Environment and Security in the Twentieth and Twenty-First Centuries

J.R. McNeill
Georgetown University
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A chapter in Michael Brown, ed., *Grave New World*

"Had I been consulted at the moment of Creation,
I would have recommended something simpler"

Alfonso El Sabio, King of Castile and León, (1221-1284)

I. Introduction

King Alfonso the Wise noted that Creation seems unduly complex. In the seven and one-half centuries since his observation, it has grown no simpler. Indeed, if evolutionary biologists are correct, the biosphere should have gotten slightly more complicated since the 13th century, as the usual direction of biological evolution is towards greater complexity–punctuated by catastrophic simplifications of the sort not recently seen on earth. The march of science (which the King did his share to promote) has resolved many mysteries since the 13th century, but has only enhanced the sense of Nature's complexity.

International relations and international security is almost equally as tangled and inscrutable as the natural world. While there is no shortage of rigorous theory–as in biological evolution–everything of importance on the human scale is contingent and unpredictable. In the study of international affairs, as in environmental matters, there are too many mutually interactive variables, and too many non-linear effects, for human brains to understand how things work until they have happened and can be observed in detail.

Lately, an interdisciplinary inquiry has grown up that tries to link the fields of environment and international relations. It is not, as fields go, highly theoretical, but more often

based on case studies.[1] Drawing useful lessons from these cases is no easy business, in part because they combine the uncertainties and complexities of these two very uncertain and complex fields.[2] It is, therefore, an unpromising intellectual enterprise to seek connections between environment and security. This chapter, however, aims to do just that for the 20th and, to a very limited extent, for the 21st centuries. It argues that such connections existed in the past and will exist with greater force in the future, but that they have been and will remain modest in comparison to the traditional concerns of international security.[3]

II. Environmental Change in the 20th Century: A Brief History

One of the distinguishing features of the 20th century was its tumultuous environmental change. While earlier periods in earth history contained moments far more disruptive, these invariably were the work of volcanoes, asteroids or other purely natural forces. In recent millennia humankind has proved the most ecologically disruptive force on the planet, and never more so than in the last hundred years. From forests to fisheries and from soils to the stratosphere, humankind had never before altered ecosystems so comprehensively. A very rough appreciation of the magnitude of the process emerges from the following table, which seeks to give some measure to this proposition.

Table 1
Measures of Environmental Change, 1890s-1990s

Environmental Indicator	Co-efficient of Increase, 1890s-1990s
Energy use	13-15
Population	4
Urban population	13

[1]The best sampler of this literature is the *Environmental Change and Security Project Report*, edited by G. Dabelko and published by the Woodrow Wilson International Center for Scholars. It contains an invaluable bibliography in each issue.

[2]Among the more careful work, which displays fewer of the shortcomings so difficult to avoid in this field, is that of T. Homer-Dixon, e.g. his *Environment, Scarcity, and Violence* (Princeton: Princeton University Press, 1999).

[3]My discussion will not extend to intra-state conflicts that involve environmental dimensions, such as the resource wars over diamonds, gold, timber, or oil that bedevil societies with weak states in parts of Africa and southeast Asia. On these, see Michael Klare, *Resource Wars: The New Landscape of Global Conflict* (New York: Henry Holt, 2001).

World GDP	14
Industrial output	40
Freshwater use	9
Cropland	2
Irrigated area	5
Cattle population	4
Marine fish catch	35
Lead emissions to atmosphere	8
Carbon dioxide emissions	17
Air pollution in general	2-10
Forest area	0.8 (20% decrease)
Bird and mammal species	0.99 (1% decrease)

Source: McNeill 2000:360-1
Note: some of these figures deserve more confidence than others. For details, see McNeill 2000, *passim*.

The table is less than thorough. It presents only data that are fairly easily retrieved, for example bird and mammal species but not fish and insects. It neglects variables for which the co-efficient of growth in the 20th century would be astronomical, say automobiles or organic chemicals, and those for which the co-efficient would be infinite, such as chloroflourocarbon emissions, which were zero prior to the 1930s. Its figures are all global ones, whereas most environmental effects–not all–are local or regional in scope. Nonetheless, it conveys the right impression and gives some precision, where that is feasible, to the proposition that 20th-century environmental change was both broad and deep, comprehensive and thorough.

As a heuristic exercise, it may be helpful to imagine a single index of human-induced environmental disruption, conflating all the variables, and consider its history. If one did, one would find that environmental disruption, on some scale, existed from the dawn of human history, grew extremely slowly, roughly in step with human population growth, and then around 1800 or so sped up slightly. This modest acceleration came as a result of faster population growth and faster economic growth, although both were still very slow by recent standards. Technical change, in particular the emergence of coal-powered steam engines, helped too. A much more marked acceleration came around 1950. This one too resulted from faster (this time much faster) population growth, but also from the emergence of more energy-intensive economies, made feasible in particular the arrival of cheap oil–of which more below.

Throughout the whole period since 1800, and especially since 1950, the human relationship with the rest of nature has been very much in flux. Ecologically, we have–without much awareness of the process–created a regime of constant disturbance. This regime is itself

both a result of and a contributor to rapid social and economic change. Our modern social regime and our modern ecological regime co-evolved, adjusting to one another while shaping one another.

This, in very general terms, is the trajectory of modern environmental history. Let us now look more closely at two components of it, water and energy, chosen for their relevance to contemporary security concerns.

III. A Brief History of Freshwater Use

The world has always had plenty of fresh water, but it is often inconveniently distributed in time and space for human designs. Getting just the right amounts of water in the right places at the right times is an ancient art, at least 9,000 years old. Success or failure in the arts of water management was crucial in the distant past. Irrigation made crops grow where they otherwise would not, allowing states greater population, revenues, and power. Urban life depended on the ability to assure a supply of clean drinking water and to provide a means to disperse wastes. Failure to segregate drinking water from waste water assured a heavy burden of gastro-enteric diseases and made urban life all but unsustainable. The great civilizations of the ancient world, in Mesopotamia, Egypt, the Indus valley, and north China, all rested on sophisticated water management–as did the great precolumbian empires of the Americas. No great states of the past except the transitory Mongol Empire existed without great cities at their core, and all great cities required careful water management.

In the modern world water management remains fundamental. One of the differences between rich and poor societies is their ability to provide adequate clean water, and thereby to minimize the burdens of disease (and the time spent in fetching water).

Irrigation remains the most important use of freshwater, accounting for about two-thirds of global water use, down from 90% a century ago. Roughly a sixth of the world's farm acreage is irrigated, and it produces about a third of the world's food. The tenth of the world's freshwater usage that goes to cities is responsible for the comparative good health of a billion or two people (of the three billion in all who lives in cities). The enormous expansion of water use in modern history (see Table 2), has generated inestimable benefits to human health and nutrition, and sizeable ones to industry and routine household life. Table 2 outlines the quantities of fresh water withdrawn from lakes, rivers, and aquifers, and the uses to which they have been put over the past 300 years.

Table 2
Estimated Global Freshwater Use, 1700-2000

			Uses (percent of total)		
year	withdrawals (km2)	withdrawals per capita	irrigation	industry	municipal

1700	110	0.17	90	2	8
1800	243	0.27	90	3	7
1900	580	0.36	90	6	3
1950	1,360	0.54	83	13	4
1970	2,590	0.70	72	22	5
1990	4,130	0.78	66	24	8
2000*	5,190	0.87	64	25	9

*A projection, which may be too high.
Source: McNeill 2000:121, elaborated from Shiklomanov 1993 and L'vovich and White 1990.

While the benefits of this enormous replumbing of the planet have been great, it has come at a cost. Irrigation everywhere leads to the salinization of land, although at widely divergent rates. Today the accumulation of salts forces the abandonment of farmland at about the same rate as engineers bring new land under irrigation. So, in effect, irrigation amounts to a short-term maximization strategy. It is also notoriously wasteful, although again to widely varying degrees. Half the water diverted for crops never reaches a root or leaf. In some of the more poorly designed irrigation schemes in high-evaporation zones, the proportion wasted reaches 90%. Probably the most costly irrigation scheme is that of Central Asia, planned by Soviet engineers in the 1950s, a region-wide project far more ambitious than anything tried in the long history of Central Asian irrigation. The plan diverted the snowmelt waters of the Syr Darya and Amu Darya rivers into the cotton fields of Soviet Central Asia, principally Uzbekistan. Since 1960 it has strangled the Aral Sea, killing off its fishing industry and most of its fish, exposing the salt-encrusted seabed to steppe winds, which distribute airborne salt throughout Central Asia. The Aral, now about one-half its 1960 area, now has a weaker moderating effect on the Central Asian climate, which is getting hotter in summer, colder in winter, and drier, so that the Himalayan snowmelt that feeds Central Asia's rivers is declining. The usual curses of irrigation, rising groundwater and salinization, affect much of Turkmenistan's and Uzbekistan's best soils. All this in order to make the USSR self-sufficient in low-quality cotton, umarketable anywhere outside the Soviet bloc.[4]

The Soviet experience with the Aral Sea is unique in its severity but typical in its origins. While water manipulation had been a part of state efforts for millennia, in the 20th century new skills and technology, and a new ambitiousness, raised the ceiling on what states might attempt. From the end of the 19th century it was possible to generate electricity from water-powered turbines. With improvements in engineering and construction techniques it became possible

[4]For a thorough treatment see the German government's remote sensing program's Aral Sea Homepage at:http://www.dfd.dlr.de/app/land/aralsee/index.html. See also, McNeill, *Something New Under the Sun*, 162-66 and the sources cited there.

from the 1930s to build gigantic dams across all but the largest rivers. Large dams in particular acquired a certain totemic quality for ambitious states and their leaders: Nehru called dams the "temples of modern India." Like Franklin Roosevelt, Franco, Stalin, Nasser, Mao, Deng and a legion of lesser leaders, Nehru saw in big dams a mighty symbol of an energetic, modernizing state, tangible evidence of a commitment to improve life for the masses. That some of the costs of dam-building could often be shunted onto the poor and powerless, foreigners, or the future, made dam projects all the more appealing.[5]

Two notable examples of large-scale rerouting of waters in the interests of state power are Italy and the United States. When by the 1890s it had become clear that the basis of military power had shifted away from cannon fodder, horseflesh, and heroism to heavy industry, Italy appeared to be in a particularly unenviable position. It had almost no coal. Imported coal was expensive, and unreliable in time of war. The Italian solution lay in turning the alpine lakes and rivers into sources of electric power on which to construct an industrial base on the northern rim of the Po Valley. Italy built its first hydroelectric power station in 1885 and by 1905 led all Europe in hydropower. Further electrification became a major goal for fascist Italy (1922-43), which was intent on building a self-sufficient military industrial complex. This it never quite achieved (Italy still imported coal through World War II, from Germany and Poland), but by the 1930s Italy had built up its metallurgical, shipbuilding, aircraft, rail, and armaments industries to the point where Mussolini could field a semi-industrialized military in wars in Ethiopia and Spain, and could seriously rival Britain's Royal Navy as top dog on the Mediterranean Sea. Without the harnessing of alpine hydropower, fascist geopolitical ambitions would have been impossible, instead of merely impractical.[6]

The United States recast its waterways too, and on a much larger scale. The state was deeply involved from the 1930s, building dams, channelizing rivers, subsidizing irrigation and hydropower. The agricultural development of arid regions in the southwest, in California, and in Washington and Oregon depended fundamentally on government enterprise. So too did the vast hydropower schemes on the Columbia river. These were not deliberately built in order to construct a military-industrial complex, but the fact that the US was able to construct one in a single year, 1942, required as a pre-condition the cheap hydropower just recently installed.[7] Without it, the aircraft industry in Seattle and the shipyards of the Pacific coast could not have been as enormously productive as they were. You can't weld a Liberty ship together every eight

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[5]On state ambitions and environmental interventions, see James Scott, Seeing Like A State (New Haven: Yale University Press, 1998).

[6]See Piero Bevilacqua, "Le rivoluzioni dell'acqua" in Bevilacqua, ed., Storia dell'agricoltura italiana in etB contemporanea Venice: Marsilio, 1989), 255-318; J.J. Sadkovich, "The Indispensable Navy." In: N.A.M. Rodger, ed., Naval Power in the 20th Century (Annapolis: Naval Institute Press, 1996), 66-76.

[7]It had other pre-conditions as well, most notably the world's largest industrial sector which was swiftly converted from civilian to military production.

days without plenty of electricity.[8]

The vast effort to reorganize rivers and lakes for human purposes had, as always, state power as well as social welfare among its motives. State ambition and security anxiety played an equal role in shaping the energy regime of the 20th century. Only a small part of the modern energy regime derived from hydropower. The lion's share came from fossil fuels.

IV. A Brief History of Energy Use

Energy is essential for making things, for transport, and for mere survival. Before the use of fossil fuels, people could use only the tiniest fraction of the energy available on earth. By eating plants people acquired chemical energy that photosynthesis had captured from sunlight. By eating animals, or using the muscle power of draft animals, humans tapped further energy. Wind and water power, available only in favorable locations, also harnessed a fraction of the annual energy delivered to the earth from the sun. Each of these methods tapped only the annual flow of energy generated by the sun, which although abundant, was very inefficiently converted into useful forms. By burning wood or charcoal people could tap energy stocks accumulated in trees over a century or two. But ultimately all these methods provided a very limited energy harvest which meant that almost all people would always be poor, dependent upon grinding toil for their daily rice or bread.

Fossil fuels changed all that. The Dutch were the first people to make them central to their economy. They burned peat to heat their homes and fuel industries such as brewing, brick-making, sugar-refining, or glass-making (but not metallurgy, for which a peat-flame was not hot enough). Peat is accumulated vegetable matter, preserved by water. The Dutch cut it out of bogs, dried it, and burned it to harvest energy that plants had captured over a few millennia. This delivered more concentrated energy than wood or charcoal and gave the Netherlands a unique advantage (until coal) in energy-intensive industries. To a considerable extent, the prosperity of the Dutch in their Golden Age (c. 1580-1700) depended on low energy costs.[9]

While wood allowed access to stores of energy captured over centuries, and peat to energy captured over millennia, coal represented eons of accumulated energy stocks. People around the world had known of coal's uses for a long time, and Song China had used it on a large scale in its iron industry. London had burned coal for home heating from at least the 13th century. Britain had plentiful coal deposits, part of a 'carboniferous crescent' that stretched from the Scottish lowlands through England to northern France and Belgium and on to the Ruhr region of Germany. This would become the industrial heartland of Europe, as important for modern history as the Fertile Crescent was for ancient history. By 1815, annual British coal production yielded energy equivalent to what could be garnered from a hypothetical forest equal in area to

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[8]On the American military-industrial buildup see Richard Overy, Why the Allies Won (New York: Norton, 1995); on water management, Donald Worster, Rivers of Empire (New York, Pantheon, 1985).

[9]J.W. de Zeeuw, "Peat and the Dutch Golden Age," *A.A.G. Bijdragen* 21(1978), 3-31.

all of England, Scotland and Wales, twenty times what the actual woodlands of Britain could then produce. Steam engines did the work of perhaps 50 million vigorous men, far more than Britain actually had.[10] Britain was on its way to becoming the first high-energy society. Table 3 shows the difference in energy use before and after fossil fuels:

Table 3
Average Annual Per Capita Energy Use

Basic Requirements of the Human Body	1
Hunting and gathering societies	3-6
Agrarian societies	18-24
Industrial societies	70-80

The unit here is the average basal metabolic requirements of an adult human body, about 3.5 gigajoules per year.

Based on: Rolf-Peter Sieferle, *Der Europäische Sonderweg: Ursachen und Faktoren* (Stuttgart: Breuninger Stiftung, 2001), 18-19.

The harnessing of fossil fuels ratcheted up the energy supplies available for human use, thereby permitting a vast increase in human numbers and wealth. Between 1800 and 2000, the total increase in energy use was about 60- or 80-fold. The expanded energy harvest meant that for the first time in history mass poverty became unnecessary. It had other implications as well.

The most pertinent ones are the geopolitical and environmental. The wealth generated in the Netherlands through the use of peat in select industries helped underwrite Dutch imperial ambitions in the 17th century. But peat conferred no direct military advantages. Coal was different. It made cheap iron possible, and eventually steam-powered ships. Whereas in 1793 a British embassy to China was dismissed peremptorily and the Qianlong Emperor (reigned 1735-95) could suppose that Britain was of no consequence, in 1840 British gunboats could sail up rivers 10,000 miles from home and therefore British diplomats could dictate terms even to the most populous country on earth. The ships and weapons made possible and affordable by coal

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The 23 million tons of coal produced in 1815, even if burned in inefficient steam engines, could do the work of perhaps 50 million vigorous men. The total population of Britain was about 13 million, so the number of vigorous men was perhaps 3 million.

also tipped the balance in Britain's favor in India and Africa in the 19th century.[11] Britain was the first state to adjust, economically and militarily, to the potentials of coal, and its geopolitical position in the 19th century reflected this. By the 1890s, Germany too had converted its abundant coal and ore deposits into cheap metals and good weaponry, and thus also fielded a formidable industrialized military.

In the 20th century the U.S. revamped the world's energy regime by developing oil as a primary fuel. Large-scale oil production began on the shores of the Caspian Sea, late in the 19th century. America's first big gusher, in Spindletop, Texas, came appropriately in the first month of the 20th century, in January 1901. Thereafter Americans led the way in the technologies necessary for drilling, transporting, refining, and burning oil. They led the world in oil production for much of the 20th century, and in oil consumption for all of it. This was crucial to the emergence of the U.S. as a great power, because the mobile warfare--on land and sea and in the air–that characterized the 20th century after 1918 was an extremely oil-intensive business. So the U.S., like Britain a century before, profited handsomely in geopolitical terms (as in economic terms) by being the first to adapt thoroughly to a new energy regime.

The transition to fossil fuels was just as consequential in environmental terms. Coal created urban air pollution of a new intensity and lethality. By 1900 air pollution caused or exacerbated respiratory diseases that killed hundreds of thousands annually in the coal-burning cities around the world. At its worst, coal-smoke and associated sulfur dioxide and particulates could kill 4,000 people in a week, as in London in December 1952.[12] Through railroads and steamships, coal made it feasible to open up agricultural frontiers around the world, producing cotton, coffee, wheat, and after the 1880s, meat and butter, for shipment to growing cities. This led to very widespread conversion of grassland and forest into farmland and pasture in the Americas, South Africa, Siberia, Australia, and New Zealand. Oil led to still greater changes.

Oil burns more cleanly than coal. But because oil is a useful fuel in a broad range of applications, its emergence sharply raised the total amount of fossil-fuel combustion, increasing total air pollution loads. In Mexico City, for example, by 2002 air pollution, mainly from tailpipes, killed 35,000 people annually according to the municipal government. Oil also made possible machinery that revolutionized extractive industries, mining and lumber for instance. By the late 20th century humankind had become a major geological agent, moving ten times as much earth and soil as all the world's glaciers and almost as much as all the world's streams and rivers. Oil-powered machines made this possible. They also enabled people to cut timber far faster than had hitherto been possible, helping to propel the dramatic surge in deforestation since 1960. Of all the factors underlying the tumultuous environmental changes of modern times, high energy

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11An example on the Gambia River is detailed in Donald Wright, *The World and a Very Small Place in Africa* (Armonk NY: M.E. Sharpe, 1997).

12Peter Brimblecombe, *The Big Smoke: A History of Air Pollution in London since Medieval Times* (London: Methuen, 1987), ch. 8.

use, and especially the liberal use of oil after 1950, is probably the most important.[13]

IV. Environment, Security, and Resources: A Brief History

The chief contentions of the environmental security literature are that environmental changes may prove so destabilizing as to create security problems and that resource scarcity may lead to war. I will review these contentions in light of 20th-century history, and add a third: that a scarcity of security led to greater environmental change.

The first proposition is a weak one in the sense that of all the security problems and conflicts observable in history, almost none of them may confidently be put down to environmental changes. That is because until recently environmental changes happened so infrequently and proceeded so slowly that they normally gave societies ample time to adapt. The likeliest exception to this is climate change, which prior to the last 150 years took place for exclusively natural reasons. It is plausible, although uncertain, that cycles of drought helped to propel migrations that set pastoral peoples of the Eurasian steppe (Xiongnu, Turks, Mongols, e.g.) against settled populations in China, Iran, or eastern Europe. Equally plausibly, drought may have led to intensified slave-raiding and concomitant warfare in Angola and the West African sahel. These are only speculations: in general the propensity to award climate change a causative role in large-scale political events (the collapse of the ancient Indus civilization, or the classic Maya e.g.) is inversely proportional to our knowledge of these events. This should encourage skepticism.

In the 20th century, the strongest case for this first proposition is the drought cycle that befell much of Africa after 1967, hitting the sahel belt from Senegal to Somalia hardest. After more than 50 years of broadly favorable rains, which roughly coincided with the colonial era in Africa, killing drought returned in 1968. Its impact was probably greater than the previous severe drought, because in the interim population and herds had grown, and colonial policy had purposely reduced the mobility of the population to make it more manageable and taxable. In the six years after 1967, desiccation, starvation, and related diseases killed 1% of the population of the sahel, and 30-40% of the cattle, a severe blow in cattle-keeping societies. This catastrophe probably played some role in bringing on a spate of coups in the 1970s, ushering in some of modern African history's most unsavory regimes.

However, a note of skepticism is in order. The location of coups and instability does not correlate perfectly with the location of the most intense drought. The 1970s were politically turbulent in parts of Africa least affected by drought, such as South Africa and Rhodesia/Zimbabwe, as well as in the regions hardest hit. Independent African states in the late 1960s were, most of them, fully-laden camels, needing only a single straw to break their backs. The hike in oil prices in 1973 might have been that straw just as plausibly as drought. So might some less conspicuous events. So the most one can reliably say is that the drought, while

13For further elaboration, McNeill, *Something New Under the Sun*, chapters 2, 8, 10; and Christian Pfister, ed., *Das 1950er Syndrom* (Bern: Verlag Paul Haupt, 1996).

extremely disruptive environmentally, socially, and economically, probably helped bring about the dissatisfactions, instability, and coups that affected Niger, Chad, Ethiopia, and Uganda among other countries. That is a modest and guarded claim made for an extreme environmental event. Less extreme environmental events, or trends, presumably cannot carry heavier explanatory loads or support stronger claims.

All this is not to say that this first proposition is uninteresting. It is, rather, to say that it has very little use for making sense of the conflicts and security dilemmas of history. But the future is a foreign country, and things may be different there.

The second proposition concerns resource scarcity, resource competition, and warfare. This has a firmer base in modern history, indeed in all history. If one adopts a broad enough definition of the term resources, then most wars have been over resources. Prior to the industrial revolution, most states had a keen interest in both land and labor, because these, when combined, were the main source of revenues on which states subsisted. Labor must be included as a scarce resource in most contexts prior to 1800, especially where disease burdens were heavy, death rates high, and the demand for labor great. In such contexts, rulers frequently made the capture of people a primary objective of warfare. They also did so in contexts where they could easily strike against ill-defended populations, that is, where the supply of captives could be cheaply acquired. All these conditions obtained in tropical Africa before 1850, and in southeast Asia as well, both the scene of extensive slaving. Wars and raids undertaken, at least in part, to secure captives took place wherever slaving and forced labor was a way of life: in the Mediterranean before 1600, in colonial Latin America, in precolumbian America, for example. Mongol captains consciously sought to capture skilled personnel to distribute as war booty among their supporters.[14] In the Turko-Persian military tradition, which featured slave soldiers, conquerors had among their explicit goals the capture of skilled military personnel, and the capture of youths who could be trained as warriors. After 1850 the logic of forced labor declined quickly, mainly because of the onset of rapid population growth, but also because of the development of fossil fuels. The capture of labor as a motive for war quickly became vanishingly rare, although even today it is not entirely absent from, for example, the calculations behind the civil war in Sudan.

Land of course always figured as a motive in warfare wherever land, rather than labor, was the scarcer factor in producing revenue. This means, chiefly, the historically thickly populated regions of the world, Japan and China, North India, and Europe. Some lands were so rich that they were routinely fought over–Egypt or the Gangetic plain for example. As these two examples suggest, it was often land in combination with water that made control of a given territory worth warring over. Egypt without the Nile's irrigation system was as worthless as Arabia before oil. Nonetheless, whether the prize was land alone or land together with water, the conquest of territory routinely figured as a central motive for warfare.

14Artisans, entertainers, animal-keepers, translators among others. For details see Thomas Allsen, *Culture and Conquest in Mongol Eurasia* (Cambridge: Cambridge University Press, 2001).

It still does, although on a reduced scale. Only in a few places does land remain the basis of revenue. What is on or under the land is now usually more valuable. That brings us to a narrower definition of resources.

Occasionally a quest for other sorts of resources served as a *casus belli*. Just what counts as a resource changes over time. Pharaonic Egypt undertook the occasional campaign in Lebanon to secure ship timber. Ship timber, like saltpetre and flint, is no longer a strategic resource, and not worth fighting over. In the modern world the only resource worth the risks of war has been oil.

Oil became a strategic resource suddenly after 1912, when the British Admiralty began to convert the Royal Navy from coal to oil. When World War I began, the British Expeditionary Force in France had fewer than 1,000 motor vehicles. Before the war was over, it had 110,000 trucks, cars and motorcycles–and several hundred tanks. The Allies also used upwards of 100,000 airplanes in the war effort. All these engines needed fuel, which oil provided. Georges Clemenceau at the outset of the war allegedly said that if he wanted oil he would find it at his grocer's; by 1917 he thought "every drop of oil is worth a drop of blood.." In World War I the quest for oil motivated modest campaigns (German offensives in Rumania and toward Baku). The Central Powers relied on oil from Austrian Galicia, which in 1909 was th world's third largest oil producer. But that source dried up by 1917, curtailing the German and Austrian U-boat campaigns for want of fuel at a crucial stage in the war. The rapid mechanization of warfare, and the general reliance upon oil in industry, soon made oil worth fighting wars.[15]

The best examples are the Pacific war of 1941-45 and the Gulf War of 1991. In the first case, Japan had embarked on an empire-building program in Asia after 1931, and a war in China after 1937. The Japanese navy and, after 1937, the army, needed oil, of which Japan had none. The nearest source lay in the Dutch East Indies (now Indonesia). In January of 1941 the Japanese demanded access to that oil but were refused; in August the Dutch, British, Chinese, and Americans organized oil sanctions against Japan. This obliged the Japanese either to surrender their imperial ambitions, a course unacceptable to the military, or to attack and seize the oilfields of Sumatra and Borneo. Attacking the Dutch islands implied war with the U.S., so it required a prior attack on American installations in the Philippines and Hawaii, begun on December 6-7, 1941. Had the Japanese not needed oil for their war in China, they could have avoided the Pacific War which brought their defeat, which would have led to a very different recent history for East Asia.

Sometimes timing is everything. Had the great Siberian oilfields, the world's second-largest after those of the Persian Gulf, been opened prior to 1941 (they were opened in the early 1960s), the Japanese would have had a much more palatable option at hand. From their base in Manchuria, they could have attacked the USSR, which after June 1941 was reeling under German assault. Then there would have been no Pearl Harbor, no Pacific War, no constraints on

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15Data from Daniel Yergin, *The Prize* (New York: Simon & Schuster, 1991), 167-189 *passim*. Clemenceau's words are variously reported and translated.

Japanese imperialism in China, and, very quickly, no USSR. That of course is what did not happen: let us return to what did.

The Gulf War of 1991 was also mainly over oil, specifically how much of the Gulf region's supply should be in the hands of Saddam Hussein, who invaded and occupied Kuwait late in 1990 and threatened Saudi Arabia, the world's largest oil producer. At the time American officials marketed the war to the public as one over jobs (James Baker) or principle (George H.W. Bush). It was certainly not about principle: had Mozambique invaded Malawi the Americans would not have launched a war to undo it. It was about jobs in the sense that the American economy, and that of the industrial world generally, floated (and floats) on oil. Allowing a high proportion of the world's oil to be controlled by someone as unbiddable as Saddam risked recession and many jobs. Indeed, American policy towards the Middle East since the 1940s has recognized that oil is a vital economic and military resource for the U.S. It is even more vital for Japan: when the Japanese agreed to pay a goodly share of the costs of the Gulf War they understood they were paying for continued access to cheap oil. They did not suppose they were paying for a principle. American leaders have felt it necessary to invoke principle only because in the modern world fighting over resources is deemed crass and morally dubious, and thus candor on this point might undermine popular support for a given war. This is perhaps a reaction in part to Hitler's justification for his war in terms of *lebensraum*. The ancient Athenians–at least Thucydides–had no compunctions about saying that the value of Amphipolis (in Thrace) lay in its timber.

In a sense wars over oil have replaced wars over people. Before fossil fuels, a ruler's most practical way to amass energy for any given task was to amass people, which was most quickly done by enslaving them. Human beings are considerably more energy-efficient than horses, oxen, llamas, elephants or any other work animal. But in the last 150 years machines and fossil fuels provided a cheaper way to build monuments or fortresses, and the usefulness of massed, unskilled labor has plummeted accordingly.

To sum up matters so far: while environmental degradation has almost never led to interstate conflict, at least not directly, wars over resources or a common refrain in human history. They used to be fought of labor and land, but more recently are fought over oil. Before proceeding I will offer some tentative answers to an obvious question: under what circumstances are wars over resources fought?

In general, wars over environmental resources occur when valued resources are somehow made to seem more scarce or when wide differentials in power make seizure of resources easy and tempting. A sense of heightened scarcity can occur with a technological shift that suddenly makes something indispensable. Before 1910 no state needed reliable access to oil. By 1930 all great powers did, because the technology of war had changed. Heightened scarcity may also come with shifts in patterns of distribution and supply: in the 1860s the American Civil War created a shortage of cotton, which made it seem important to the Russians that they should control the oases and river bottoms of Uzbekistan, where they might grow their own cotton; the Russian push there began in 1864. States (and societies) may also feel the pinch of resource

scarcity in times of rapid population growth. This often took the form of land hunger and provoked ambitions of territorial conquest, as in the case of the U.S. Indian wars of the 19th century, the Chinese and Japanese pushes into Manchuria, and in other cases too numerous to mention.

The U.S. also fought its Indian Wars because they were so easy to win. Seizing resources becomes more tempting when it appears cheap and easy to do so. Farmers have routinely displaced hunting and gathering peoples from potential farmland because their technological and numerical edge made it simple to do. The Russians acquired Siberia and the Japanese Hokkaido because resistance was so feeble as to make the resources of those lands seem cheap to acquire. In the first decade of the 20th century, the Germans fought wars in what is now Tanzania and Namibia on the unconfirmed (and ultimately disappointed) hopes of finding useful natural resources. So, in short, wars over scarce resources are most likely when circumstances conspire to make the specific resources in view suddenly seem more valuable, or make the cost of taking them seem low. Such circumstances are most likely to arise in times of rapid and uneven population growth (or decline) and times of technological dynamism (when hitherto unvalued items suddenly become resources).

A third proposition, not prominent in the environmental security literature, is that security anxiety affects environmental change. Some researchers have shed light on the environmental effects of war itself, generally aiming to show that combat is bad for all life and land.[16] It usually is, although there are some exceptions, such as the flourishing of North Atlantic fish populations during WWII while fishing fleets were stuck in port. More important than combat, however, is the business of preparing for war. This is because more states prepare for war than actually fight wars, and because war itself is usually briefer than periods of preparedness.

States have long altered environments in the interest of security. They sometimes pursued forest conservation for strategic reasons. Qing China in the 17th and 18th centuries tried to maintain a wooded blockade ('the willow pallisade') between Chinese cultivators and steppe pastoralists in Manchuria. Naval powers from the 13th century, if not before, sought to conserve forests for ship timber; Venice perhaps took this the furthest. More recently, after the shocking defeat of 1870, the French army won the power to preserve public and private forests in eastern France so as to channel any future German invasion along well-fortified corridors. (The next German invasion came via Belgium in 1914).[17]

16E.g. Arthur P. Westing, *Warfare in A Fragile World* (London: Taylor & Francis, 1980); Westing, *Environmental Hazards of War* (Newbury Park: Sage, 1990); Daniel Faber, *Environment Under Fire* (New York: Monthly review Press, 1993).

17On these examples, see Patrick Caffrey, "The Forests of Northeast China, 1600-1953: Environment, Politics, and Society" Ph.D. dissertation, Georgetown University, 2002**; Karl Appuhn article**; Jean-Paul Amat, "Le rôle stratégique de la fôret, 1871-1914: Exemples dans les fôrets lorraines," *Revue historiques des armées,* 1(1993), 62-9.

States also brought on environmental change by seeking to stockpile strategic resources, whether food, rubber, oil, or soldiers. Mussolini, for example, wanted Italy to become self-sufficient in food so as to be less vulnerable to blockade of the sort he had seen weaken Germany in WWI. So he mounted the 'Battle for Wheat' encouraging Italians to clear forests and plant wheat on sloping and other marginal lands, inviting a surge of soil erosion. Crash programs of this sort proliferated in the 20th century when susceptibility to the interruption of international trade made autarky appealing, especially when war loomed. The USSR and China after 1949–for ideological as well as strategic reasons--undertook several such campaigns, of which the most famous example is the backyard steel furnaces of the Great Leap Forward (1958-60), a great leap backward for Chinese forests which provided fuel for the inefficient furnaces. Such programs amounted to a form of environmental roulette, but states willingly played because the ecological bills, if understood at all, fell due much later than would the political and military bills of unpreparedness.[18]

The most obvious connection between security anxiety and environmental change is the nuclear weapons programs organized after 1942. In the U.S. and especially in the USSR these led to the contamination of sizeable areas, to numerous health problems and premature deaths. The hair-raising risks taken, normally secretly, with their own populations show the lengths to which security anxiety during the Cold War drove both the Americans and Soviets. The plutonium buried at Hanford Engineering Works in the state of Washington, or dumped in Lake Karachay (in the southern Urals) will remain deadly for about 24,000 years, a long lien on the future. Cleaning up after the nuclear weapons programs will prove much more expensive than building the warheads and missiles in the first place, and will never be done completely.[19]

Less directly, states helped shape ecological change by building transport infrastructure in the name of military preparedness. New roads and railroads, aside from their immediate environmental impact, invariably change land use and human settlement patterns, especially in thinly populated areas. The Trans-Siberian railroad is a case in point. Built mainly for military reasons, it opened the gates to settlement and cultivation in the southern Siberian forest and northern steppe. It also made practical numerous mining and logging enterprises. The highways built in Brazilian Amazonia after1960 also had strategic reasons behind them, and also led to waves of migration, settlement, forest clearance, and otherwise unimaginable mining and logging businesses. Even the U.S. interstate highway system begun in the 1950s–which strongly affected land use and settlement patterns–featured military considerations prominently among its justifications.

18On the environmental aspects of the Great Leap Forward, Judith Shapiro, *Mao's War Against Nature* (New York: Cambridge University Press, 2001), 67-93.

19For details see Stephen Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons since 1940* (Washington: Brookings Institution, 1998), ch. 6; and McNeill, *Something New Under the Sun*, 342-4 and the works cited there. The best English-language source on Soviet and Russian nuclear environmental issues is the Norwegian Bellona Foundation. Visit: www.bellona.no.

Lastly and least directly perhaps, states have often sought (and occasionally still seek) to maximize their supply of soldiers by various pro-natal policies. Insofar as these are successful (which is rarely far) they affected environments by raising population. Third Republic France, Fascist Italy, Nazi Germany, and Stalinist Russia all encouraged women to bear more children, with modest success. In Europe the only pro-natalist effort that produced a real surge in births was that of Ceauşescu's Rumania, which doubled its birth rate in 1966. Ceauşescu, who was interested in pursuing an independent foreign policy that carried serious risks, set a goal of 30 million Rumanians by the year 2000. He outlawed all forms of birth control and assigned the secret police the duty of making sure Rumanian women did not shirk their duty. Mao, too, thought that millions of additional Chinese would enhance the military security of China, and, with brief exceptions, resisted efforts to curtail population growth in his country.[20]

Of course in most cases these population and transport policies had many motives behind them, of which security anxiety was only one. The point here is simply that historically, and especially in recent history, the ordinary business of preparing for war has helped drive states to actions that carried profound environmental consequences. Normally these consequences went unconsidered, but when they were not they were underestimated.

V. Prospects

The prospects for security problems to arise from environmental changes are better than ever. That is not to say they outrank more traditional causes of conflict. They do not, nor will they any time soon. But they are real enough to merit attention, and indeed now command attention in places such as the Pentagon.

The chief reason that environmental changes are more likely to play a larger role in security issues in the future than they have in the past is that ecological pressures of the sort most relevant to international competition are higher than ever before. Many of the reserves and ecological buffers–forests, unexploited fisheries, unpolluted fresh water–have been pared down. Put another way, there is less slack in the human-environment system now.

Against that is the welcome fact that the technological, and perhaps administrative, capacity to deal with environmental shocks and problems is also greater than ever before. The power of this to check conflict, however, is limited by the unwelcome fact that this capacity is so unevenly distributed around the world, and by and large is weak in places where the need for it is strongest.

20On Rumania see Jean-Claude Chesnais, *Le crépuscule de l'Occident: Démographie et politique* (Paris: Robert Laffont, 1995), 171-78. On Chinese population history and policy during the Mao years, see James Lee and Wang Feng, *One Quarter of Humankind: Malthusian Mythology and Chinese Reality* (Cambridge, MA: Harvard University Press, 1999); Judith Shapiro, *Mao's War Against Nature: Politics and the Environment in Revolutionary China* (New York, Cambridge University Press, 2001), 21-65.

Let us return to water and energy. At present some 30 or 40 countries in southwest Asia and North Africa are, by the conventional measures of hydrologists, short of water. They are also, as it happens, countries with population growth rates among the highest in the world, so that their scant water will have to be shared more widely in the years to come. Ethiopia and Sudan could make very good use of the Nile water that makes Egypt viable, and the temptations and pressures to do so will rise with growing populations. Similarly, Turkey in its quest to develop the poorer and politically disaffected southeast, could find uses for the waters of the Tigris and Euphrates, the lifeblood of Syria and Iraq. Indeed the Turks have built a series of dams that give them the option of impounding the water of those rivers. In a severe drought, Ethiopia and Turkey would feel the urge to take a larger share, despite the clear threats voiced by downriver neighbors. The likelihood of frictions over these rivers is high, but the likelihood of war over those frictions is governed by other factors. That is true of all the other international river basins over which conflict might break out, among which the leading candidates are probably the Indus and the Jordan, where frictions are great for other reasons.

There are other ways in which water might affect security besides quarrels over supply. The economic strength of every society depends on (among many other things) its water. This will presumably be less true in the future, as sectoral shifts in the world economy emphasize agriculture and industry less and services more. But that process is slow and less than universal. To take only two large cases, both the U.S. and China face adjustment to looming shortages of groundwater. The cattle and wheat economy of the High Plains in the U.S. has rested in recent decades on a large aquifer called the Ogallala, which stretches from north Texas to South Dakota. Cheap energy allowed farmers to pump up Ogallala water at great rates since the 1940s, and now about half of it is gone. The aquifer recharges slowly, over thousands of years, so in effect this is water-mining. In 20 or 30 years the water will be gone, and the U.S. will have to find another source for beef and wheat–or find some more water somewhere, an idea that worries Canadians and residents of Great Lakes states.

Moving water rather than shifting patterns of production appeals to the Chinese leadership, which faces a broadly similar problem in North China. There too water is short, and agriculture and industry must either find more, grow more efficient in their use of water (there is plenty of room for that), or cut back operations. The current preferred choice is to reroute some of the water of the Yangzi to the north, a gigantic project that recalls in its towering ambition the Soviet plans to redirect some of the flow of the Siberian rivers from the Arctic to Central Asia. Whether or not the Chinese will carry through with the "Southern Waters North" scheme remains to be seen. Without it they face limits on production. With it, they need massive capital investment (that other infrastructure projects would lose) and create another source of vulnerability in the form of water pipelines, sitting targets for missiles or terrorists.

In the past, while water has motivated countless quarrels and much small-scale violence, it has yet to serve as a cause for war. It is somewhat more likely to do so in the future, but only in contexts where frictions are already high and war, should it break out, would have, as it normally does, many causes. In the meantime, water shortage will continue to constrain the

economic development of dozens of countries, confine their military potential below what it otherwise might be. Climate change, should it continue on the path of the last 20 years, will exacerbate the trends in most cases by making dry regions a bit drier.

Although the economies of the rich and powerful countries of the world are growing less energy-intensive, the overall demand for energy will continue to increase and fossil fuels will for some time remain the heart of the world's energy system. Thus the uneven match between the geography of petroleum production and the locii of oil consumption will continue to bedevil world politics for decades to come. In just which ways, of course, remains quite unpredictable, especially as the emergence of Central Asian oil and gas has begun to shift the balances. Control of these resources, and the offshore oil of the South China Sea, are plausible candidates as sources (or intensifiers) of international conflict. As natural gas slowly acquires a larger place in the world's energy mix–as it has been doing for decades and will almost surely continue to do– the geopolitics of fossil fuels will perhaps become less volatile, because gasfields are distributed much more widely around the planet than oilfields. No single country can have the power in that market that the U.S, had in the oil market early in the 20th century, and no combination of countries could easily acquire the power that OPEC had in the late 1970s.

Looking further forward, the fossil fuel energy regime will one day come to an end. Just what will replace it, when, and how, is up in the air. Some authorities think the world's oil supply will begin to grow short very soon (between 2004 and 2008), but this is a minority opinion.[21] Nonetheless, it will happen one day and someone will take advantage of the shift in analogous ways to the deft exploitation of coal that Britain achieved 200 years ago or the quick and canny adaptation to oil that the U.S. pulled off 80 years ago. The future energy regime may or may not be as easy to turn to geopolitical advantage as those of coal and oil were, but it is sure that there will be winners and losers in the transition, and the winners will be selected from among those who pioneer the shift. On the strength of historical evidence, one should not expect the U.S. to be among the pioneers: typically beneficiaries of the old regime try to prolong it. Current American energy policy is fully consistent with this observation.

Perhaps substitutes for oil will emerge soon enough to prevent serious conflict, and (less plausibly) perhaps efficiency and conservation in water use will mitigate any potential international crises over water. Even should both these things happen, environmental considerations will impinge on international security. That is because environmental change in almost any form amounts to environmental degradation for someone, and environmental degradation leads to environmental refugees, that is, people who migrate because of deteriorating ecological circumstances at home.

The coming decades look to be another age of migration. This is true for many reasons, only one of which is environmental degradation. But in places where peasant populations are large and growing, and the material basis (soils, water, forests) for their livelihoods is wearing

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21K.N. Deffeyes, *Hubbert's Peak: The Impending World Oil Shortage* (Princeton: Princeton University Press, 2001).

thin, the pressures and temptations to uproot and try to get to a richer country will intensify. Richer countries have shown wide variability in their willingness to accept migrants, an issue of some importance in rich-country politics now and surely of yet greater importance in the decades to come.

By far the most volatile relationship in this respect is that between Europe and Africa, including North Africa. Demographers expect that the world population will grow to about 9-10 billion by 2050, and that more than 95% of the growth will take place in poor countries, and that African ones will grow fastest. This means that adding the next three billion people to the global population will be a more difficult business than was adding the last increment of three billion (which happened between 1960 and 2000). A much larger share of the next three billion will be born into circumstances of greater shortage of soil, water, and forest, and will see migration as their best option. Because Europe is easily accessible from Africa, especially North Africa, because Africa will likely continue to have the highest rates of population growth, and because Africa's environment is fragile and already heavily stressed, the likelihood is strong that the greatest pressures will emerge between Africa and Europe. Sometimes location is everything.

How European countries will react is an open question, but it is likely that they will not all agree, that their capacity to enforce their (or EU) policy will be unequal, and that anti-immigrant politics will have a strong future. This implies a resurgence of European nationalisms with attendant pressures on the integrating and globalizing trends of recent decades. Almost inevitably this will add fuel to the fires of religious chauvinism, both within Europe and probably among Muslims suffering backlash effects in Europe and among their sympathizers elsewhere. Developments along these lines are likely to complicate the security picture, especially in Europe, but also in North Africa and the Middle East.

Ethnic and religious tensions deepened by currents of migration may also affect other regions, but probably less acutely. The flows from Mexico, Central America and the Caribbean to the U.S. and Canada will likely not grow quickly, because population growth in the sending countries is slowing down fast. In any case, environmental refugees will not likely figure prominently in this migration.

VI. Conclusion

In the spirit of King Alfonso, this chapter sought to simplify the very complex nexus between environment and international security. It offers four main ideas, all based on historical perspectives. First, that in modern times environmental perturbation has grown to the point where it must be reckoned a serious factor in all manner of human affairs, security included. Some of this modern environmental disturbance derived from anxieties about international security, although modern patterns of energy use and population growth were probably more important. Second, that in the past such conflicts were routine if one adopts a generous definition of resources and environment, because there have been numerous wars over land, labor, and energy. But if one adopts more conventional and more restricted definitions, such wars have been rare, and in the modern world confined to struggles to secure oil. Third, that environmental

perturbations and resource scarcities will likely figure more prominently in the future than they have in the past, because ecological buffers are becoming thinner with time, and that where they lead to war they are most likely to concern water and oil. Fourth, in the longer run and the larger sense, the big shifts in energy regime and population growth that are sure to come will revise this picture in fundamental ways, but ones quite impossible to envision. Just what constitutes a resource will always be changing. And just which parts of the environment are valued, which are preserved, which are transformed and on what scales–all this will be changing too. For all our scientific expertise, modeling skill, and theoretical sophistication, we remain subject to the unforeseen, the unintended consequence, the non-linear effect. In the security arena, the stakes grew much higher in the modern era, and our knowledge of how both the natural and political worlds work grew too. But we still cannot generate precise and reliable ideas about threats and risks until they are upon us. We must respect the wisdom of King Alfonso.