met with surrounding nature. In fact, these early instances of environmental times contributed to the shift in usage of the word environment from the Ratzelian external influence that Febvre fought so forcefully against to the soon to emerge new orthodoxy of environment as vulnerable life condition and possibilist responsibility that Febvre favored.

An Earth Time Machine

Environmental times were to a large extent established through empirical relationships and these could be translated into models. Lotka's population dynamics is a case in point. His models became a mainstay of systems ecology, which modeled energy flows and food chains in ecosystems. Introduced in the 1920s, they had been codified into textbook knowledge by the 1950s.[56] It didn't take long until these models were also directed towards the future, projecting or predicting more changes to come as rates of change themselves changed, mostly upward. The challenges that societies faced in their provision of energy, food, textiles, and natural resources such as water and timber and other raw materials were no longer framed by linear thinking, but rather by multidimensional mathematics. A key element was the increasing awareness that what made these interactions nonlinear was human activity. Societal

metabolism, consumption, and production, hyperactivated natural processes, or in some instances halted or even killed them. This was the case with species extinctions, then still a not so much modeled issue but steadily growing and inspiring many postwar conservationists, including ecologist William Vogt, a cofounder of the rising and soon prevailing understanding of "the environment."[57]

Furthermore, the rates of change in the many conditions of the earth—erosion, salinization, the accumulation of chemicals in water and soil, growth of atmospheric CO_2, etc.—formed patterns of *covariation*. A challenge, but also a pathway to success, was to conceptualize these as integrated phenomena across borders formerly guarded by different experts. The notion that oceans, atmosphere, ice sheets, soils, forests, wildlife, and even public health were interdependent, demanded a merger of disciplinary understandings of each, and the development of new principles. That human agency was recognized as a key factor behind the change helped explain the interest. Slowly but surely it became evident to these early environmental experts that they were trying to come to grips with the future of the earth as an integrated product of human impact. Ecology, which was so important to the self-understanding of the later environmental awakening, was part of this rapid evolution—as the work by Vogt and his contemporary fellow ecologist Fairfield Osborn testified—but by no means the only discipline involved. When, for example, systems ecology became important in the postwar years, much fueled by the war effort, it mirrored the same pattern that had already become established in other disciplines, with far reaching quantification based on comprehensive data collection in order to monitor change.[58] Sooner than one might think, "Anthropocene" impulses were released, as if the idea, once time and human agency had been combined in this environmental way, could only lead to the conclusion: humankind was "becoming for the first time *a large-scale geological force*."[59]

It soon became fairly commonplace to make this kind of statement. Geographers in particular made it a special tradition to identify the remarkable agency of human societies of all possible kinds and how they, aided by time and technology were able to transform nature into landscapes quite radically. The Princeton conference in 1955 abounded with examples of this metanarrative, which sat well with the equally prevailing modernization theory. Still, the latter had very few elements of environmental concern.[60] From the emerging environmental sciences came a very different message. Theirs were not necessarily times of progress. Vogt's and Osborn's books in 1948 already abounded with narratives of gloom and destruction. As the modern understanding of "the environment" came into circulation, more systematic predictions of future environmental change started to appear, soon providing a temporal genre of its own. It built on older tropes of decay,

decline, or apocalypse, but now it was supported by equations and masses of data and was persecuted by new strands of self-professed environmental expertise.[61] An early prediction of an ice-free Arctic sea in fifty years was made by US physicist Paul Siple in 1953.[62] The modeled temporalities could reach back to explain the past as well once it had been established that there were environmental times involved, based on human agency that had always been there. A seminal debate was conducted in the United States from the 1920s to the early 1950s when Berkeley geographer Carl Sauer could finally demonstrate that much of the American prairies were the result of elaborate aboriginal fire regimes, an understanding that ecologist James C. Malin and others had found implausible: primitive tribes just could not achieve such comprehensive undertakings.[63]

The middle decades of the twentieth century were important for this emerging environmental reading of material change and therefore, by implication, the idea that bio- and geochronologies were interwoven with societal times. This was a sea change, a profound disruption of the human-earth stability. The taken-for-granted nonanthropogenic orthodoxy still reigned as the dominant outlook, and although landscape change was accepted as a human achievement, the large majority of scientists held it out of the question that, as Nobel laureate physicist Robert Millikan put it in 1930, humans could bring "any titanic physical damage" to something as large as the earth, for whose protection God must also surely have provided "foolproof mechanisms."[64] But there were already then dissenting voices. One came from Russian scientist Vladimir Vernadsky who coined the concept biosphere in his book *Biosfera* (1926, in Russian), translated into French 1929; it was not translated into English until much later (1998), once the concept had already been adopted by UNESCO and Vernadsky had started a global career.[65]

In the 1940s, Vernadsky's ideas on the biosphere entered wider English-language circulation via Yale ecologist Evelyn Hutchinson. Modern man was eroding his own survival by wasting "parts of the *biosphere* which provide the things that Homo sapiens as a mammal and as an educable social organism needs or thinks he needs. The process is continuously increasing in intensity as population expands."[66] Of particular influence for this line of thought was the use of energy budgets, revived in the 1920s and with Lotka again in a pivotal role.[67] The temporal articulation was aided by the parallel, partly related process of configuring the biosphere into an "environmental object," which was yet another major scaling effort that asserted a sense of context or even holism.[68] Vernadsky held that human activities could affect the biosphere on a grand scale and that they had already done so through mass extinctions and the release of greenhouse gases. Many deviating voices were refuted or marginalized at the time, but in retrospect it is possible to see them as an inexorably assembling choir whose resounding voice would soon be heard.

Environmental times, without anyone ever using the concept, were in the mid-century decades from turning into a common understanding, a giant earth time machine, or rather a massive array of different temporal processes from the tiniest cell to the entire atmosphere or geological strata that all shared only one thing in common—their blind watchmaker who was neither God nor natural selection, but humans.

The turning point came right after World War II and meant a decisive turning away from previous orthodoxy into an understanding that humans could indeed, as it was to be framed in the Princeton 1955 conference, play a major role in "changing the face of the Earth." The conference was organized by broad-minded thinkers such as Carl Sauer and Marston Bates in Geography and the polymath planner and historian Lewis Mumford. A few quotes from the many contributions to this conference might serve as a token of the new orthodoxy that was now taking shape, or rather spreading to become an orthodoxy. In a powerful essay, by far the longest included in the conference proceedings volume and heralding his forthcoming *Traces on the Rhodian Shore* (1967), Berkeley geographer and intellectual historian Clarence J. Glacken observed that ever since Charles Lyell and his *Principles of Geology* (1830–33) there had been an understanding, percolating under the surface, that humans served as a geological force of some magnitude, and already in the early twentieth century "several geologists were calling man the dominant geological force of the planet." Terms like "psychozoic era," "anthropozoic era," and "mental era" were suggested by different authors. Vernadsky proposed "noosphere," echoing Jesuit paleontologist and philosopher Pierre Teilhard de Chardin's idealistic perception of the world humans shared with God.[69]

Climatologist C. Warren Thornthwaite, also president of the World Meteorological Organization since its inception in 1951, voiced skepticism to major human influence on climate but cited, in awe, a Soviet textbook of climatology from 1952: "Only under socialism has it become possible to exert a systematic and planned influence upon nature: draining marshes, lowering the level of permanent ice, irrigating deserts, and planting forests. The supreme form of planned influence upon nature and climate is a system of scientific procedures which the people have named Stalin's Plan for Reforming Nature."[70] In general, Thornthwaite disbelieved the prospects for such schemes, as much as he disbelieved the necessity for George Perkins Marsh's calls for prudence a century earlier. We may be able to change the face of the earth, but humanity will not be able to change climate, Thornthwaite still argued in 1955, when evidence to the contrary was emerging that indeed it was possible, perhaps inevitable, for humankind to massively impact future global temperatures.[71] In several other contributions to the Princeton meeting large-scale geoengineering projects were advocated to manipulate precipitation or the climate of

towns. Conventional modernization still held most of the turf, but the ice was about to break, quite literally.

Extending Times in Ice

So far in this chapter we have observed a set of critical moments in time when a range of economic, social, and epistemic contexts became manifest where the new *awareness* of the growth of anthropogenic times and rates of change took place in the environment. A question comes out of this observation: how did all these times relate to one another? One answer has already been implied: they were all part of the emerging environmental understanding of human surroundings and life conditions, which provided them with a common framing. If *Drosophila* multiplied in hours, soil erosion happened in days, glacial retreat required years, and an ice-free Arctic ocean could happen in just a half century. This endless variability of timescales still didn't hinder understanding since they all belonged in the same category of man-made temporalities that ultimately set new standards for societies as well as for life on earth in general as the human enterprise kept growing.

But there was another answer. The timekeepers of science were aware of the differences in timescales and they realized that there was a potential to be released if these could be better understood, perhaps even calibrated. Such "synchronization" sometimes expanded to translations of timescales discovered in one element, such as ice, clay, soils, or seeds to one of the others, or to processes such as melting, erosion, diffusion of vegetation, or the spread of disease.[72] Sometimes even the conflicts between proponents of different timescales of change worked on such translations to justify their argument. Such was the case with Sauer and Malin on the issue of the American prairies, and they were not alone. Scientists who had been working on natural variabilities in the Quaternary were understandably affected, sometimes provoked when botanists and ecologists arrived and suggested that what had been regarded as "natural" time was in fact part of the human and cultural timescale, hence environmental.

In the remote North Atlantic region, the production, and applications, of environmental times became unusually active in the postwar years. The geopolitical interest in the region was strong during the Cold War and resources flowed to geophysical research, including glaciology, but also to other environmental field sciences, and to climate science.[73] Decades of glaciological work in Svalbard and Fennoscandia had produced detailed knowledge on the decadal and centennial timescales, supplementing paleo-ecological time layers that went much further back in time and also encompassed vegetation studies. Interpretations could not always speak well to the rising environmental approaches which led to epistemic isolation and few contacts between

meteorologists and geophysical theorists who had already advanced far in the quest to understand climate variability over longer timescales, including anthropogenic climate change.

In only a few years this northern region became the place of multi-scientific approaches to temporal problems.[74] In the early 1950s Danish, Swedish, and American palynologists and botanists researched Greenland's paleoecology, observant on temporal comparisons. In addition, Danish, Swiss, and US glaciologists used the massive engineering infrastructures in the Camp Century site in northwest Greenland to produce the tallest ice core to date, almost 1400 meters.[75] What both of these lines of research offered was a temporal expansion, allowing for a climatic record reaching a hundred thousand years back in time.[76] In the 1960s and 1970s it was already well established that the rates of change of climate in the present was well in line with the most rapid changes in the past, hence ice cores could also become "climate change messengers."[77] These new rates of change were a case of environmental times, which led to new translations of recorded time into fields of knowledge far away from the ice, such as oceanography.[78] It was even possible to translate the ice core record to Greenland's short cultural history, as did Danish geophysicist and ice-drilling pioneer Willi Dansgaard who in his later career almost turned into a full-fledged historian chasing the roots of the demise of the Norse colonization in the Middle Ages.[79]

Environmental times led in many directions. The common denominator of these translations was that they enhanced possibilities of comparing and calibrating timescales that emerged from very different geographies and materialities so as to enable a comparative synchronization of the times that had become increasingly man made, but still required nonhuman, nonenvironmental baselines to make sense of and to determine the level of impact that humans had wrought. A community that specialized in this approach to time and materialities was Earth System Science, which started to form institutionally around 1980 and in due course produced a new, decisive articulation of the idea of the Anthropocene.

Environmental Times in the History of Synchronization

There is an even larger question coming out of this story that has to do with history as we conventionally understand it: these things that take place in the ordinary world of humans. If we accept, for the sake of the argument, that the characterization of environmental times and their emergence given above is reasonably true, how should we understand *this case* of synchronization work in relation to others? Or, of what larger pattern of synchronization is the synchronization of environmental times a part?

The concept "synchronization" was articulated by Norwegian Germanist scholar Helge Jordheim in the 2010s in a string of studies in the context of world and global history. Jordheim identified a particular need for synchronization of "the world" in the era of Europe's Early Modern global expansion. A first major process of creating a general time frame of a common humanity took place when Biblical time gradually collapsed and was replaced by times of cultures, "races," and nations unified by ideas of progress that would transform into a "modern" interpretive frame of time.[80] Multiple groups of actors contributed during this process and thus served as what we might call global synchronizers. Eminently of course, philosophers of time such as Giambattista Vico in the early and Johann Gottfried Herder in the late eighteenth century, but also navigators, mapmakers, and geographical thinkers such as Kant and Buffon, worked tirelessly to combine natural and geological timescales across world regions.[81]

Using Jordheim's concept, could we conceive of other strands and periods of synchronization work? As Vanessa Ogle has demonstrated, a wave of "pluralization" and "transformation" of time followed with the formation in the nineteenth and early twentieth centuries of a universal time linking continents and economies under a regime of global time zones, calendars, and rapidly developing communication technologies.[82] We could see this as a second wave of synchronization with primary agency now performed by astronomers and observatories—as described by Gustav Holmberg in Chapter 2 of this volume—representatives of major religions (Islam, Christendom), engineers, trade and shipping companies, banks, international organizations, and nation states. But, again, geographical knowledge played an important role by providing "new ways of thinking about global space" that brought geopolitical elements to universal time zoning (Alfred Mahan, Friedrich Ratzel, Albrecht Haushofer), or popularized versions of synchronized "Worldwide Interchange" (Friedrich Naumann).[83]

In the decades around 2000 the Anthropocene became what may be seen as the conceptual epitome of a third wave of synchronization. Although the Anthropocene concept itself appeared quite recently, the synchronization it represents had significant antecedents in the twentieth century, through material and geographically bounded work in the field. Anthropocene discourse, as it has been generated chiefly among the institutionally alert and successful Earth System Sciences, has rested on an integrative understanding of geophysical, biological, geo- and biosocial timescales, and how it informs the human-earth relationship thus has a prehistory with different sites and constellations.[84]

An essential precondition for this recent and still ongoing synchronization was the environmental times that had been articulated over the preceding

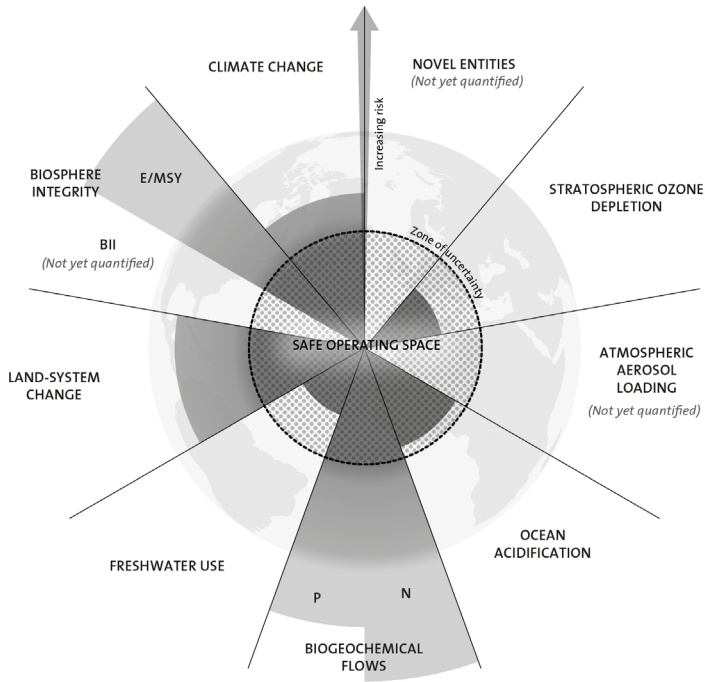

Figure 3.1 The Planetary Boundaries Diagram as a synchronizing device. The diagram summarizes the idea that the earth system has inbuilt boundaries, which must not be transgressed. The inner circle shows the safe operating space for nine planetary systems, while the darker wedges show estimated current positions for each variable. Although there are no numbers in the diagram, eight of the nine boundaries have been assigned a digit, for example 350 ppm for atmospheric CO_2. With rates and directions of change of the nine systems known, the diagram could also be read as a perpendicular "clock," synchronizing human-earth relationships in one single chart. The chart would then show how soon a boundary is likely to be reached. Or, for those earth system indicators where boundaries have already been transgressed, how soon the system can be brought within limits again, if effective environmental governance is provided. Credit: J. Lokrantz/Azote based on Steffen et al. 2015.

decades of the twentieth century. A case in point of one of the most significant achievements of Earth System Science is the idea of "Planetary Boundaries" published as an article in *Nature* in 2009 with many follow-up studies since then.[85] It argues that planetary stability can be subsumed under nine critical dimensions—such as rate of species loss, CO_2 levels in the atmosphere, ocean salinity, and six others—for which quantified boundaries are presented.

Each of the boundaries has been calibrated against a background of previous change and conclusions drawn from their past "performance." Their time scales of change differ wildly, and they did so in pre-Anthropocene, or even prehuman, times of (mostly) natural variability as well. The now emerging Anthropocene *Weltanschauung* builds significantly on environmental times identified and investigated in the past. More than that, without multiple environmental times established by previous work over generations, the idea would not have been conceivable. Hence, the planetary boundaries diagram with symmetry across all nine boundaries in a circular pattern can be readily seen as a *synchronizing and time-binding device*, a chart which brings on a seemingly uniform timescale to rates of change that actually differ considerably. Such devices are abundant in Anthropocene research where they serve the purpose of demonstrating, often in sharp, sometimes baffling detail how environmental times are predicated on human agency.

To understand these processes fully, and especially their interactions, it is required to pursue synchronizing work and to push it even further than the Planetary Boundaries chart, which is little more than a stylized sketch, suggests. That kind of work is necessary for us to understand more fully "the environment," "climate," and other major conditions of the world that humans inhabit and interact with. In fact, these conditions are now of such a major significance that we can consider their synchronization into a comprehensive understanding linked to human economic, social, and other processes of the planetary metabolism on a par with synchronizing "the world" and "global time" in preceding centuries. Ultimately, synchronization practices are necessary for humans to continue to inhabit the world where they are becoming more numerous, more mobile, and more demanding of resources and space for their *genres de vie*. The three waves of synchronization suggested here are neither exhaustive nor consecutive; there will surely be more waves articulated, and they will overlap to a larger or lesser degree. Their rationale may also be different. Environmental times and social times are rapidly becoming ever more integrated and both of them are times we cannot escape living in.

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