1

Exploring the Earth's Hidden Face

What is ecology? How does it perceive the world? The concepts developed by this science are partly used by ecologists: it is difficult to understand the second without knowing the first, especially because for some professionals in the discipline like François Ramade, applied ecology is the science about the ecological crisis [RAM 03]. The question of the relationships between human societies and nature is obviously older than this discipline, which emerged at the end of the 19th Century; the search for the origins of ecology as a science tends to be conflated with the debate about the causes of the ecological crisis that established ecologist political action. Broadly defined, ecology offers a reading of our industrial societies that is rather different from the ones provided by economics or even sociology: while these sciences focus primarily on the benefits of modernization and leaving underdevelopment behind, ecology reveals a growing and unsustainable footprint on the planet; a fact that remains globally as poorly perceived as it is poorly understood.

1.1. What is ecology?

Two French textbooks can serve as references: two volumes by François Ramade [RAM 03, RAM 05] and a more accessible book by Denis Couvet and Anne Teyssèdre [COU 10]. Both books refer to Ernest Haeckel's definition of ecology [HAE 84]. Ecology is "the global science of the relations of organisms with their exterior surrounding world in which we include, broadly, all conditions of existence" [RAM 03, p. 2]. The specific subject of ecology is the biosphere, which designates "the region of the planet in which life is possible on an ongoing basis and that includes all living

creatures" [RAM 03, p. 5]. It is a subset of the ecosphere, which includes the lithosphere (solid zone), hydrosphere (liquid zone) and atmosphere (gas zone). Relative to the enormity of the globe, the biosphere is an extremely limited zone: a few kilometers of maximum thickness, while Earth's radius is 6,400 km. Known life forms are never found outside of this thin layer, being dependent on fairly restrictive conditions, from a cosmological point of view, which explains why the Earth appears to be quite alone in the immensity of infinite space.

The biosphere is irregular and diversified. Apart from the physical environments (liquid, solid and gas), the term "biodiversity" appeared in the 1980s [MAR 16] to designate and consolidate three types of diversity: genetic (DNA), special (diversity of species) and ecosystems. A species is a set of individuals that can breed with one another, which results in a population [COU 10, p. 134]. A total of 1.7 million different species have been counted since Linnaeus (1707–1778) and tens of millions of others must still be identified, mainly among small organisms such as bacteria or insects. The average life span of a species is estimated at several million years; some, like sharks, are several hundreds of millions of years old. The ecosystem is everything constituted by individuals living in interaction (or "biocoenosis") and their chemical and physical environment (or "biotope") [COU 10, p. 11]. Ecosystems vary in size. The largest is the biosphere, then the biome: these are the rainforests, prairies or deserts that are distributed according to altitude and longitude. Land can also be classified in this way: mountain, steppe, tundra or the brown earth of the deciduous forests. The multiple subsets involved extend to ecosystems that are just a few square centimeters. The precise boundaries of the units are up for debate; division is a recurring issue because everything is connected with everything, hence the frequently used metaphor of the "web of life", suggesting the absence of seams; however, ecologists rely on criteria like the degree of internal coherence, interaction or interconnection.

In an ecological analysis, the organism is either not human or understood in a narrowly ecological way, out of concern for disciplinary and paradigmatic rigor as well as out of respect for the scientific division of labor. It is defined as "an elementary ecological agent, whose metabolism, actions and reactions (movements, dietary/reproductive/social behaviors, impact on habitat, etc.) contribute to transformations and higher levels of organization" [COU 10, p. 10]. Ecology is sub-divided into sub-disciplines: behavioral ecology focuses on interactions between individuals and their

environment; population ecology considers these interactions from the perspective of the dynamics and genetics of populations of individuals. The environment includes ecosystems, and physical and chemical influence factors like climate, soil composition, topography, water circulation or even mineral salts (phosphorus, nitrogen, potassium, calcium, magnesium, sodium and trace elements). Based on the characteristics of the environment and the individual, two limits (minimum and maximum) can be roughly set beyond which a given environment can be considered inhospitable for a given species, knowing that it is always possible for an individual to make temporary forays outside of their comfort zones. The environment evolves: the Sahara, lush during the ice age, became a desert. Species can move and adapt to new conditions, within certain limits.

Despite an apparent stability, everything circulates and everything is interconnected: the water cycle (transpiration, evaporation, precipitation, runoff, etc.) and gaseous elements (carbon, oxygen and nitrogen, which compose the atmosphere, the molecules of cells, etc.), and sedimentary geochemical cycles such as sulfur or phosphorus (indispensable for cellular reproduction) [RAM 03, p. 430]. It is a complex, multi-scale order, in which the physicochemical elements move at different speeds, different viscosities, determined by and determining the movements of the living world. Although everything is mobile, the biosphere also presents a remarkable stability and regularity: seasons return, populations of individuals, which do not stop proliferating, maintain relatively fixed quantitative relations with each other (large predators reproduce little, unlike their prey). Our body is an example of this stability in the permanent fluidity: after a space of two years, we no longer have one single identical atom; materially speaking, we are *entirely other*, and yet our social and psychological identity is preserved. Life also operates on a large scale: small blue algae generated the chemical composition of the atmosphere over billions of years and it is still the activity that maintains the current proportions between the different chemical elements carbon, nitrogen and oxygen. "From an evolutionary point of view, the biosphere as we know it today appears to be the result of an extraordinary combination of favorable cosmic, geophysical and geochemical circumstances" [RAM 03, p. 35]. This led James Lovelock to formulate the famous "Gaia hypothesis": that the biosphere is equipped with the same homeostatic properties as a living being [LOV 74, RAM 03, p. 34], even if the Earth does not eat or reproduce in the same way as an organism (for more detail, see [DUT 16]).

Ecology includes several theoretical frameworks and methods. Approaching ecosystems only from the perspective of the flow of matter and energy is eco-energetics [ODU 76]. Three distinct functional units emerge: autotrophs, which synthesize mineral elements with solar energy; producers, which transform light energy into chemical energy; and heterotrophs, which are either consumers (animals) or decomposers (bacteria and mushrooms). Knowing that energy only comes from the Sun and that every living being only converts the energy contained in its prey with losses, we can establish "ecological pyramids" from grass to large predators that show connections of dependency. Another way to see things is to proceed by observing populations, which reveals different interactions between species: predation, interspecies competition (rivalry for the same resource), antagonism, commensalism (B is the host of A), cooperation (mutualism – association with reciprocal benefits) and symbiosis. In symbiosis or mutualism, "the two organisms are related by links that are both structural and functional, the association being so direct that the symbiotic organisms generally cannot develop – or at least, they encounter greater difficulties surviving – without their host" [RAM 03, p. 272]. Ramade cites the example of micro-organisms that attach nitrogen to the roots of plants: without them, no plants; but without plants, no micro-organisms. Every species has a functional role in the ecosystem, occupying an "ecological niche" that indicates "the profession of the species" [RAM 03, p. 322]. Ecosystems are not static; they evolve, develop or, on the contrary, weaken. They demonstrate "resilience", that is, the capacity "to resist an exterior disturbance" [RAM 03, p. 394] such as storms, changes in climate and fires. Publications tend to establish a relationship between the complexity of trophic networks (that is, biodiversity) and the resilience of ecosystems.

Ecology also has an "applied" component that is found in the books of Ramade as well as in Couvet and Teyssèdre. Ecology intends to "scientifically" (that is, based on the concepts and methods of ecology) measure the transformations of the biosphere, particularly under the effect of a particular species that has played a major role for some time now: humanity. It distinguishes the "proximal" (or secondary) causes from the "distal" (or primary) causes: on the one hand, the practices that are directly involved in the evolution of ecosystems (such as cutting down trees) and, on the other hand, their more distant determinants like economic policies or the behavior of actors, which ecologists believe fall quickly outside of their field of expertise, obeying other logics than the ones they know how to deal with. Therefore, they limit themselves to measuring the effects on the biosphere.

The "applied" character of this component is also translated by the elaboration of solutions whose goal is to avoid the reduction of biodiversity or to restore it: this is the ecology of conservation or preservation (*in situ* or *ex situ*, for example in zoos or other locations such as the Svalbard Ark situated under a mountain in Norway) and the ecology of restoration. At an even higher level of interaction with human societies, the ecology of reconciliation mobilizes engineering and the economy to integrate biodiversity into decisions. The study of human values and behaviors requires implementing an interdisciplinarity that, when it becomes permanent, leads us toward the creation of new disciplines applied to human societies such as eco-energetics, ecological economics, the study of "socio-systems" or sustainability studies; there are many names around today. With the rise of ecologism comes the term "ecologist", which scientists claim in order not to be confused with activists [VRI 17, p. 36]; however, the debate over this issue still persists (for example, [GUI 14]). On this topic, we must underscore a distinction in the French debate: the term "ecologist" is reserved to designate scientists, while "ecologism" is the name of the activist movement; in English, "ecologist" designates both, including in this book. One way to overcome the difficulty is to call the activists "environmentalists"; however, in French, "environmentalism" is reserved for "light" ecology, which is concerned with proximal causes and not distal causes. In this book, we chose to preserve the English usage, and so the term "ecologist" designates both activists and scientists and the context makes it possible to distinguish between the two.

1.2. Ecology, a new science?

While attributing the creation of the word to Ernst Haeckel, French historians of ecology suggest that this author played no role in the constitution of the discipline as a modern science [ACO 88, p. 17, DEL 91, p. 8]. They all agree that ecology was gradually constructed like the other sciences at the turn of the century, each historian highlighting a given reference point that they deem more essential than another one. The British Ecology Society was a pioneering figure with its creation in 1913; the United States followed soon after and founded The Ecological Society of America in 1916 [ACO 88, p. 96]; the pioneers are Eugen Warming, Henry Cowles and Frederic Clements. Jacques Grinevald emphasizes, however, that the concept of the biosphere was invented in Soviet Russia by Vladimir Vernadski [VER 29, GRI 07]. In the case of France, the *Muséum national d'histoire naturelle* (MNHN) founded in 1793 played a major role in the study and protection of

nature, although it does not seem to have been on the cutting edge of the construction of concepts. It was a part of the continuity of the works of Buffon including the monumental *Histoire naturelle* in 36 volumes, which was a bestseller at the time. Étienne Geoffroy de Saint-Hilaire (1772–1844) accompanied Napoleon in Egypt and participated in building the wealth of the Museum's collections; this naturalist stated a half-century before Darwin that species evolved and transformed, in opposition to his colleague Georges Cuvier (1769–1832), who defended a fixist perspective. In 1854, his son Isidore Geoffroy Saint-Hilaire created the *Société zoologique d'acclimatation*, which became the *Société impériale zoologique d'acclimatation* (1855–1870) before taking the name of the *Société nationale de protection de la nature* (SNPN), which is still active today. The concepts of ecology were slowly introduced into French naturalist circles; a more detailed study of the evolution of these concepts remains to be conducted because historians have not detailed their circulation. Its appearance in the public space was more delayed; the concept of ecology retained a narrow and technical meaning until the 1970s [ACO 88, p. 19]. In their general public texts, trailblazing scientists like Jean Dorst (1924–2001) or Roger Heim (1900–1979), director of MNHN from 1951 to 1965, were more willing to speak about "nature" or "the environment", although the analyses deployed already borrowed extensively from the categories of ecological science, in terms of flow, interconnections, environments and populations.

The relative consensus of French historians about the evolution of ecology and its importance in challenging limitless growth masks serious disagreements when it comes to situating this science in relation to older issues. Essentially, if ecology concerns the relationships between organisms, who could do without these teachings, human or beast, under threat of condemning themselves to a rapid disappearance? The definition proposed by Haeckel does not break completely with the older definitions, particularly with the notion of the "economy of nature" proposed by Carl von Linnaeus (1707–1778); although it is fixist and creationist, nature is a place of continuous interactions. Haeckel was a disciple of Darwin, and it is above all on the explanations of long periods of time that they diverge: "Ecology or the geographical distribution of organisms [is] the science of all relationships between organisms in the surrounding world, with organic and inorganic conditions of existence; [it is] what we call the economy of nature, the mutual relationships between all organisms, living in one and the same place, their adaptation to the environment around them, their transformation through the struggle for survival, especially parasitism phenomena, etc. It is

precisely these facts about the 'economy of nature' that, in the superficial opinion of people around the world, seem to be the wise measures of a Creator carrying out a plan; yet these facts, say I, when seriously examined, necessarily result from mechanical causes. These are the facts of adaptation" [HAE 84, p. 551, DEL 91, p. 61, DEW 92, p. 500]. These interactions are not unknown either in "first nations", "aboriginal" or "indigenous" populations. The anthropologist Philippe Descola wrote extensively on this subject in France [DES 10, DES 86, DES 05, DES 14, DES 11], helped by or preceded by many others, in particular the ethnologist Robert Jaulin (1928–1996), who played an important role in the creation of political ecology, with the social psychologist Serge Moscovici (1925–2014). Ecology is therefore thought of as a *philosophia perennis*, an awareness that has always been present, in diverse forms, of which even non-humans are aware. The continuity is not total, of course; ecology is also a modern science, in the sense that it uses counting or instrumentation methods that are radically different from aboriginal knowledge (satellites, etc.); however, some aspects are similar, such as the observation of populations that is practiced by aboriginal peoples with great precision, up to the level of the non-human individual and its personality.

If we assume that knowledge is power, then the quest for the origins of ecology as a science (an applied science in particular) also interferes with the research about the causes of what is called the "ecological crisis" or "environmental crisis" [LAR 97a]. For the biologist Jean-Pierre Raffin [RAF 93], the forefathers are Alexander von Humboldt (1769–1859) and Georges Perkins Marsh (*Man and Nature*, 1864), of naturalist inspiration [DOB 12a]; for the ecologist Yves Frémion [FRÉ 07, pp. 19–29], it is the anarchist geographer Élisée Reclus (1830–1905); this claim of double natural and libertarian descent is also found in the English-speaking world, because for Donald Worster [WOR 09, p. 28], the pioneers are Gilbert White [WHI 13] and H.D. Thoreau (1817–1862). Others go back further and anchor ecology in another, spiritual framework; thus Lynn White Jr., for example, in an article published in 1967 and well-known in France, uses ecology to challenge Christianity, which put humans at the center of creation [WHI 02]. For the philosopher Catherine Larrère and the agrologist Raphaël Larrère, protecting nature is "a modern task" [LAR 97b, p. 175], which only appeared when humans were, thanks to the power of their tools, able to have an impact on nature that was disproportionate to what had been observed in the past. This list is not exhaustive but to the extent that defining its roots also overlaps with qualifying the problem, it covers the main possible positions:

universalist (the relationship of humanity to nature, in general), political (to the extent that knowledge is power, again) and civilizational or cultural (the specific question of industrial modernity).

1.3. What can we learn from ecology and the natural sciences?

Due to its theoretical framework, ecology considers the human species to be part of ecosystems the same way that other populations are, which is what makes its scientific identity unique; generally, it is reluctant to differentiate more, notably within humans, considering that to be the responsibility of social sciences like sociology, economics and political science. Considering human beings as a species is also one of the reasons that leads ecology to immediately position itself on a global scale: that of the biosphere. In 1975, the biologist Joël de Rosnay, future director of the *Cité des sciences et de l'industrie* (Paris) published *Le macroscope* [ROS 75], a book in which he states that we are now confronted with complexity and that the macroscope, in which ecology and the science of systems have a firm place, is the appropriate tool. De Rosnay is a prospectivist, a talented popularizer and a huge supporter of the systemic approach that characterizes one of the five currents of French ecologism, following Kerry Whiteside, and which includes Edgar Morin and the *Groupe de dix* (Henri Atlan, Jacques Attali, Jean-François Boissel, Robert Buron, Joël de Rosnay, Henri Laborit, André Leroi-Gourhan, Edgar Morin, René Passet, Michel Rocard, Jacques Robin, Jacques Sauvan and Michel Serres) who tried to formalize the "new paradigm" which is based on political ecology (complexity, etc.) [ROB 75, ROB 89, RIB 78, p. 27]. An ecological reading of the contemporary world shows that the human species has placed an enormous weight in the biosphere. We will provide a few points of reference here on the biosphere and the proximal and distal causes of its evolution, in French and British thought, on a global scale.

1.3.1. *The planet*

Generally, the ecological sciences show that the pressure of humanity and more specifically of industrialized societies on ecosystems has augmented regularly and even increasingly quickly since the mid-19th Century, to the point that the geologist Paul Crutzen created the hypothesis of a new geological era called the Anthropocene [CRU 02]. The term appeared in the 2000s in France, notably thanks to the works of the historian Christophe

Bonneuil [BON 16]. The Anthropocene means that humanity must now be considered as a geological force, whose scope equals that of other ecological processes like the carbon cycle, whether this provokes a feeling of victory or concern. The word is new but the sentiment is not; in 1952, Roger Heim, director of the Museum, published *Destruction et protection de la nature* [HEI 52] and then, in 1973, he published *L'angoisse de l'an 2000: quand la nature aura passé, l'homme la suivra* [HEI 73], which supported similar arguments; even earlier, in 1855, Eugène Huzar expressed concern about the possible implications of science for the future of humanity as a whole [HUZ 08]. In contrast, in 1868, Élisée Reclus praised trade and shipping routes, which he believed to be the means by which humanity would become self-aware: the idea that humanity had become a "geological agent" [REC 68, Tome 2, Chapter 3, p. 670] thrilled him. Indications of the influence of human populations on the global or biospheric scale include global warming, the thinning of the ozone layer, the destruction of biodiversity to the point that many scientists are discussing the sixth mass extinction of life on earth, and quantities of displaced material. We can read in scientific articles published in peer-reviewed journals that the 20th Century saw the disappearance of 260 times more species of vertebrates, 500 times more mammals, 200 times more birds and 300 times more species of fish than the ordinary pace of evolution; one out of every four species of mammals are endangered, as are one out of very eight species of birds, and more than one out of every three amphibians. Humans and their domesticated animals represent the incredible proportion of 97% of the total biomass of terrestrial vertebrates, which only leaves 3% for about 30,000 species [SMI 02, p. 284]. The human species uses 160% of the Earth's ability to renew itself [WWF 16]. The human appropriation of net primary productivity (HANPP) doubled over the course of the 20th Century, reaching 30% globally [VIT 86, HAB 07]; some areas like Europe and India are already at 40% and 65%, respectively. Pastures, crops and cities, which covered 5% of land surface in 1750 and 12% in 1900, represent almost 83% today. 83% of the biomes on ice-free land surfaces are partially or totally anthropized. The Millennium Ecosystem Report estimates that 60% of ecosystems are damaged or used by humanity in an unsustainable way [MIL 04].

The same report indicates the five proximal causes of this situation: overexploitation, pollution (pesticides and various chemicals), habitat transformation (for example, when a forest is cleared to make way for a prairie used for intensive farming), invasive species and climate change [MEA 04]. Some "distal" causes are also noted. Meat-based diets require

dedicating nearly two-thirds of land globally either to animals or their food, causing 18% of global greenhouse gas emissions; in order for 7 billion people to eat like a person in a developed country, it would require 20% more than the entire amount of land available on Earth, cultivable or not – at the current state of technology. The standardization of agriculture and livestock farming has caused a reduction in domestic biological diversity from 50 to 75%. A study published in *Science* showed that at the current rate, the oceans will be totally depleted before 2050 [WOR 06]. The lithosphere has also seen unprecedented changes. The consumption of oil, carbon and uranium has increased 40-fold between 1800 and 2000 [STE 11][1], mainly in industrialized countries. The depletion of the most concentrated deposits has led the industry to resort to riskier and more energy-intensive operations, often situated in poor or dominated regions. Copper production costs have been rising since the 1960s. The centralist engineer Philippe Bihouix showed that the depletions are interdependent because one of the ways of counteracting the depletion of material resources is to spend more energy, but inversely, more energy (solar panels, wind turbines, etc.) require using more materials [BIH 10]. Today, more than 10% of energy worldwide is used to extract raw materials, including the energy itself. The world motor vehicle fleet represents 1,000 billion tons; even if the Chinese have four times fewer than the French, per capita [SMI 02, pp. 186, 283–284]. These few figures also show a huge diversity in the responsibility of human beings: aggregate indicators, like the ecological footprint, reveal enormous inequalities, which are largely correlated to the degree of consumption of societies and individuals. These inequalities vary depending on the aspects considered in the biosphere (climate, biodiversity, chemicals, energy, etc.) and are not always based on income: one study showed, for example, that greenhouse gas emissions are primarily correlated to level of education[2].

1.3.2. *France*

This country has remained relatively on the sidelines of the process of evaluating the state of ecosystems and has only published one exploratory study [CRÉ 09]. The figures concerning France's ecological state are inadequate and contested, which has pushed the MNHN to increasingly resort to participatory research involving thousands of volunteers in the

1 http://rsta.royalsocietypublishing.org/content/369/1938/842, see the graph.
2 http://transports.blog.lemonde.fr/ 2014/11/ 03/ plus-on-est-diplome-plus-on-emet-de-co2-en-se-deplacant/.

observation of nature[3], not without protest from professionals against resorting to free labor. The official data suggests that half of all wild species are endangered. The state of habitat conservation is only judged to be "favorable" by national statistics in 20–30% of cases; in 35% of cases, they are "poor" and, in 38% of cases, they are "inadequate"[4]. These statistics only include "habitats of community importance" which only cover 12% of French territory. The best-preserved zones are the ones without any economic importance, like mountain peaks. The five causes indicated by the Millennium Ecosystem Assessment (MEA) are factors in this country. Overexploitation manifests notably by the elevated appropriation of primary production: HANPP amounts to about 50% on the national land, a calculation that only covers a part of French consumption, as demonstrated, for example, by the fact that this country can no longer meet its consumption using its only fishing zones, which are, however, very extensive: in 2016, the New Economics Foundation's "fish dependence day", which calculates the day of the year on which the national stocks would be depleted, was 30th May[5]. In 2008, the WWF revealed that France's biological footprint had doubled between 1961 and 2005, surpassing its national biocapacity by 60%, despite considering the huge Guyanese forest for the absorption of GHG emissions [WWF 08]. France emits the equivalent of 490 million tons of CO_2 greenhouse gases or 7.5 tons per inhabitant. The authorities highlight that this is one ton less than in 1990. In addition, the performance seems to be better than Germany, which is considered "green", but in reality emits 11 tons per inhabitant; the good French result seems to be due to the decent recourse to nuclear energy. Some associations have contested this view of things and insisted that the calculation account for transboundary exchanges [RAC 13]; in this case, France and Germany are tied, since France is credited with 10.6 tons per inhabitant. The difference comes more from the evolution of the French economy than from the atom: specialization in the service sector has made it possible to relocate the most polluting activities, while continuing to industrialize life styles. The two countries have emissions per inhabitant that are a great deal higher than those that would be generalizable on a global scale, because the recycling capacities of the biosphere per inhabitant are around two tons per inhabitant. France must therefore divide its emissions by

3 To the point that scientific publications derived from the volunteer work are now more numerous than those by professionals.

4 http://www.statistiques.developpement-durable.gouv.fr/indicateurs-indices/f/2491/0/etat-conservation-habitats-naturels.html.

5 http://neweconomics.org/2017/03/fish-dependence-2017-update/.

4 at the minimum and this is indeed the objective that is included in its legislation[6].

The proximal causes are more or less the same as the ones that were identified on a global scale. Industrial agriculture accounts for 40–50% of the French landscape: there are vast windswept fields nourished by massive mineral inputs creating a flow of tractors, trucks, planes and boats, hence an expenditure of 500 liters of fossil energy per hectare [BAZ 09], primarily related to mechanization and input (fertilizer and phytosanitary products). This is less than 1% of French consumption, but 20–60% of the cost of food products [OCD 11]. The productivity obtained by mechanization involves the simplification of ecosystems and the disappearance of a large part of domesticated varieties. The simplification of landscapes or "land redistribution" is a major cause of the decline of wild species. Birds, amphibians, etc. are deprived of their habitats; bird populations in agricultural landscapes have decreased by 30%. Other species are proliferating, like green algae, whose growth is stimulated by excess fertilizers, of which France is the seventh largest consumer in the world; it is also the third largest user of pesticides per hectare globally. The massive use of energy also makes agriculture a significant contributor to greenhouse gas emissions (approximately 20%); consumption of meat has practically tripled in a century (on average, from 30 to 100 kg per inhabitant per year) and livestock farming represents 56% of the emissions in the industry. French agriculture is caught up in the phenomenon of specialization of territories characteristic of industrialization, and Limousin, a major agricultural region, imports 90% of what it consumes [LAV 06]. The GHG emissions of food [SPI 12] amount to 1.5 tons of carbon dioxide per inhabitant: a figure close to that of emissions resulting from automobile use. Industrialization has also affected distribution: 85% of shopping is done in superstores, where stock is unaffected by the seasons. Food represents 30% of road freight flows and 40% of tonne-kilometers [MIN 17].

From a material perspective, on average, the French consume 46 tons per year per inhabitant, 60% of which is imported [COM 09]. According to the same official document, 70% of the French economy is based on exhaustible resources and although their extraction decreased by 4% in France between 1990 and 2006, giving credence to the idea of a "dematerialization", imports increased by 25%. Only one-quarter is recycled: France is behind on almost all

6 Law n° 2015–992 from August 17, 2015, concerning the shifts toward green growth.

the European directives on the subject, with the exception of glass and steel. With tertiarization, construction has taken first place in energy consumption: 42% of the total and 19% of national greenhouse gas emissions. Progress has been made on the old as on the new since the 1970s: between 1973 and 2001, the average consumption of older vehicles decreased by 44%; however, the effectiveness is compensated by the numerical growth and area, mainly consecutive to the decrease in the number of inhabitants per home (divorce, single parent families, etc.) [CAS 08]. In total, the sector consumes 50% more energy than in 1973. The increasing difficulty of extracting raw materials is the primary cause of the increase in construction costs, about 50% in ten years [TOM 13]. France is also affected by climate change: slightly more than 1°C over all of its territory. This translates notably into earlier harvesting dates and milder winters globally. Vegetation is very sensitive to climate, unlike cities which are not very affected or can react, often by using more air conditioning systems. Despite recurring droughts causing temporary restrictions in the agricultural sector, France has not seen significant difficulties with its water supply. The effects of climate change are therefore relatively minor as of yet, which contributes to hiding the issue.

A French household travels 20,000 km per year (or 10,000 km per vehicle), a distance that has not stopped increasing since 1950, with the exception of 2008, under the combined effects of the economic crisis and rising oil prices. Surveys show that lifestyles as a whole have become "motorized": work only represents 50% of travels; the rest include accompaniment (8%), shopping (10%), other personal affairs (9%), and hobbies and visits (23%) [RAU 06, COM 10]. Local travel[7] represents 99% of travel and 60% of mileage: it structures the lifestyles and spaces. Roads and parking lots represent 3% of the territory; between 1995 and 2005, urbanization grew by 17%, four times faster than the population. The pace of artificialization has not stopped growing, passing from 40,000 hectares per year in the 1960s to double that between 2006 and 2009. The area equivalent to that of a French department disappears on average every seven years. Commercial or tertiary zones have contributed to this increase, 60% of which takes place at the expense of the best agricultural land [COM 11]. Legislative systems are failing and agricultural spaces have not stopped being chipped away by urban populations, hence the conflicts between users [LEV 11]. Oil represents 95% of the energy used by the transportation sector. Road infrastructure uses about 18% of the GDP: 350 billion euros.

7 Defined as situated in a radius of 80 km as the crow flies.

Finally, lifestyles have been industrialized in a differentiated way: the upper classes have spent less carbon per euro, but they spend more. The impact of food is generally ignorant of the level of income, with qualitative differences: the upper classes are less dependent on the agri-food industry and pay for quality. All lifestyles are dependent on cars but higher incomes drive for more kilometers and tend to have "cleaner" cars. Equipment and habitats are also both dependent on high carbon content products, with some differences: multi-equipment and quality for higher incomes, and mass-produced products for lower incomes (Ikea, Decathlon, etc.).

1.3.3. *The United Kingdom*

This analysis will be quicker because many elements are similar, even if the trajectory of the United Kingdom in industrialization and development is unique. The country was one of the first to industrialize, which makes it a commonly studied case. Without going into detail, the United Kingdom moved from an economy that was strongly nationalized but damaged following World War II (cities bombed and empire lost), to a period of prosperity similar to what happened in France in the 1950s and 1960s with a slight "delay" compared to France in terms of household equipment or education. The oil crisis strongly affected the national economy and conflicts multiplied along with deficits and inflation. The United Kingdom was cornered and requested a loan from the IMF, which had some conditions. The arrival of Margaret Thatcher initiated a profound transnationalization of the economy through neoliberal measures, which provoked an increase in inequalities. Inflation was halted. Public assets, which are still numerous, were privatized; the conservative government showed itself to be extremely firm against the various forms of contestation. The country gradually deindustrialized to arrive at 80% services, which is comparable to France. GDP and population levels were also similar. 535,000 workers are employed in agriculture, which is very intensive: the numbers are very close. Coal consumption dropped from 157 million tons in 1970 to 37 million in 2015, and it is now entirely imported; there are only 2,000 miners. The United Kingdom has specialized in substantially different services from France, notably finance and pharmaceuticals; the country shelters oil multinationals (BP and Shell) rather than water and waste multinationals like Vivendi. 75% of goods purchased are manufactured outside of the country.

A general assessment of the state of its ecosystems also seems to be underway in the United Kingdom[8]. While awaiting the results, the Royal Society for the Protection of Birds highlighted in its 2016 report that 56% of British species have declined since 1970, whereas 15% of them are extinct or on the brink of extinction [RSP 16][9]. An article published in PLOS considered the two main causes to be agriculture and climate change, with urbanization curiously not seeming to be much of a cause [BUR 16]. The European Environment Agency published four separate reports for each part of the United Kingdom (England, Northern Ireland, Scotland and Wales)[10]; the global result was a recent decrease in greenhouse gas emissions in the order of 25% during the period from 1990 to 2015, due to several causes: moving from coal to gas, which is much more efficient in terms of energy produced per kilo of greenhouse gas; depletion of oil in the North Sea which led to importing it and therefore relocating the emissions; and the economic crisis of 2008. The demand for energy is stable, even down from the 1980s; this is also true for France. The effects of global warming are limited, even if the average temperature has increased. The UK's recycling rates are better than France's, particularly with a rate of 90% in construction. The United Kingdom is no more committed to renewables than France. River pollution has generally decreased.

British lifestyles are similar to French ones in ecological, material and energy terms, with a few differences such as lower urbanization, while resulting in similar densities; 5,000 inhabitants per km^2 for Greater London and 6,000 for the Paris region – on this subject, the Île-de-France region reflects exactly the average distribution of land use in the rest of the country between forests, agriculture and artificialized zones. Supermarkets were established in the 1960s with the same principles (parking lots, etc.), only the chains and signs are different. Automobiles in particular drive 12,000 km per year and the British have one for every two inhabitants, which is also comparable to France. There is a debate between historians over dating the consumer society, but there is a consensus that points to an acceleration in the middle of the 20th Century; a threshold that also makes sense in terms of the aggregate material and ecological impact, although for some variables like sulfur dioxide and urban pollution, the 19th Century may have been much worse. In terms of internal differentiations, the United Kingdom is

8 http://uknea.unep-wcmc.org.

9 http://www.rspb.org.uk/community/ourwork/b/biodiversity/archive/2016/09/14/state-of-nature-2016-summary-of-the-report.aspx.

10 https://www.eea.europa.eu/soer-2015/countries/united-kingdom.

distinguished by greater inequalities, and the UN's Economic and Social Council even pointed out their harmful implications in terms of respecting human rights[11]. Real wages have decreased in the United Kingdom since 2007, while they have significantly increased in France. However, the wealth of the richest 10% in France is greater than the comparable number in the United Kingdom: 50% versus 44%.

1.3.4. *What must be done? Three positions: green growth, degrowth and other development*

Andrew Dobson proposed differentiating between "light green" and "dark green"; the former acknowledges the issues but positions itself in favor of pursuing growth and finding cleaner technologies, while the latter challenges the first with three arguments: the insufficiency of technological solutions, the exponential effects of growth (which are counter-intuitive) and the interdependency of the issues, which invalidate all partial solutions [DOB 00, p. 62]. This typology can be transposed to the case of France, as suggested by Guillaume Sainteny [SAI 97, p. 57]: "The subject of ecology was first constructed, in its origin as in its tonality and appearance, as a fundamental critique of industrial society and its productivist, technocratic and consumerist aspects" that the pursuit of growth symbolizes. In 1973, the first ecological candidate at a presidential election, René Dumont, explained that "ecology is a critique of industrial society" and that it intended to "break an industrial growth that had become ridiculous and negative" [COL 78, pp. 10, 16]; "we must find a way to get out of the system quickly" [DUM 73, p. 6]. From there, a gradation from light green to dark green can be imagined, between those who believe that the problem must provoke a significant change in lifestyles and others for whom technology will find solutions, either because the problem is not that bad or because the solutions are more important than discerned by the supporters of the first approach.

The majority of Andrew Dobson's book is dedicated to the implications of a "dark" green position in various sectors of human activity: business that must be relocated to limit travel; agriculture that must become more local and more versatile ("organic"); decentralization and local resilience that goes against the endless expansion of the "megamachine" (an expression used by Serge Latouche [LAT 04] and borrowed from Lewis Mumford [MUM 50]); a reduction of energy consumption and a movement toward renewables; and

11 E/C.12/GBR/CO/6, July 14, 2016.

we could add new ways of living, with biodegradable materials, new ways of looking after ourselves, knowing ourselves (sciences) or dressing ourselves. As noted by Pascal Acot, ecologism is "a vision of the world and a lifestyle rather than a more or less organized movement in defense of nature" [ACO 88, p. 236]. Some areas are less in agreement than others; the changes to implement in matters of communication and new (digital) technologies are disputed, for example, between those who see a way to relocate and share ("the commons") [ROB 75, ZIN 06] and others who believe, on the contrary, that these are situated in the continuity of industrialization and that they must be rejected [FLI 12]. Moreover, Dobson noted these divergences, for example, between Rudolf Bahro who is very anti-technology and others like Jonathon Porritt who is less so [DOB 00, p. 84]. The references are also similar: the MIT report at the Club of Rome, which Dobson considered to be a major point of reference, also played an important role and was translated into French by a major publisher shortly after its publication [MEA 72]. French ecologist literature is full of "degrowth"-inspired texts, even if the word is not often used, starting with René Dumont's book, *L'utopie ou la mort!* (1973) or the success of Edward Goldsmith's book *Changer ou disparaître* [GOL 72]. The critique tends to fade away in the 1980s and 1990s before coming back in force at the start of the 2000s under the explicit banner of degrowth.

However, some movements that we could classify as "ecologist" do not advocate for either dematerialization or for a radical rethinking of growth. In the case of France, the *négaWatt* association in the field of energy or the *Confédération paysanne* in the field of agriculture can be considered as representatives of this third current. *NégaWatt* played a very important role in placing an energy scenario on the agenda that is not only 100% renewable but also very realistic [NÉG 17][12], in so far as the scenario does not foresee a massive reduction in travel or inhabited areas. The observation also extends to other domains identified in Dobson's analysis: an important movement wishes to preserve certain gains from modern technologies while criticizing the argument of dematerialization; he therefore suggests a "green growth" that would no longer be the growth of the GDP but that of new indicators such as the state of the environment, democracy or inequalities [GAD 05, MÉD 99]. The degrowth movement critiques these position as so many illusions, as illustrated by the positions in the journal *La Décroissance*, which is very critical toward the Greens in government and public figures like Nicolas Hulot. Some positions evolve, such as that of former Green party member Yves

12 https://negawatt.org.

Cochet, who began to use a catastrophist rhetoric starting in the 2000s, anticipating the collapse of the oil supply [COC 04], whereas before he had tried to maintain a certain circumstantial realism, even becoming a minister in Lionel Jospin's government. Considering more than two scenarios is also the tendency of the available scenario exercises such as the Millennium Ecosystem Assessment, which proposes four [MEA 04]: the TechnoGarden, which corresponds to dematerialization; the Adapting Mosaic, a radical version of which would correspond to degrowth, if it was chosen; Order from Strength, which would be an endured degrowth; and finally, Global Orchestration, which designates a successful global cooperation.

"Other development" is differentiated from the two previous currents in various ways. The catastrophist movement objects to its negative and weakly mobilizing dimension. On the contrary, as Yves Cochet claimed that he was never as listened to after he became a catastrophist, a strategic debate should be held on this topic. Supporters of "other development" object increasingly often that the realization of progress here and now requires convincing people about the utility of actions that are necessarily small scale, as a first step, because ecologists do not have a cultural or political majority or the material powers necessary to radically change lifestyles (building economical homes, relocating activities, etc.). The room to maneuver most often involves calling upon a "hummingbird" strategy, to use the expression popularized by Pierre Rahbi's movement[13]. However, "other development" concurs with the radical movement about the futility of the path of dematerialization, which it considers as an act of faith in technology. Two major arguments can be advanced against the digital, for example: its own ecological impact and the increasing consumption that it causes ("rebound effect") [FLI 12]. The idea that the service economy could present a lower ecological impact was overturned by Jean Gadrey, an expert in the field [GAD 10]. The carbon footprint of the education of a student at the University Paris 1 amounts to between 90 and 240 kg of carbon, for example, excluding the impact of trips made outside the Ile-de-France region[14], knowing that this travel represents nearly 75% of the emissions of the Télécoms school in Évry[15]. Many other examples can be found. Hence, 40% of the city of Paris' GHG emissions are also related to international tourism [APU 09].

13 https://www.colibris-lemouvement.org.
14 http://www.univ-paris1.fr/fileadmin/devdurable/bilan_carbone_up_1__131_pages__0ct_09.pdf.
15 Student report. Little work is available on these issues.

1.4. What should be taken seriously? Risk, relativism and constructivism

Everyone realizes that ecologism is based on the teachings of ecology, acknowledging a fairly broad meaning for this term, including engineering sciences (measuring the flows of matter and energy, similar to an Odumian vision of ecology), urbanism, ecological economy or even the contributions of associations and volunteers. Even if these concepts vary and do not always comply closely with the use that is made of them by ecological science, the connections are numerous; knowledge circulates, influences, is composed and recomposed, without being able to draw a clean boundary. This is not without difficulties: crowd-sourced sciences are strongly critiqued by some professional scientists who want to establish a watertight boundary between a "common sense" deemed "pre-scientific" that characterizes the profane and the methodological search for the truth over which the scientist has the entire monopoly; there are many conflicts and not without connections to political issues such as industrial interests or a certain vision of progress. The *Association française d'information scientifique*[16] (AFIS) and the academies of science[17] and medicine[18] are among the French institutions that are regularly in conflict with ecologists. The question of the climate has prompted very significant conflicts, such as a petition that was signed by 400 researchers in climate science following the publication of the book *L'imposture climatique* (2010), written by former socialist minister and geochemist Claude Allègre; the petitioners called upon, among others, the minister of research to react to the "false accusations" of their colleague[19]. A heated debate at the *Académie des sciences* opposed the climatologist Édouard Bard from the prestigious *Collège de France* to the geophysicist Vincent Courtillot, who defended positions similar to those of Allègre. There are many similar examples around genetically modified organisms (GMOs), nuclear power, endocrine disruptors, alternative medicines, vaccines, and many other questions related to ecological issues.

This situation leaves the general public and the social sciences on the sidelines: who should they believe, for lack of being a professional in that area? What should they think of ecologists? The catastrophes reported are

16 http://www.pseudo-sciences.org.
17 http://www.academie-medecine.fr.
18 http://www.academie-sciences.fr.
19 Huet S., "Climat : 400 scientifiques signent contre Claude Allègre", *Libération*, April 1, 2010.

hardly perceptible, for the moment, except through new reports and scenarios; the unconvinced citizen wonders what they ought to take seriously. How do they position themselves, between the three options stated in section 1.3.4 (degrowth, other growth and dematerialization)? How can they know what the future holds? How can they determine responsibility since the causes are also human? The difficulty posed by these debates is that they generally require understanding a set of complex arguments that concern not only ecological knowledge of environments but also the state of technological choices, the evaluation of possibilities, and the various implications on all these levels: democratic, sanitary, environmental or social. The many interactions explain that the systems and complexity are very present themes, not without a certain bandwagon effect; both insist on the specificity of problems including several parts or variables that are related to one another, with feedback loops and nonlinear or emergent effects, which also extend to the interaction of knowledge between them: interdisciplinarity and transdisciplinarity are necessary. The history of energy as traced by Jean Debeir, Daniel Hémery and Jean-Paul Deléage illustrates this integrative approach which does not often have the choice of proceeding any other way than *ad hoc* [HÉM 86]. We will return to the two main difficulties: the articulation of knowledge and underlying political issues. We will clarify certain issues around the concept of nature by distinguishing three main meanings.

1.4.1. *Social sciences and natural sciences: the "Great Divide"?*

Faced with the ecological issue, the social sciences have tended to support a radical constructivism, affirming that the concept of nature was entirely produced by human relations. The philosopher and sociologist Bruno Latour met with great success in 1999 by declaring the end of what he called "the Great Divide" which, according to him, meant that "nature [must] die" for political ecology to come into being, considering that it had never yet existed [LAT 99]. The statement, while excessive and pretentious (nothing seems to have existed before the arrival of the hero), did however translate fairly well the malaise felt by many social sciences faced with a concept of nature that they were accustomed to deconstructing and that ecologism asked them to take seriously, which appeared suspicious. The subject of the *Association française de sociologie's* conference in 2015 suggested, for example, as if it

were self-evident, that sociology was a science "against nature"[20], that is, what is presented as nature has always been constructed, and the work of sociology precisely consists of deconstructing it. In their articles, which are considered foundational in France, the sociologists William Catton and Riley Dunlap referred already in 1978 to Thomas Kuhn [KUH 08] to explain "the impasse" at which sociology found itself in their era when it tried to consider the question of the environment. Like Dobson, they suggested the existence of a "paradigm" problem to explain the lack of understanding shown by traditional sociology in response to the "new environmental paradigm" underlying the sociology of the environment that they hoped for. This criticized the "paradigm of human exceptionalism" [CAT 78] of classic sociology that starts from, or seems to start from, the premise that human beings are not in nature and that they are only determined by relations between humans, whether they are political, economic or social. Ecological concepts such as the "carrying capacity" of an ecosystem are therefore logically foreign to "standard" sociologists. These reasons are effectively why the sociology of the environment became a distinct epistemic community, notably in the case of France (for example, the sociology *of the environment*, with its own references and specific shared evidence [BAR 12]); Catton and Dunlap were mobilized to legitimize the domain, even if a tradition of rural sociology had similar positions, albeit less formalized [DOB 12a, p. 1, BIL 12].

Epistemologically, the constructivist theory finds its limit in the question posed by Ian Hacking [HAC 01]: the social construction of what? Hacking suggested that there are two kinds of objects: objects that are materially indifferent to the categorization to which they are subject (such as a rock) and objects that are interactive and can react (such as a nationality). The debate is vast and it did not wait for Hacking to crystallize in France. Unlike the physical, which is the background of Hacking's analysis and, more broadly, the Cartesian concepts of nature as a set of fixed laws, ecology has the specific characteristic that it is concerned with a set of objects (such as "the climate") that are only partially indifferent to the designation to which they are subject: there is only an "ecological crisis" because ecosystems are no longer what they were (factual) or because they are not as they should be (normative). It is because they are vulnerable and they can take on different states that ecosystems can be politicized, unlike the eternal laws of nature. Serge Moscovici addressed the subject in the 1960s, stating that human

20 http://afs-socio.fr/.

civilizations always have an interest in a "state of nature" that they partially produce and depend on [MOS 99]. Total constructivism results in a world without matter and without its own density, entirely dependent on human minds, like Philonous in the *Three Dialogues* by the Irish philosopher and Bishop George Berkeley (1685–1753). He believed that matter does not exist and he was led to put God himself as the direct basis of perceptions, which evidently poses a major problem for a scientific approach, for which the reference to nature specifically does not allow taking a position on the basis of Being. As suggested by Michel de Fornel and Cyril Lemieux, naturalism ("phenomena exist before and externally") and constructivism ("describable world phenomena do not exist previously and externally to the social work accomplished to categorize them") each draw strength from the other's weaknesses in reality [DEF 08, p. 9]. Constructivism risks relativism and losing what is real: everything becomes an illusion produced by the senses; while naturalism can impose realities that are only constructions. Naturalism and constructivism are more productive when they are articulated together like two moments in the knowledge process, always incomplete; and here the model proposed by Karl Popper is largely sufficient to circumvent the problem, including in the social sciences, because this author admits that they are not predictive but interpretive [POP 56]. Popper suggested that knowledge is the result of testing theories that can always be revised. We can complicate this further by adding that knowledge is inserted in larger systems that Thomas Kuhn calls paradigms. And what we have presented up to this point of ecology as a science and its implications regarding the state of the world and technical choices constitutes the background (or "paradigm") on which the discussion of a given point will break away in the ecologist debate, and that it will be very difficult to explain in a few sentences or show to a neophyte. Following Sartre, the subject is not purely arbitrary; it is choice, engagement, artificiality, which is determined from real-world issues, causes and consequences in which we are always complicit. It is therefore difficult to be a coherent anti-naturalist [HAB 06].

To summarize, the social sciences frequently conflate three definitions of the concept of nature. The first definition designates the essence of a thing: the nature of a horse is what is preserved beyond the diversity of empirical individuals. This issue of essence is classic in philosophy and it also opens a debate in natural sciences because the precise boundaries of species are subject to discussion, as well as their classification; certain cases such as viruses, the duck-billed platypus or the blob (*Physarum polycephalum*) still pose problems. It is common to consider that all the classifications have their

exceptions but the question of order remains. The debate is much livelier in the social sciences because human identity is very variable, related to extremely elaborate symbolical institutions, regardless of which society is considered: myths, laws, social roles, etc. The work of the social sciences being generally to deconstruct these orders, which are partially experienced as self-evident by the individuals studied, the undertaking of "denaturalization" is essentially integral to the profession; but as Bourdieu already stated about the university, the social sciences can also strengthen a certain order [BOU 79, BOU 89]. We can therefore distinguish critical sociology from a more positivist one that does not challenge the established order and its legitimacy. A second definition of nature refers to the totality of Being as secularized and emptied of the supernatural: the cosmos, the Big Bang, the nuclear center of planet Earth or quantum physics. The social sciences only rarely consider stating that the Big Bang is only a social construction; they very often accept the results, only potentially discussing its origin. Nature, in the sense of the greater whole, is opposed to the supernatural that designates, according to Kant, everything that is found beyond public and repeatable experience. "Nature" in the sense of ecologism falls under a third sense: that of the relations of humanity to its environment to the extent that it can be modified. Clearly, the issue does not directly concern the Big Bang nor quantum mechanics, nor even the cosmos in its entirety: it pertains to the much more limited space of the biosphere. This third sense is effectively woven from social relations because there is indeed someone who destroyed nature, whereas there is no one, from a scientific point of view, who is the author of the Big Bang, nor anyone who created the law $E = MC^2$ that describes the transformation of matter into energy and *vice versa*: not everything is constructed because there are many ecological causes and effects, for example the properties of CO_2 as greenhouse gases.

What is critiqued by the ecologists and researchers who focus on the ecological crisis is that social constructivism has a tendency to deny the existence of their object of political mobilization or study. Ecologism becomes a movement without a goal, strictly incomprehensible and absurd. The interpretation therefore tends to liken it to movements that are just as irrational and absurd. The remarks are fairly repetitive in this area; *La petite peur du XX^e siècle* by Emmanuel Mounier (1948), intended to critique Bernard Charbonneau and Jacques Ellul, constitutes a kind of handbook on the matter. He likened their remarks about ecology to the reaction of a person traveling in a car who does not know the first thing about it, and which breaks down [MOU 48, p. 18]: "It is an infantile reaction of incompetent and

panicked travelers". It generally invokes the myth of the sorcerer's apprentice that will inhabit human nature for all eternity and which ecologists only rehash without the least originality, just like the myth of the pact with the devil. The increase in power over nature is considered to be an increase in responsibilities; the power of humanity to destroy itself is integrated by Mounier in the passage of humanity to the age of maturity, at the end of childish innocence. What is implied is obviously that only immature beings can refuse this responsibility. The critique of the machine is likened to the reaction of primitive peoples to an unknown fruit, with a quote from Lévy-Brühl, famous theorist of the "primitive mentality" [LÉV 22]. The desire to protect nature is denounced as nostalgia for an eternal nature that never existed. Alluding to the Luddites, Mounier considers that by acting this way, "the worker reacts brutally, with a juvenile reaction, like a child breaks an object that hurt them. These worker reactions were spontaneous, lacking any justification, primitive to the strictest degree. […] The worker movement, after a few shake-ups at the start of the Industrial Revolution, remained overwhelmingly foreign" [MOU 48, p. 32]. Everyone will recognize several analyses of this type penned by less comprehensive social sciences.

More seriously, perhaps, total constructivism in knowledge often goes hand in hand with total constructivism in the transformation of nature: it is this sequence of the establishment of facts to the establishment of norms that Frédéric Neyrat recently pointed to by identifying an "unconstructible part" of the Earth [NEY 16]. This point is, of course, found in Mounier, who does not doubt for a second the reality of technical mastery. The constructivist argument is transformed into a technophile and productivist bias: if everything is constructed, in law, then everything must be able to be, in fact. The sociologist Alphandéry and his colleagues, although rather sympathetic with the ecologist movement, yield to this falsely neutral position when they consider that Westerners should be "convinced of being threatened by ecological catastrophes, persuaded of the dangers that weigh on the planet and worried about the world they will leave to future generations" [ALP 91, p. 5]. They "should be" "convinced" and "persuaded": this is an opinion that seems to be based on nothing precise and therefore seems irrational. The "convinced" are separated from the "skeptics" who alone enjoy a rational attitude, because it is characterized by doubt and therefore reflexivity. Neutrality would therefore consist of doubting the existence of an ecological crisis; however, this argument is no less engaged with the state of the world than the one that, on the contrary, supports the position that the

problem is serious. Doubting climate change has no more "scientific virtue" than doubting the imminent arrival of nuclear fusion.

The unease not only arises from the fact that the natural sciences are difficult to understand, criss-crossed by confrontations, with various positions and uncertainties related to the state of research at a given moment, likely to evolve at a later date, or even masked interests such as industrial or public funding, or simply professional issues; but it also comes from the fact that establishment of proof involves reasoning only on past facts, whereas it is the future that concerns ecologism. The sciences are invalidated by this dimension of the future that they cannot objectify because it has not yet occurred. Hence, the foundational dimension of the MIT report to the Club of Rome [VIE 11]. It would be tedious to cite all of the scenarios that could have been made in the domains of agriculture [INR 09], energy [NÉG 17, AIE 17], transportation [SCH 09], habitats [CHE 10], polluting emissions like greenhouse cases, information technologies [GES 08, FLI 12, BIO 08], ecosystem uses, etc. Their multiplication reinforces the ecologist claim of a "paradigm shift" since this effort to clarify the future indicates that it is not self-evident. Ecologism played a major role, from this point of view, in institutions; we mentioned *négaWatt*, founded by ecologists, including Pierre Radanne who was in the Friends of the Earth in the 1970s, but we could also mention the journal *Futuribles* (a contraction of "future" and "possibilities" in French), launched in 1960 by Bertrand de Jouvenel, also known for being the author of foundational ecologist texts such as *Arcadie* [DEJ 02a]. The fact of taking the possibility of a "catastrophic" future seriously is a methodological choice that does not necessarily lead researchers who are interested in it to become ecologists on a political level: these are some hypotheses among others about facts that will occur in the future.

1.4.2. *Expertise and public decisions*

The debates are often opaque and disagreements between experts leave citizens hanging: who should they believe? Who should they trust? Where is the truth? How can they know if these are fanciful hypotheses or, on the contrary, reasonable expectations? What are the experts' interests, what are their personal convictions, and how can they be distinguished from the knowledge they provide? The debate turns toward the issue of public decision, expertise, risk and critique of progress, the reason for which Kerry Whiteside was right to highlight the pioneering work of Denis Duclos [DUC 89, DUC 91,

DUC 93]. According to ecologism, the agenda for development as a "long-term endogenous and cumulative process of progress, productivity, and reduction of inequality […] allowing an increasing number to move from a situation of precariousness, vulnerability and insecurity to a situation of greater control over uncertainty, instability and the satisfaction of basic needs" [HUG 06] is in crisis, because the means (increasing productivity) is in conflict with the ends: reducing inequality and instability. Industrialization and modernization now generate inequalities, risks and fears instead of reducing and alleviating them. If we have confidence in ecology, then it is a great symbolic break, as underscored by Ulrich Beck in a best-selling book which considered that economic progress, technology and individual progress have gone hand-in-hand since the World War II [BEC 01, p. 431]. In as much as the risks incurred are "new", as suggested by Godard *et al.*, they are not very objectifiable, calculable, perceptible or controversial; they can be "major" (wide range and low calculability), susceptible to threshold effects (brutal, nonlinear change), or insidious, as with pesticides and endocrine disruptors [GOD 02].

No relativism is possible, if not in bad faith, as suggested by Sartre; we are engaged, the question is to find out in what. The fact of only concentrating on the representations of actors leads to what Catherine and Raphaël Larrère call a "sociocentrism", that is, a focus on the social management of risk, rather than on the risk itself [LAR 97b, p. 114, LAR 12]. On the contrary, the heuristics of fear evoked by Hans Jonas in his *Principe responsabilité* [JON 90] involves taking the worst scenario seriously. And far from being a philosophical problem reserved to a few specialists, it is a practice that is spreading, at all levels of governance, through future-oriented exercises: regions, cities, companies, etc. The possibility of different technological futures leads to reintroducing democracy in "technical" domains when it appears absent or insufficiently present, a thought which gave rise to various publications [CAL 01, FEE 99, SCL 03]. Denis Duclos proposed defining ecologism as a form of restoring modes of scientific and technical risk control to civil society [DUC 89, p. 216]. A recurring concern from ecologists is that the political class is united around the "technological fortress" [DUC 89, p. 228], and is content to gamble on wisdom, following the example of Raymond Aron: "There is nothing to prevent us from imagining the dissemination of wisdom at the same time as nuclear weapons" [ARO 69, p. 209]. Patrick Lagadec demonstrated with empirical data that the French authorities indeed have a tendency to practice denial and shut down when faced with new risks [GOD 02, p. 30]. One of the most famous and the

most caricatured is the matter of the Chernobyl cloud: while all the bordering countries were putting confinement measures in place, in April 1986, the authorities declared that France was not affected, although it is now known that the regions in eastern France were 8–10 times more exposed than those in western France.

From the citizen's perspective, the problem resides in the expertise, that is, in the passage from the sphere of natural or social sciences, where many contradictory hypotheses are proposed, discussed and confronted (sometimes violently) and may still be for a long time, to the sphere of politics, where decisions are made, in a context where time passes with a certain irreversibility – we cannot, for example, massively extract carbon from the atmosphere, and no one can see how to cool an Earth whose temperature has risen from 4 to 6°C. Thus, ecological questions generate multiple systems of expertise, from the Intergovernmental Panel on Climate Change (IPCC) to citizen conferences such as the one organized in 2002 about climate change by the *Commission française de développement durable* presided over by Jacques Testart. Citizens have shown themselves to be capable of learning and understanding very quickly. They hierarchize information and theories: the report submitted by the citizen conference is very well argued. The problem is that expertise is rarely exemplary: on the contrary, it is hotly disputed, invaded by particular interests. Beyond expertise, the question of the construction of what Joseph Gusfield calls a "public problem" [GUS 09] is posed: making the climate or GMOs a question in media agendas [COM 15]. There again the clashes are heated, between industrial interests that see above all a threat to their investments and a civil society that plays with expertise, stunts or civil disobedience to compensate for its small size and construct a counter-legitimacy. This desire to politicize issues that are deemed "technical" by other political movements leads certain authors to talk about "technical democracy" [CAL 01, FEE 99, SCL 03] and the implementation of various systems of participation that are also criticized as sometimes being only instruments that legitimize decisions that have already been made by the population.