CHAPTER 6

Thanatocene: Power and Ecocide

As the twentieth century progressed, wars became both deadlier and more frequent.[1] The First World War killed more than all the wars of the nineteenth century had together, while the Second World War alone made up half the number of dead in the past 2,000 years of warfare.[2] Advances in productivity and in destructiveness went hand in hand: the cost of destruction steadily decreased throughout the nineteenth and twentieth centuries. In relation to its destructive power, military technology has never been so cheap. Besides, from the eighteenth century on, West European states considerably expanded their tax-raising powers. Historians estimate that Great Britain, particularly precocious in this field, already mobilized 20 per cent of its GDP for war-making in 1800.

War has thus become more affordable, particularly for rich states. Statistical analysis of wars shows that in the twentieth century the richest countries have tended to be at war more often than the poorest: the top third of countries in terms of wealth have been responsible for half the wars of the twentieth century. Before 1914, on the other hand, the richest countries tended to be less frequently involved in

1 Mark Harrison and Nikolaus Wolf, 'The Frequency of Wars', *Economic History Review*, 65:3, 2012: 1055–76.

2 Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*, Cambridge: Cambridge University Press, 2001, 8.

armed conflicts. The United States, for example, was involved in 9.3 per cent of all wars between 1870 and 1945, and 11.2 per cent in those since then.[3]

In the twentieth century, moreover, the rich states waged wars of a totally different kind from any in the past. Their troops were supported, and to a certain degree replaced, by extraordinarily powerful machines fed by colossal industrial, technological and logistic systems, war machines that required growing quantities of raw materials and energy and had an unprecedentedly heavy impact on the environment.

Even in peacetime, military-industrial complexes destroy. The Cold War, for example, saw a peak in the environmental footprint of armies. By the late 1980s, military training camps, often polluted with radioactive waste, munitions, etc., covered 1 per cent of the Earth's surface (including 2 per cent of the United States). The maintenance and training of Western armed forces consumed enormous quantities of resources: 15 per cent of West German air traffic, for example, was linked to NATO military exercises. In 1987, the American army was responsible for 3.4 per cent of the nation's oil consumption, comparable figures being 3.9 per cent for the Soviet Union and 4.8 per cent for the UK, as well as 1 per cent of all coal and 1.6 per cent of electricity. If we add to this the carbon dioxide emissions bound up with arms production, then between 10 and 15 per cent of American emissions during the Cold War were attributable to the military.[4]

Efficiency has a very different meaning when the object is to kill rather than be killed. The development of contemporary weapons systems illustrates the tendency to energy exuberance that is intrinsic to the military. During the Second World War, General Patton's Third Army consumed one US gallon of petrol (3.7 litres) per person per day. This figure reached nine gallons during the Vietnam War, ten gallons for Operation Desert Storm, and fifteen gallons during the Second

3 Harrison and Wolf, 'The Frequency of Wars'.

4 Michael Renner, 'Assessing the Military's War on the Environment', in Lester Brown (ed.), *State of the World 1991*, New York: Norton, 1991. See also John R. McNeill and David S. Painter, 'The Global Environmental Footprint of the U.S. Military, 1789–2003', in Charles Closmann (ed.), *War and the Environment*, Austin: University of Texas Press, 2009, Chapter 2.

Gulf War. Present-day military technologies have reached unheard-of levels of energy consumption. An Abrams tank in the US Army burns four litres per kilometre. A B-52 bomber burns 12,000 litres of jet fuel per hour, and an F-15 fighter 7,000 litres, comparable to the consumption of an average family car in a whole decade. In 2006, the US Air Force consumed a total of 2.6 billion gallons of jet fuel, as much as was used overseas during the whole of the Second World War.[5]

The basic transformation of the Western way of making war, its deep integration in the industrial system, the way in which the military are embedded in research and development,[6] all underlie the argument of the present chapter that the Anthropocene is also (and perhaps above all) a Thanatocene.[7]

A natural history of destruction

On 27 July 1943, at 0100 hours, the Allies dropped 10,000 tonnes of incendiary bombs on Hamburg. By 0120 the city was consumed by a fire-storm that rose to a height of 2,000 metres. The writer Hans Erich Nossak, in one of the rare eyewitness accounts of the immediate post-war years, emphasized the ecological consequences of the Allied 'strategic bombing'. During autumn 1943, in Hamburg,

> rats and flies ruled the city. The rats, bold and fat, frolicked in the streets, but even more disgusting were the flies, huge and iridescent green, flies such as had never been seen before. They swarmed in great clusters on the roads, settled in the heaps to copulate on ruined walls.[8]

5 Sohbet Karbuz, 'US Military Energy Consumption – Facts and Figures', resilience.org, 21 May 2007.

6 Amy Dahan and Dominique Pestre (eds), *Les Sciences pour la guerre. 1940–1960*, Paris: Éditions de l'EHESS, 2004.

7 For more long-term historical perspectives on the link between war and environment, see John R. McNeill, 'Woods and Warfare in World History', *Environmental History*, 9:3, 2004: 388–410; Richard Tucker and Edmund Russell (eds), *Natural Enemy, Natural Ally: Toward an Environmental History of War*, Corvallis: Oregon State University Press, 2004; and Joseph P. Hupy, 'The Environmental Footprint of War', *Environment and History*, 14:3, 2008: 405–21.

8 Hans Erich Nossak, 'Interview mit dem Tode', 1948, quoted in W. G. Sebald,

In 1945, after visiting the ruins of Cologne, Solly Zuckerman, a zoologist and one of the founding fathers of British operational research, had the idea of writing an article on the environmental consequences of strategic bombing. In his memoirs, he explains that he abandoned this because the absolute desolation that he had witnessed 'cried out for a more eloquent piece than I could ever have written'.[9] Zuckerman had proposed to his publisher an intriguing title: *The Natural History of Destruction*.

Perhaps out of respect for human victims, historians have generally not taken up this project. So, if specialists in warfare study the environmental circumstances of battles (the role of terrain, the Russian winter, the impenetrable Ardennes Forest, etc.), the environmental consequences of war are far less well known, i.e., the effects of bombing, trench warfare, artillery or incendiary devices. Besides, the distinction is scarcely satisfactory: mud, for example, all-pervasive in the European wars of the twentieth century, is more an effect of the destruction of soil by the passage of military vehicles than a pre-existing characteristic of the terrain.[10] Likewise, it is because forests played a fundamental defensive role (from the war of position in the Ardennes in 1914 to the guerrilla tactics of the Viet Cong) that they have suffered so much from warfare.

Contemporary observers of wars were well aware of the environmental devastation these caused. In France in the 1820s, for example, the Revolutionary and Napoleonic wars were blamed for the reduction in forest cover as well as for the cooling of the climate. If the armed forces of modern times were always very greedy in terms of timber for ships and guns (around 50 cubic metres of wood were needed to smelt one tonne of iron, or the annual sustainable production of ten hectares of forest),[11] the industrial wars of the twentieth century devoured still greater quantities: in 1916–18, when German

On the Natural History of Destruction, New York: Modern Library, 2004, 35.

9 Ibid., 32.

10 See Clyde Edward Wood, *Mud: A Military History*, Dulles: Potomac Books, 2006, 10–13.

11 Rolf Peter Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution*, Isle of Harris: White Horse Press, 2001, 64.

U-boats interrupted Britain's trade routes, the country had to fell nearly half of its commercial woodland in order to satisfy military needs.[12] Similarly, during the Second World War, Japan lost 15 per cent of its forests.[13]

Because it came into the calculation of war reparations, French engineers of the 1920s studied very closely the woodland devastation of the First World War. They distinguished between losses due to exceptional felling (two years' production), losses by direct destruction (50,000 hectares),[14] and losses of woodland made unusable by gunfire.[15] A total of 3.3 million hectares of agricultural land were also affected by battles. Trench warfare left a soil that was sterile, full of metal fragments and unsuited for agriculture, though it would be the object of reforestation in the 1930s. The volume of earth churned up by artillery (up to 2,000 cubic metres per hectare) was equivalent to 40,000 years' natural erosion.[16]

On top of these palpable consequences, deliberate environmental destruction and its tactical and strategic role is a subject still in need of exploration. The 'scorched earth' practices of the nineteenth and twentieth centuries, whether offensive (during the American Civil War, the US invasion of the Philippines, the Boer War, the second Sino-Japanese War) or defensive (the German Operation Alberich of 1917 in the Somme, the opening of the Yellow River dikes by Chiang Kai-shek's troops in 1938, Stalin's destruction of Soviet resources in 1941), should be analysed as environmental phenomena.

12 A. Joshua West, 'Forests and National Security: British and American Forestry Policy in the Wake of World War I', *Environmental History*, 8:2, 2003: 270–93.

13 William Tsutsui, 'Landscapes in the Dark Valley: Toward an Environmental History of Wartime Japan', *Environmental History*, 8:2, 2003: 294–311.

14 Jean-Paul Amat, 'Guerre et milieux naturels. Les forêts meurtries dans l'Est de la France 70 ans après Verdun', *Espace géographique*, 16:3, 1987: 217–33, and Jean-Yves Puyo, 'Les conséquences de la Première Guerre mondiale pour les forêts et les forestiers français', *Revue forestière française*, 56:6, 2004: 573–84.

15 In the 1960s the French forestry office established a triage system to record timber that was unusable due to munitions remnants.

16 Paul Arnould, Micheline Hotyat and Laurent Simon, *Les Forêts d'Europe*, Paris: Nathan, 1997, 114.

The Vietnam War is certainly the most well known and best documented case in which destruction of the enemy's physical environment constituted a pre-eminent military objective. It was at this time that Barry Weisberg coined the term 'ecocide'.[17] The American infantry could only advance with the aid of 'Rome plows', powerful bulldozers that grubbed up forests and crops. A special six-tonne bomb, the Daisy Cutter, was also developed, with a shock wave that could instantly create zones for helicopter landing in the middle of the jungle. An estimated 85 per cent of the ammunitions used by the US Army were targeted not at the enemy but at the environment sheltering them: forests, fields, cattle, water reserves, roads and dikes.[18] In 1972, the French geographer Yves Lacoste showed how the US Air Force bombed the dikes of the Red River Delta at its widest part in order to maximize the devastating effect on the population.[19] As he put it, geography and environmental sciences were used above all to make war.

Noting the inability of incendiary bombs and napalm to destroy the humid Vietnamese forests, the US Army finally sprayed defoliants developed from agricultural herbicides (Monsanto's 'Agent Orange'), the mutagenic effects of which on the human population still persist nearly half a century after the end of the war.[20]

It is estimated that 70 million litres of herbicide were sprayed between 1961 and 1971, contaminating 40 per cent of Vietnam's arable land, while the country also lost 23 per cent of its forest cover.

Vietnam was also the theatre of a major project of climate engineering. Between 1966 and 1972, in order to cut the Ho Chi Minh trail running from China to South Vietnam, the US Army carried out more than 2,600 aerial missions with the aim of inducing artificial rain by

17 Barry Weisberg, *Ecocide in Indochina: The Ecology of War*, San Francisco: Canfield Press, 1970.

18 Greg Bankoff, 'A Curtain of Silence: Asia's Fauna in the Cold War', in John McNeill and Corinna R. Unger (eds), *Environmental Histories of the Cold War*, Cambridge: Cambridge University Press, 2010, 203.

19 Yves Lacoste, *La géographie, ça sert, d'abord, à faire la guerre* (1976), Paris: La Découverte, 2012: 60–3.

20 Thao Tran, Jean-Paul Amat and Françoise Pirot, 'Guerre et défoliation dans le Sud Viêt-Nam, 1961–1971', *Histoire et mesure*, 22:1, 2007: 71–107.

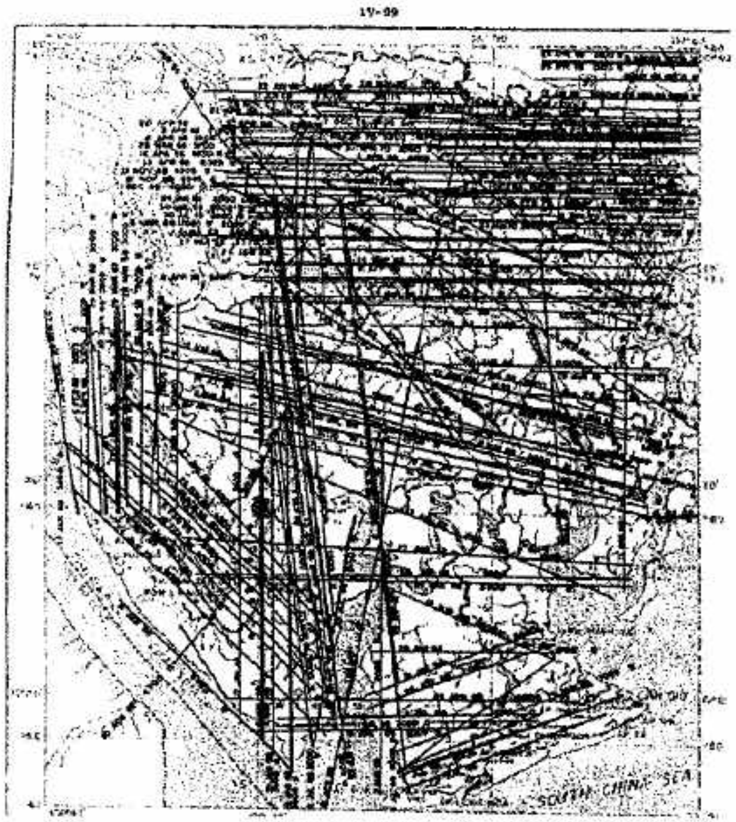

Figure 9: *Defoliant spraying in South Vietnam, 1968–1970*

cloud seeding. At a time when America was mired in the Watergate scandal, revelation of this secret climate war aroused great emotion, and the USSR pressed home its advantage by taking the question to the UN. In 1977, the General Assembly adopted a convention, still in force, forbidding 'the hostile use of environmental modification'. Despite its basic focus on military use, this convention also prohibited 'deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space'. This text is the most

solid legal basis for banning experiments of climate engineering that are currently projected with a view to countering climate change.[21]

If the case of the Vietnam War is the best known, it is far from being unique: the destruction of enemy resources and environment was a constant in Cold War conflicts. In 1950, the British Army began to experiment with defoliants in Malaysia, to prevent their Communist opponents from carrying out agriculture in the jungle. During the Korean War, the US Air Force systematically bombed dams and irrigation systems. North Korea lost 75 per cent of its water supply. In Afghanistan, Soviet forces also targeted irrigation systems, and close to half the Afghan cattle were killed during this war.[22]

Napalm, an incendiary mixture of oil and gelling agent invented by the Harvard chemist Louis Fieser in 1942 with support from the DuPont company, played a central role in the ecocides of the Cold War, by its capacity to burn vegetation – as well as the people this sheltered – over large areas. Used already in the Pacific War, it was employed on a massive scale in Korea (32,000 tonnes), by the French army in Vietnam and in Algeria (where two-thirds of French planted forests were destroyed) and by the British against the Mau Mau Rebellion in Kenya.[23]

Brutalizing nature

Generalizing somewhat, we could hypothesize that war, by creating a state of exception, has justified and encouraged a 'brutalizing' of relations between society and environment.[24] If nuclear weapons are the most palpable example of this, the 'scorched earth'

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21 James R. Fleming, *Fixing the Sky*, New York: Columbia University Press, 2010, 179–88.

22 Bankoff, 'A Curtain of Silence', 226.

23 Robert M. Neer, *Napalm: An American Biography*, Cambridge: Belknap Press, 2013, 91–108.

24 The concept of brutalization was introduced by George L. Mosse to describe the banalization of violence brought about by the First World War. See *Fallen Soldiers: Reshaping the Memory of the World Wars*, Oxford: Oxford University Press, 1990.

policy of modern war should also be studied as both ideology and practice. In 1940, British MPs pressed Kingsley Wood, the air minister, to destroy the Black Forest by incendiary bombs. And it was likewise in terms of biotopes that Churchill explained the meaning of the total war he was waging: to 'make Germany a desert'.[25] It is a revealing fact that the most severe punishment envisioned for Germany was an environmental one: Henry Morgenthau, the US Treasury secretary, proposed to convert Germany into a country 'primarily agricultural and pastoral in character'.

Besides the immediate theatre of operations, war preparations and the organic link between the military, R&D and technological choices have played a fundamental role in the arrival of the Anthropocene.

Certain connections are so self-evident that they have scarcely been studied up till now. By learning to kill humans in an efficient fashion, the military have also learned to kill living things in general.

In the second half of the twentieth century, for example, fishing techniques were indirectly revolutionized by the military. Nylon, which made it possible to manufacture nets several kilometres long, was closely linked with the Second World War – developed by the DuPont company to replace Japanese silk in producing parachutes, bulletproof vests and special tyres. After the Second World War, mechanisms for detecting enemy ships and submarines were applied to industrial fishing. Acoustic detection, radar and sonar, followed by GPS (a Cold War creation), multiplied fishing capacities exponentially and made deep waters and ocean trenches accessible. Moreover, this expensive equipment started a vicious circle, as it was necessary to capture ever more fish to make it profitable.[26] World catches increased by an annual 6 per cent in the 1950s and '60s before declining from 1990, when the application of technology no longer

25 Quoted in Jörg Friedrich, *The Fire: The Bombing of Germany 1940–1945*, New York: Columbia University Press, 2007, 61.

26 Philippe Cury and Yves Miserey, *Une mer sans poissons*, Paris: Calmann-Lévy, 2008, 112–13, and Paul R. Josephson, *Industrialized Nature: Brute Force Technology and the Transformation of the Natural World*, Washington, DC: Island Press, 2002, 197–253.

compensated for the reduction in fish stocks. In the early 2000s, stocks of large fish were down to a mere 10 per cent of their level before the Second World War.[27]

Military machines, by their particular power applied to destructive capacity, constitute archetypes of what Paul R. Josephson proposes to call 'brute force technologies'. Tanks, for example, provided a developmental model for a range of tracked vehicles used in forestry (clear-cutters, harvesters, forwarders)[28] or civil engineering (bulldozers). Indirectly, therefore, they contributed to damaging the lithosphere: mining, the proliferation of forest tracks to render the natural resources of Siberia or Amazonia accessible, the development of suburbias, etc. An interlinked history of mining and military technologies could be written: from the black powder used by German miners in the seventeenth century through to Alfred Nobel's dynamite which made mountain-top removal possible.

The 'peaceful' use of nuclear weapons could also be included in this category. In 1949, the Soviet ambassador to the UN justified his country's first nuclear tests by invoking civilian aims: 'We want to put atomic energy to blowing up mountains, changing the course of rivers, irrigating deserts, laying new lines of life there where the human foot has rarely stepped.'[29] This inaugurated the 'atoms for peace' discourse that Eisenhower took up in 1953. The following year, Camille Rougeron, considered the great French strategist of the Cold War, published a monograph describing the possible applications of the bomb: to alter climate and the course of rivers, melt glaciers, build underground power stations, mine otherwise inaccessible minerals, etc.[30]

In the United States, the secret 'Project Plowshare' was launched in 1957 by the Atomic Energy Commission. Edward Teller, father of the H-bomb, proposed the construction of a second Panama canal with the help of 300 nuclear explosions. Another option involved 764 bombs for

27 Cury and Miserey, *Une mer sans poissons*, 83–5.

28 Josephson, *Industrialized Nature*, 88–91.

29 Francis W. Carpenter, 'United Nations Atomic Energy News', *Bulletin of the Atomic Scientists*, 6:1, 1950: 19.

30 Camille Rougeron, *Les Applications de l'explosion thermonucléaire*, Paris: Berger-Levrault, 1956.

a canal route across Colombia. In 1958, the US administration studied the possible use of the H-bomb in building an artificial port on Cape Thompson in Alaska. In 1963, the AEC and the Californian highways department proposed constructing a freeway across the Bristol Mountains in the Mojave Desert by exploding twenty-two nuclear devices.

The most promising use for nuclear explosions seemed to be for extracting bituminous oil from Alberta. A hundred underground explosions were planned, to liquefy the oil and make it extractable by existing technologies. This project was well advanced in 1962 when Canada changed its mind on the desirability of nuclear tests. In Colorado, on the other hand, the Americans did use the bomb to extract gas, but it turned out to be too heavily contaminated with radioactive elements to be marketable. The growing opposition to radioactive contamination led to Plowshare being abandoned in 1977. Altogether, over twenty years, the US spent $770 million and conducted twenty-seven explosions for civilian aims. The equivalent Soviet programme (Programme no. 7 on Nuclear Explosions for the National Economy) was still more destructive, with a total of 128 explosions to test thirteen possible civilian uses.[31]

Transfers between war and agriculture, both technological and ideological, have become better known thanks to the work of historians Sarah Jansen and Edmund Russell. The development of chlorinated gases during the First World War demonstrated the insecticidal properties of certain organochloride compounds. The US Army's Chemical Warfare Service, in particular, showed the effectiveness of chloropicrin in the battle against typhus. In 1916, the chemist Fritz Haber proposed using the gases developed for warfare by the German Army for exterminating pests. Together with entomologists and foresters, he tested different compounds and different forms of spraying on fields, in flourmills and in barracks. In 1925, this application to forestry served as a pretext for Haber and the German Army to conduct experiments with

31 Scott Kirsch, *Proving Grounds: Project Plowshare and the Unrealized Dream of Nuclear Earthmoving*, New Brunswick: Rutgers University Press, 2005.

chemical shells that were forbidden by the Versailles Treaty.[32]

In the United States, the chemical industry underwent a change of scale during the First World War, as a result of the need to substitute for German imports and the demand for explosives. DuPont, Monsanto and Dow grew into powerful corporations. The income from confiscated German patents financed a trade association, the Chemical Foundation,[33] which particularly promoted the conversion of the gas warfare industry to pesticides. The biplanes of the First World War, symbol of the alliance between military technologies and agriculture, were used to spread herbicides.

But it was especially after the Second World War and the invention of DDT, another organochloride compound, that the damaging dream of a purified nature entirely subjected to agricultural needs took concrete form. DDT, invented by the Swiss chemist Paul Hermann Müller in 1939, was used on a massive scale by the US Army from 1942 on, to struggle against typhus and malaria during the Pacific War. Very rapidly, farmers were faced with the problem of resistance. In Korea, the US Army also noted the ineffectiveness of DDT against certain mosquitoes. This was the start of an endless battle between innovation and evolution. The 1950s were marked by the rapid development of the American chemical arsenal, centred on organophosphate compounds such as Sarin, gases known as 'innervating' on account of their capacity to block an enzyme in the nervous system. As they had a similar effect on insects, phytosanitary and military inventions reciprocally fuelled one another. For example, it was working on the basis of the pesticide Amiton that British researchers at the Defence Science and Technology Laboratory at Porton Down perfected the powerful battle gas VX.[34]

War and chemistry powerfully contributed to the development of a culture of annihilation: from the First World War to the Second, the transition was steadily made from a control of pests based on

32 Sarah Jansen, 'Histoire d'un transfert de technologie', *La Recherche*, 340, 2001.

33 Benjamin Ross and Steven Amter, *The Polluters: The Making of Our Chemically Altered Environment*, Oxford: Oxford University Press, 2010, 20.

34 Brian Balmer, *Britain and Biological Warfare: Expert Advice and Science Policy 1930–65*, Basingstoke: Palgrave, 2001.

entomology (protecting crops by the use of predators on insects, or by natural substances) to a logic of extermination. Stephen Forbes, one of the great American ecologists, explained in 1915: 'The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures.'[35]

During the Second World War, insect phobia and racism mutually fuelled one another: Japanese and Germans were often caricatured with the features of insects, beetles or vermin to be exterminated by means of chemical insecticides. Nazi Germany took this process of dehumanization to its culmination. Connections both ideological (degeneration, purity, species health) and technological (Zyklon B was a pesticide developed by Haber) linked the extermination of pests with that of Jews and others in the death camps. We should finally note that, from the Second World War to the publication of Rachel Carson's *Silent Spring* (1962), the chemical industry in the US enjoyed a great prestige thanks to its involvement in the war effort, despite awareness of the danger of pesticide residues in foodstuffs and their acute toxicity for agricultural workers.[36]

Figure 10: *A Japanese depicted as a louse in a wartime US magazine*

35 Quoted in Russell, *War and Nature*, 23.

36 Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge*, Berkeley: University of California Press, 2006, 134–51.

Autarchic technologies

Along with the invention of brutal technologies for killing people and, by extension, life forms in general, we have also to examine a set of more complex historical phenomena that indirectly link war and the Anthropocene. For example, the imperative of supplying a war economy leads to the duplication of productive infrastructure and finally the build-up of excess industrial capacity in many fields. Or again, industrial mobilization, war emergency, blockades and the imperative to substitute imports play a role in the establishment of autarchic productive systems that are particularly polluting and devouring of energy.

The first major industrial chemical system based on the Leblanc process for synthesizing soda, using sulphuric acid and sea salt, appeared during the Napoleonic Wars: in 1808–09, deprived of natural soda that had been imported from Spain (the ash of marine plants, indispensable to the textile, soap-making and glass industries), French chemists succeeded in synthesizing this 'artificial soda'. The process was very likely the most polluting industry of its time: the production of two tonnes of soda emitted one tonne of hydrochloric acid vapour, which corroded everything in its vicinity and particularly destroyed crops and trees.

Beside its direct environmental effects, the historical consequences of this artificial soda are very important, as it was to protect these extraordinarily polluting chemical works, often owned by industrialists close to ruling circles (Jean-Antoine Chaptal above all, who was at the same time chemist, industrialist and interior minister) that the 1810 decree on classified establishments was issued. This decree caused a fundamental shift in the logic of environmental regulation: from now on, factories were subject to administrative jurisdiction (the *préfectures* and the Conseil d'État), in other words by institutions swayed by national considerations, and thus far more industrialist in their mentality than local jurisdictions or the town police of the ancien régime.[37] Since in 1810 the empire was at its

37 Thomas Le Roux, *Le Laboratoire des pollutions industrielles. Paris 1770–1830*, Paris: Albin Michel, 2011, and Jean-Baptiste Fressoz, *L'Apocalypse joyeuse. Une histoire du risque technologique*, Paris: Seuil, 2012.

apogee, this industrialist shift in environmental regulation had repercussions throughout Europe.

The second major chemical system born from war and the project of national autarchy was based on a reaction discovered in 1896 by the French chemist Paul Sabatier: hydrogenation. By way of a catalyst, hydrogen can be added to a number of organic and inorganic compounds.[38] The hydrogenation of nitrogen to obtain ammonia (NH_3) was perfected by the German chemical firm BASF just before the First World War, and turned out to be of prime importance during the war, since nitrate was an essential component of explosives and the Germans were cut off from guano supplies coming from Chile and Peru. It was still more important in agriculture, making possible the production of artificial fertilizers to replace imports of guano or the effort of recycling organic matter.

The synthesis of ammonia is certainly a key piece in the historic jigsaw of the Anthropocene: artificial fertilizers have deeply disturbed the natural biogeochemical cycle of nitrogen on a global scale, leading to the eutrophication of estuaries and the release of nitrous oxide, a powerful greenhouse gas, into the atmosphere. Ammonia synthesis also requires extreme conditions of pressure and temperature (400°C and 200 bars), thus consuming great amounts of energy.

The other major hydrogenation process involved carbon and the production of synthetic fuel. Once again, the context of national self-sufficiency and war preparation was the determining factor. One of the great priorities of the Nazi four-year plan of 1936 was self-sufficiency in fuel. Hermann Göring was in charge of supervising fuel production, and the IG Farben company was commissioned to produce artificial petrol. In 1944, the Germans produced 25 million barrels in this way. In energy terms, the process was highly inefficient, requiring six tonnes of coal to obtain one tonne of petrol. After the war, this technology was abandoned except in East Germany, cut off from the international oil market, and South Africa under apartheid. China is currently interested in the technology in order to increase its strategic

38 David Edgerton, *Shock of the Old: Technology and Global History since 1900*, London: Profile Books, 2008.

oil reserves. In the perspective of peak oil, coal hydrogenation would make possible a continuation of the Thermocene in the medium term, and accordingly an aggravation of climate change with incalculable consequences.[39]

Mobilizing the world

War, by disturbing or interrupting trade relations, forces states and businesses to explore new supply solutions. If autarchic technologies are the response of the dominated, the hegemonic powers – Great Britain and the US – preferred a geographical expansion of the material base of their economy. Historically, wars have contributed to the discovery of new sources of strategic materials and thus to integrating new spaces into the industrial exploitation of nature.

In this light, it is highly significant that long-distance trade first grew to mass proportions during the Napoleonic Wars. Up till then, it was only high-value products that crossed the Atlantic: above all, sugar (50,000 tonnes per year in the late eighteenth century), followed by rice, tobacco and precious metals. In 1808, the continental blockade imposed by Napoleon cut off the British supply of timber from the Baltic, a resource indispensable to the Royal Navy. Britain turned therefore to North America. Timber exports rose from 21,000 tonnes in 1802 to 110,000 in 1815. This exploitation of American timber created trading habits, and far from going into reverse at the end of the war, it continued its sharp increase in peacetime. Before the war, only 6 per cent of British timber imports came from America, a figure that rose to 74 per cent after 1815. This transformation in the timber trade was a major historical phenomenon, as in a few years it tripled the capacities of transatlantic shipping and thus made possible the waves of mass emigration of the nineteenth century.[40]

39 Alexander Gladstone, 'Coal Emerges as Cinderella at China's Energy Ball', *Financial Times*, 1 May 2013.

40 James Belich, *Replenishing the Earth: The Settler Revolution and the Rise of the Anglo-World, 1789–1939*, Oxford: Oxford University Press, 2009, 106–14.

War also imposes an increased mobility on men and things. It requires new infrastructures whose economic and environmental effects persist long after the return of peace. Thus it was to resolve logistic problems bearing on the supply of army and navy that the Grand Junction Canal between London and the Midlands was inaugurated in 1805, then the Grand Union Canal the following year. The most well-known example is that of the German motorways. If Nazi propaganda vaunted the modernity of these great infrastructure projects and their contribution to economic revival, the precocious development of motorways in a country still only little motorized actually aimed at resolving Germany's strategic dilemma, i.e., its vulnerability to a coordinated attack on both eastern and western fronts. In 1933, Fritz Todt was charged by Hitler with constructing 6,000 kilometres of motorway in five years. The justification of this programme was drawn from the First World War and the famous 'taxis of the Marne' that had saved France from defeat in September 1914. Thanks to Todt's motorways, 300,000 men could cross the Reich from east to west in just two days.[41]

By extension, it would be possible to argue that the petrolization of Western societies in the 1950s and '60s was prepared during the Second World War. The British case is a striking example. Before the war, this country was the world's leading exporter of energy. The war and the massive resort to American oil made it the leading importer by the 1950s. Besides, the war required the construction of refineries and a network of pipelines to take oil to military airfields. This infrastructure, extremely expensive and financed largely out of public funds, made possible the mass expansion of the automobile in the post-war years.[42]

After the war, American suburbanization (and thus motorization) was encouraged by the nuclear threat. Strategists saw US cities from

41 Adam Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy*, London: Penguin Books, 2008, 46; Thomas Zeller, *Driving Germany: The Landscape of the German Autobahn, 1930–1970*, New York: Berghahn, 2007, 51–66.

42 David Edgerton, *Britain's War Machine: Weapons, Resources, and Experts in the Second World War*, Oxford: Oxford University Press, 2011, 181.

the point of view of strategic bombing. Given the success of the German policy of industrial dispersion from 1942 to 1944, they deemed it indispensable to spread the US industrial system more widely in order to make it more resilient to the nuclear threat. In 1951, a national policy of 'industrial dispersion' began. The government granted tax reductions, as well as favourable access to strategic resources, low-interest loans and military contracts, to businesses that agreed to relocate away from industrial centres. Satellite towns and ring roads (such as Route 128 around Boston) emerged during this time as the preferred locations for strategic industries. The suburb was officially promoted as a pleasant context for life, far from pollution and traffic jams.[43]

Eisenhower, who had been very impressed by the German *Autobahnen*, launched under his presidency one of the most ambitious civil engineering projects of the twentieth century: the construction of 70,000 kilometres of freeway in fifteen years, at a cost of $50 billion (the total cost of the Marshall Plan was $15 billion).[44] This colossal investment was justified to Congress for reasons of national defence: the freeways would permit the evacuation of cities in case of nuclear attack. In 1956, after years of negotiation, Congress passed the National Interstate and Defense Highways Act. The routes of these interstate highways partly followed military objectives, crossing regions that were thinly populated so as to serve the 400 American military bases. The width of the roads, tunnels and bridges was fixed to accommodate military vehicles.[45]

The war also played a fundamental part in establishing the infrastructure of economic globalization in the second half of the twentieth century. The global nature of the war raised tremendous logistic challenges for merchant shipping. In Suez in 1941, 117 ships were waiting to be discharged, and 171 in Bombay in May 1942. The ports of the Middle East were transformed in order to receive American war

43 Peter Galison, 'War against the Center', *Grey Room*, 4, 2001: 5–33.

44 Stephen B. Goodard, *Getting There: The Epic Struggle between Road and Rail*, Chicago: University of Chicago Press, 1996, 184.

45 John R. McNeill and Corinna R. Unger (eds), *Environmental Histories of the Cold War*, Cambridge: Cambridge University Press, 2010, 7.

Figure 11: *German motorways in 1936*

material. Because the war was global, it reconfigured the conditions of globalization.[46] In January 1941, the United States launched an emergency programme of cargo construction, the 'Liberty ships'. Over 2,700 were built between 1941 and 1946. The result was that the volume of global merchant shipping was greater in 1946 than in 1939, despite the loss or obsolescence of half of all pre-war ships. The destruction of war and the Liberty ships explain the conversion of world shipping to oil: from a level of 30 per cent before the war to 52 per cent after.[47]

The history of containerization, which deeply shaped the economic globalization that we have seen since the 1980s, has also been linked to the history of war. In 1956, Malcolm McLean, the

46 Michael B. Miller, *Europe and the Maritime World: A Twentieth-Century History*, Cambridge: Cambridge University Press, 2012, 276–88.

47 Edgerton, *Britain's War Machine*, 82.

head of a major road transport business, bought two Second World War tankers which he converted into container carriers. The business stagnated until the Vietnam War opened an immense new market. In 1965, the US Army was faced with logistic disaster: defective ships, theft, losses, etc. Lacking trained dockers and suitable cranes, ships awaiting discharge piled up in the port of Saigon.[48] Their contents had to be offloaded into small boats, which increased both costs and losses. In 1966, McLean persuaded the Pentagon to entrust him with logistics, and by 1973 the Sea-Land Service's income from the military was $450 million. McLean, not wanting his container ships to make the inward journey empty, decided to seek port facilities in Japan, then experiencing rapid economic growth. The Japanese government grasped the opportunity, and the ports of Tokyo and Kobe were rapidly equipped with the necessary infrastructure. The reduction in transport costs increased Japanese exports (electronic products and vehicles) bound for the United States, beginning what is now called 'globalization'.

Burn, kill

One of the major historical challenges for the Anthropocene is to study the many connections to be made between Thermocene and Thanatocene. The military played a major role in the deployment of high-energy technologies, in which power mattered far more than efficiency.

During the Napoleonic Wars, European governments paid increased attention to coal. The proliferation of cannon foundries accelerated the development of mines. In France, the legal framework was simplified, the rights of concessionaires strengthened, while the state financed mineral prospecting on a major scale. In 1811, mining engineers conducted large-scale surveys in the region of Saint-Étienne with a view to locating sources of ore and tracing the boundaries of

48 Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, Princeton: Princeton University Press, 2006, 175.

concessions. While coal was still rejected for domestic consumption on account of its dirtiness and bad smell, the army signed large purchasing contracts that stabilized and encouraged mining investment. According to Chaptal, coal production in France rose from 250,000 tonnes per year in 1794 to 820,000 in 1814.[49] Suddenly it became a strategic resource. The Saar, annexed to France by the Treaty of Campo Formio in 1797, underwent an expansion of its iron mines and an initial development of coal.

The British navy played a historically fundamental role in the globalization of coal. In 1824, the East India Company used steamships in Burma in its war against the kingdom of Mandalay. From the 1830s, they were used on the China coast by British opium traffickers. These small gunboats gave the traffickers tremendous assurance. When threatened by the governor of Canton, William Jardine, a large shipowner and an opium trafficker on the side, replied haughtily: 'Our commerce must not be subject to arbitrary rules that gunboats could break by a few rounds of mortar on this town.' The first Opium War (1839–42) demonstrated the superiority of steamships over the Chinese military junks. As well as steam propulsion, their metal hulls enabled the British gunboats to navigate in shallow waters and thus proceed up rivers to pursue enemy embarkations or threaten inland cities.[50]

It was at that point that the Admiralty, along with the British Geological Survey, organized a global survey of coal resources suitable for ensuring its supply lines: Bengal, Australia, Java, New Guinea, Malaysia, Brunei, Palestine, Syria, Nigeria, Socotra, Aden, Natal, etc. The British Empire developed a dense network of coal mines and supply points that were the basis of its naval domination until the twentieth century. For those countries already in the British orbit,

49 Jean-Antoine Chaptal, *De l'industrie française*, vol. 2, Paris: Renouard, 1819, 113. Denis Woronoff gives higher figures: 600,000 tonnes in 1789 and 900,000 by the end of the empire. See *Histoire de l'industrie en France*, Paris: Seuil, 1994, 194.

50 Daniel Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century*, Oxford: Oxford University Press, 1983, 17–58.

asking for geological expertise was also the most rapid and effective way of attracting British capital and engineers.[51]

The British Admiralty also played a major role in the conversion of world shipping to oil and, more generally, in the harmful union between the military and oil in the twentieth century. In July 1911, the German warship *Panther* was cruising off the coast of Agadir. According to Churchill, appointed First Lord of the Admiralty in September, the superiority of the Royal Navy vis-à-vis its German rival was an absolute imperative, with the survival of the empire at stake. Pressed by oil interests, he was also convinced of the tactical interests of oil: more concentrated than coal in terms of energy, it gave ships a greater radius of action and a faster speed; it saved both space and manpower, and could be more rapidly loaded. But the empire had no oil of its own and had to provide this. The British government bought a 51 per cent share in the Anglo-Persian Oil Company and signed a twenty-year contract for supplying the British navy. This decision inaugurated a century of rivalries and wars in the Persian Gulf.[52]

The First World War confirmed the strategic importance of oil. In 1914, the British Expeditionary Force in France had only 827 motor vehicles; by the end of the war, it had 56,000 lorries, 23,000 cars and 34,000 motorbikes. The war was perceived by the general staff as a victory of trucks over locomotives.[53] It accelerated research into oil combustion, and the speed, performance and power of engines doubled in four years. With state support, automobile constructors renewed their equipment, introduced assembly-line work and generalized the application of Taylorism, making it possible to use semi-skilled workers. In France, the automobile industry quadrupled its capacity.[54] More than 200,000 combat aircraft were produced by the belligerent states.

51 Robert A. Stafford, *Scientist of Empire: Sir Roderick Murchison, Scientific Exploration and Victorian Imperialism*, Cambridge: Cambridge University Press, 1989.

52 Daniel Yergin, *The Prize: The Epic Quest for Oil, Money and Power* (1991), London: Simon & Schuster, 2008, 137–47.

53 Ibid., 156.

54 Jean-Pierre Bardou et al., *La Révolution automobile*, Paris: Albin Michel, 1977, 114.

War and the Great Acceleration

It was the Second World War, however, that made for the decisive break, marking a leap forward in energy terms in relation to its predecessor. The average American soldier in the Second World War consumed 228 times more energy than in its predecessor. The main strategic advantage of the Allied armies lay in their almost unlimited supply of American oil. The new role of aircraft sharply increased demand. US Air Force statistics indicate a consumption of aircraft fuel of close to 50 billion litres, of which 80 per cent was consumed within the United States, underlining the major importance of logistics and the military-industrial complex in military consumption.[55] The share of oil consumption represented by the US military rose from a pre-war level of 1 per cent of the national total to 29 per cent in 1944. In parallel with this, the United States strongly developed its extractive capacity from 1.2 to 1.7 billion barrels per year.

Oil logistics were transformed in the course of the war: pipelines and refinery capacity were steeply increased in response to military needs. The production of aircraft fuel (100-octane aviation spirit) formed one of the most important industrial research projects of the Second World War. Investment in the process of alkylation rose to $1 billion, half the total of the Manhattan Project. By the end of the war, the United States could produce 20 million tonnes of aircraft fuel per year, followed by Great Britain with only 2 million.[56] Similarly, two gigantic pipelines (Big Inch and Little Big Inch) were constructed at breakneck speed in 1942 to connect the oilfields of Texas to New Jersey, from where oil was shipped to the European front. These pipelines, initially conceived to ensure safe transport immune from German U-boats, are still in service today.

The 'Great Acceleration' of the 1950s should naturally lead us to investigate the key role of the Second World War in the history of the Anthropocene, and the US war effort in particular. More precise quantitative studies could show that the Great Acceleration was the

55 http://www.usaaf.net/digest/operations.htm

56 Edgerton, *Britain's War Machines*, 185.

result of the industrial mobilization for the war, followed by the creation of civilian markets designed to absorb the excess industrial capacity.

Between 1940 and 1944, US industrial production increased more rapidly than in any other period of history. Whereas it had grown by an annual 7 per cent during the First World War, it tripled between 1940 and 1944 (production of raw materials increasing by 60 per cent).[57] Businesses that had been crippled by the problem of over-production in the 1930s were reticent to develop their productive capacity as much as military needs demanded. Investment in production was thus largely financed out of public funds: the US government paid for infrastructure, equipment and machinery, leaving the management of production to private companies. The share of industrial investment in US public expenditure also reached an absolute historical record in 1943 of 70.4 per cent (it is now less than 10 per cent).[58] The result of this orgy of public investment in productive infrastructure or transport was a fifteen-fold multiplication of aircraft and munitions production, tenfold for shipping, three times for chemical products and bauxite, twice for rubber, and so on.[59] Road transport measured in kilometre-tonnes more than doubled, air transport multiplied by six, and the volume of oil transported by pipeline increased five times.

The problem of productive over-capacity and its reconversion in peacetime may be illustrated by the case of aluminium. Production of this metal is both very polluting and highly energy-intensive: the bauxite has first to be converted into alumina (aluminium oxide), then alumina into aluminium. Today, aluminium production consumes 4 per cent of global electricity. In France, which was the cradle of the aluminium industry between the wars, the industry took root in the Alps on account of the abundance of hydro-electricity. Before the Second World War, the uses for this costly mineral were very limited.

57 Alan S. Milward, *War, Economy and Society, 1939–1945*, Berkeley: University of California Press, 1979, 63.

58 Alan Gropman (ed.), *The Big 'L': American Logistics in World War II*, Washington, DC: National Defense University Press, 1997, 150.

59 Milward, *War, Economy and Society*, 69.

The development of military aviation during the Second World War radically changed the situation. In the United States, production increased from 130,000 tonnes in 1939 to 1.1 million in 1945, and in Canada from 66,000 tonnes to 500,000 tonnes. World production grew three times during the war, with North America supplying three-quarters of the total. As a result, the geography of bauxite itself changed: France, Greece and Italy, which had been the main sources, were replaced by Suriname, British Guyana and Jamaica.[60] Bauxite production is very polluting on account of the heavy metal residues that contaminate ground-water, and the shift of sources of ore to poor countries simplified the extraction process.

After the war there were several initiatives to find outlets for the aluminium industry. In Britain, a law passed in 1944 provided for the emergency construction of 500,000 prefabricated houses. The aircraft industry saw in this a possibility of reconversion and produced en masse both family homes and schools, using aluminium and asbestos.[61] In the United States, the Beech aircraft company asked the architect Buckminster Fuller to design aluminium houses. The aluminium industry went on to conquer several markets for industrial equipment, automobiles, transport, turbines, etc. Despite health warnings, it was sold as a material for cookware par excellence, neither rusting nor giving off a taste, a good conductor of heat, a preservative and emulsifier in food, an anti-agglomerant in cosmetics, etc.

The history of Volkswagen and its flagship post-war product, the 'Beetle', well illustrates the connections between warfare and civil consumption. In 1933, Hitler charged the Austrian engineer Ferdinand Porsche with developing a 'people's car' for less than 1,000 Deutsche Mark. To finance the factory, the Nazi regime set up a Volkswagen savings plan that people had to subscribe to for several years before being able to obtain a car. No Volkswagen was delivered to individual

60 Germaine Veyret-Verner, 'Une industrie en pleine expansion: l'aluminium', *Revue de géographie alpine*, 44:2, 1956: 311–42; Matthew Evenden, 'Aluminium, Commodity Chains and the Environmental History of the Second World War', *Environmental History*, 16:1, 2011: 69–93.

61 Brian Finnimore, 'The A.I.R.O.H. House: Industrial Diversification and State Building Policy', *Construction History*, 1, 1985: 60–71.

customers during the war. On the other hand, the Wolfsburg factory produced more than 70,000 'Kübelwagen' for the Wehrmacht on the basis of Porsche's designs. After the war, Volkswagen converted the Kübelwagen into the Beetle.[62]

The contemporary aircraft industry is likewise a product of the Second World War, both technologically (aluminium, radar, jet engines) and institutionally: in Chicago in 1944, fifty-two countries signed the convention that founded the International Civil Aviation Organization, the aim of which was to promote 'the development and international expansion of trade and travel'. One article of the 1944 convention prohibits the taxation of aircraft fuel and so makes it hard to realize current projects to tax air travel as a means of combating climate change. Despite the increase in oil prices, travelling by plane is still extremely cheap in terms of cost per kilometre. Aviation is the economic sector whose emissions of CO_2 are rising most rapidly, doubling approximately every ten years.

The Second World War thus prepared the technological and legal framework for mass-consumption society.

62 Winfried Wolf, *Car Mania: A Critical History of Transport*, London: Pluto, 1996, 87–101.