Edited by

Alan Mikhail

Water on Sand

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I

The Eccentricity of the Middle East and North Africa's Environmental History

J. R. McNeill

This chapter aims to provide a global and comparative perspective on the environmental history of the MENA. It will draw attention to and briefly explore some of the eccentricities of the region as seen from an environmental history point of view. These eccentricities should not be misconstrued as exceptionalisms. Every one of them is shared with some other part or parts of the world, even if they are all eccentric in the sense that they are unusual. What is routine or commonplace in the MENA may be eccentric from the global perspective, as is true to some degree of any sizable region on the face of the Earth.[1]

In trying to adopt a global framework for contextualizing the MENA, I am consciously avoiding an East/West binary or Asia/Europe dichotomy. Herodotus, Montesquieu, Marx, Weber, and legions of lesser scholars have found that a convenient framework for their arguments, and many of them lumped the MENA together with China and India into one Asian category against which to contrast Europe's uniqueness. This approach, while not extinct, is deservedly less popular among scholars today. I aim instead for a global contextualization of the MENA's environmental history.

My vantage point is that of a generalist in environmental history with only modest acquaintance with the MENA's history and less with the debates and controversies that enliven the region's historiography. In the late 1980s and early 1990s, for a book on Mediterranean mountain landscapes, I devoted some attention to the Rif massif in Morocco and to the western stretch of the Taurus

Mountains in Anatolia. But that research was undertaken without any knowledge of Arabic or Rifian Berber, and with insufficient grounding in Turkish (and none in Ottoman Turkish). Twenty years later, I remain an outsider to Middle East Studies.

Within the field of environmental history, I have my own eccentricities reflected in the pages that follow. My approach, both in general and here, emphasizes the material components of environmental history. The genre of environmental history, broadly speaking, includes three main (but overlapping) approaches. One is concerned with biophysical changes to the environment, why they occurred, and what they meant for human communities. My work falls mainly into this category. A second approach emphasizes the conscious and intentional regulation of the environment, mainly through state political and legal action. One could, for example, write an interesting study of official state responses to Tehran's or Cairo's air pollution. The third approach focuses on cultural and intellectual perceptions of, and responses to, the environment. This usually takes the form of examining popular environmentalism or the writings of influential authors. One could, for example, write a useful treatise on the environmental thought of Ibn Khaldun, whose *Muqqadimah* contains many ideas about the relationships between power, wealth, and nature.

The eccentricities I consider below all belong in the category of comparative material environmental history. Comparative environmental history of the MENA could be of almost any sort and need not be confined to the material realm. One could profitably compare the record of environmentalism in MENA societies to those elsewhere, an exercise that would surely raise interesting questions. One could also ponder the environmental engineering ambitions of postcolonial states in the MENA with those in South Asia and sub-Saharan Africa, or the impact upon behavior of the MENA's religious traditions compared to those of religions elsewhere. If it is the case that the MENA's environmental history is in its infancy, then the comparative environmental history of the MENA is a newborn.[2]

The eccentricities of MENA environmental history considered below, as a result of my own eccentricities, are concerned with water, grass, and energy. I do not argue that these eccentricities as a whole either favored or disadvantaged the region. Such generalizations cannot be sustained across millennia because conditions change. At certain times, such as during the late nineteenth-century age of coal and steam, it is probably safe to say that the MENA stood at a disadvantage with respect to many parts of the world because most of it lacked coal. Such specific statements—anchored in particular historical moments—are plausible. But generalizations made for all time are not. In any case, to historians for whom the past is more than a horse race among

civilizations or world regions, such statements—even when plausible—only scratch the surface. My goal, rather, is to show some of the ways in which the MENA's environmental history has been distinctive and, where I can, how those distinctive characteristics—or eccentricities, as I call them—carried broader consequences.

Eccentricities of Water

Let us begin with salt water and maritime peninsulas. The Middle East (not North Africa) has a distinctive and historically consequential pelagic geography. It features four peninsulas of salt water: the Black Sea, the easternmost Mediterranean,[3] the Red Sea, and the Persian Gulf. Unlike China or northern Europe, the MENA is not blessed with a sprawling network of easily navigable rivers, but all its seas are excellent for sailing, with comparatively reliable winds and few catastrophic storms. Add to them the Nile and the Tigris-Euphrates, and one has a navigable network equal to that of anywhere in the world. The interpenetration of land and sea and the density of bays and peninsulas of the Middle East is rivaled in Southeast Asia and perhaps the Caribbean, and on a smaller scale by the geography of the Baltic and North Seas. All three of these spaces, however, were (and are) subject to much more frequent cyclones and gales than the MENA's seas.

The antiquity of urbanization, markets, and societies in which long-distance trade played a strong role owes something to this configuration of land and sea. The unusually strong development of caravan trade draws historians' gazes away from the importance of seaborne routes to the region. Indeed, the elaboration of terrestrial trade networks to some extent resulted from the existence of maritime ones: the incentive to trek over challenging terrain from Trabzon to Kirkuk derived from the complementarity of goods stockpiled in those towns through their seaborne and riverine networks.

It could be—although this hypothesis seems less secure—that the configuration of the MENA's seas also lent them to piracy. As in the Caribbean and Southeast Asian waters, the numerous narrows and choke points, combined with countless hideouts provided by the irregularities of coastlines and their proximity to defensible crags and bluffs, encouraged the rise of piracy and seaborne protection rackets (some of which became known to history as states). The historical record is replete with stories of piracy from at least the time of Pompey, who in 67 BCE tried to exterminate it in Mediterranean waters, down to the present day, when twenty-first-century Somalis batten on ships sailing in and out of the Gulf of Aden.[4]

One further eccentricity of the MENA's seas may have also carried historical consequences: all but one are poor in fish. The Black Sea is the exception. The several large rivers that flow into it—the Danube, the Dnieper, and the Don above all—bring abundant nutrients to feed the lower trophic levels of the marine food web, which in turn feed populations of anchovies and sprat, which in turn feed top predators such as tuna, mackerel, and bonito. Until recent decades, when overfishing and pollution have undermined the catch, the Black Sea supported vibrant fisheries and fishing communities. Its surrounding peoples probably got more protein than most MENA populations and were probably a little healthier as a result. Its surrounding states enjoyed a reserve army of seafaring men who could be lured or impressed into naval duty if the occasion warranted. The famous Ottoman reconstitution of the navy in the months after the Battle of Lepanto in 1571 was a feat that rested on such a reserve army, a luxury unknown to MENA states beyond the Black Sea.[5]

The other MENA seas are warmer and carry lesser quantities of dissolved oxygen, as a result inhibiting aquatic life. All are poor in nutrients compared to the Black Sea, because they are less influenced by the influx of river water. The Mediterranean coast from Alexandria east to Gaza was an exception to this rule of impoverished seas until the Aswan High Dam in 1971 blocked the Nile's flow of nutrients into Egypt and the eastern Mediterranean. So was the head of the Persian Gulf until oil pollution soiled its waters. But none ever had the fisheries (or fishermen) of the Black Sea.

Even the Black Sea never had the bounty found in some of the world's other fisheries. Compared to the waters of the Humboldt Current off of Peru, the Japan Current in the northern Pacific, or the upwellings created by seafloor banks in the North Atlantic, the MENA's seas were fish poor. Fresh water fisheries, in the Nile Delta for example, could compensate to some small degree, but nowhere on Earth do fresh waters support the cornucopia of edible fish found in the deep oceans where cold, oxygen-rich water wells up to the surface. With less fish protein available, MENA populations, like those of the Eurasian Steppe and much of Africa, relied more heavily on domestic animals to avoid or minimize protein deficiency. Thus the prominence of livestock in MENA economic history may be connected to the biotic character of the region's seas.

The second eccentricity of water that shaped life and history in the MENA is more familiar: the sharply uneven distribution of fresh water, the prevalence of aridity, and the consequent ecological responsiveness to even modest climate change. That responsiveness took the form of florescence in times of plentiful rainfall (the mid-Holocene greening of the Sahara for example) and of crisis in times of low rainfall.

A few landscapes, however, were almost exempt from this sensitivity to fluctuations in rainfall. First, tall mountains with reliable snowpacks—the Moroccan High Atlas or the Elburz in Iran, for example—served as water towers insulating their neighborhoods from droughts lasting, as most do, only a few years. The Elburz and some mountains in eastern Anatolia have year-round glaciers that yield meltwater even in the driest months, though more in centuries past than today (because the glaciers used to be larger). Second, big river basins that drew their water from large catchments or reliable monsoon rains provided some insurance against drought in Iraq and Egypt. These areas, however, grew so dependent on these rivers that on the rare occasions when prolonged drought cut their flows sharply, the resulting human disasters were all the more complete. The best example is an old one: the prolonged drought of the twenty-second century BCE that coincided with (and likely produced) the ends of the Old Kingdom in Egypt and the Akkadian Empire in Mesopotamia.[6] The parts of the MENA with more or less reliable fresh water were the ones where people settled and built cities and states.

But most of the MENA lacked enough water for dense settlement to arise.[7] In recent millennia, more than 90 percent of the region's surface area has supported scrub vegetation and seasonal grasses, but not forest or rain-fed agriculture. No conventionally constituted world region, with the possible exception of Australia, has nearly so high a proportion of arid land. This circumstance predisposed societies to develop a particular expertise in water management, namely getting the most out of limited water rather than—as in some other settings—keeping water away from dwellings and fields. The variety of technologies and management systems that have evolved over the past 6,000 years for this purpose is impressive, as is the spread of a handful of "best practices"—such as the *qanat*/*khattara*—in the last 1,500 years. As arid regions go, the MENA has an abundance of fossil water in aquifers (far more than Central Asia, the Gobi Desert, Australia, or western North America), encouraging the emergence of complex and labor-intensive water management schemes, including deep wells and *qanat*s in Iran and the *khattara* of Morocco.

For a thousand years or more, landscapes such as eastern China, northern India, and Western Europe (north of the Pyrenees) featured broad expanses of continual settlement. Villages dotted the land, their fields or pastures abutting one another. The MENA had no such broad expanses. It instead had small zones of continual settlement, such as western Anatolia or the river valleys, together making up an archipelago. The settlement pattern resembles that of Polynesia more than that of China or India, with larger and smaller "islands" of habitation existing where enough water could be found.

The size and borders of some of these "islands" changed with the climate. While in the Nile valley or Mesopotamia the water source remained fairly reliable and shortages were extreme anomalies, a few years of below-average rainfall on the Iranian or Anatolian plateaus or in Syria or Cyrenaica meant less to eat. A decade or two of below-average rainfall meant lower population and shrinking arable land. A century or two of below-average rainfall might have meant abandonment of villages and fields.

Large parts of the MENA had a keen sensitivity to climate change, rainfall in particular, roughly analogous to high latitudes where agriculture was marginal for reasons of temperature. In Scotland or Finland, for example, a few colder-than-average years in the seventeenth century meant starvation and population decline.[8] These lands were vulnerable because they had little farming, in contrast to agriculturally well-suited areas like France or Bengal. Much of the MENA was similarly marginal for farming, with other of its lands being vulnerable because they were marginal for pastoralism. A 20 percent reduction in average rainfall over a decade could be disastrous in Syria or Tunisia but inconsequential in Korea or Poland, just as a lowering of average temperatures by one or two degrees Celsius for a few years spelled catastrophe in Scotland or Finland but was meaningless in Portugal or Punjab.

One of the interesting avenues for future research in MENA environmental history is to integrate climate change into general social, economic, and political narratives.[9] How plausible is it to suppose that drier conditions in the seventh through ninth centuries favored the extension of pastoralism at the expense of agriculture and thereby made the Arab conquests of Syria and Persia easier? And should one believe that wetter conditions in the tenth to the thirteenth centuries helped undergird the prosperity, urbanism, and commercial efflorescence of Fatimid and Abbasid times?[10] Historians of Europe and China have begun to factor climate shifts into their analyses. By and large, they appear to have stronger documentary bases from which to work, although, as Sam White shows in Chapter 3, the Ottoman archives contain a fair share of helpful data. So far, Europe, China, and North America are much better served by proxy evidence—things such as tree rings, fossil pollen, and calcite deposits in caves that paleoclimatologists use to understand climate change—than is the MENA. This is not likely to change because climate history research is rarer in the MENA than in China, Europe, and North America, and because there are fewer old trees for dendrochronologists to study and fewer bogs and lake beds for palynology in the MENA than in those other major regions. But even with these constraints, there is ample room for historical climatology in the MENA and for historians to weave its findings into their reconstructions of the past.

The geography of sea and land, rainfall regimes, and climate change affect people and history everywhere. The MENA is not unique. But these phenomena affected the MENA differently than they affected most places. The interpenetration of land and sea is something the MENA shared with the Caribbean and Southeast Asia. Vulnerability to drought and deep social investment in water management was shared with the Amerindians of the U.S. Southwest and northwest Mexico. High sensitivity to climate change characterized Scotland and Finland as well as the MENA, albeit with respect to temperature rather than rainfall. Taken individually, these characteristics are atypicalities—at most, eccentricities. But taken together, the combination of these characteristics is distinctive and certainly eccentric. They affected the region's history in ways both obvious and subtle.

Eccentricities of Grass

To date, environmental history as a subdiscipline is most developed for North America, Europe, and India. In most cases, forests, forest management, and deforestation loom large. Although the MENA had and has its forests (and some scholars have probed their history) by and large the more important natural biome (land cover) in the MENA has been grasslands—although in many cases it is hard to know whether grasslands are natural or the result of grazing and burning. Several parts of the world feature (or featured) broad grasslands: central North America, the Pampa of South America, the West and East African savannas, the South African veld, and the steppe belt of Eurasia from southern Ukraine to Mongolia. The American grasslands did not host pastoral populations until the sixteenth century, for lack of suitable animals. When Spaniards and Portuguese brought horses, cattle, and other herbivores to the American grasslands, a form of mobile pastoralism[11] briefly flourished in South America, but in North America the presence of vast bison herds made it more attractive to hunt herbivores than to raise them. Grasslands in Africa and Asia, on the other hand, have served for several millennia as home to mobile pastoralists living off herds of sheep, goats, cattle, and horses.[12] The herds of the MENA's grasslands probably included a larger share of goats than herds elsewhere, which is one eccentricity and likely reflects the quality of forage more than cultural preferences. A second eccentricity is the often high proportion of herders within some MENA societies: in the 1520s, a quarter of the inhabitants of Anatolia and perhaps 60 percent of the population in the Ottoman Arab provinces were nomads or semi-nomads.[13] A third eccentricity is the proximity of grasslands

(and pastoralists) to the MENA's great urban centers and the interdigitation of steppe and sown. This quirk of ecology had some interesting implications.

No great cities stood anywhere near the grasslands of the Americas or Africa (unless one counts Timbuktu) until the middle of the nineteenth century, when European settlement fundamentally changed the equations of energy, population, trade, and technology that determine whether and where cities might exist. In the steppelands of Eurasia the situation was sometimes broadly the same as it was throughout the MENA: steppe and city often stood not far apart. But generally in Eurasia the great grasslands lay at a distance from population centers, sharing long borderlands with arable zones, in the heart of which lay the big cities. China's cities, for example, were located mainly in the east (and after 1000 in the south), near the sea, and far from the steppe. Europe's cities too stood a long way from the grasslands. Part of the reason for this arrangement was that before the era of the railroads, cities in cool latitudes needed so much firewood that they had to be located near or downriver from forests (seaports were the only exception). According to one calculation, before fossil fuels a European or Chinese city needed wood from an expanse of forest 50–200 times its own area.[14] Cities without good waterborne transport links had to maintain woodlands all around them. At warmer latitudes this constraint was relaxed somewhat, but grasslands generally did not produce enough fuel to serve as urban hinterlands. In the MENA, unusually, no big city except Istanbul stood more than a couple days' ride from steppe or desert.

The MENA is one of the few places on Earth where grasslands and arable lands exist in a mosaic. From Balochistan to Morocco, grasslands exist interspersed with arable lands. None of these areas is comparable in extent to those in the Americas, in sub-Saharan Africa, or the Eurasian Steppe. Nor are there broad expanses of arable land of the sort seen in southern and eastern China for the last thousand years. In land use and land cover, the MENA has for millennia had more of a patchwork than elsewhere, its arable land and pastures and (comparatively modest) forests all in close proximity to different biomes. This fragmented pattern maximized the interaction between pastoralists and farmers, between tribal confederations and agrarian states. Such interaction was of course normal wherever there was pastoralism. But the MENA was eccentric in the degree to which pastoral and agrarian communities interacted, the degree to which their lands intersected. To put it in terms of geometry, the MENA's grasslands and farmlands both had longer perimeters per unit of area than was normal elsewhere on Earth.

The interaction of pastoralist and farmer over millennia became genetically inscribed among MENA populations in the form of a biological

eccentricity—high rates of adult lactose tolerance. All infants are able to digest milk. Almost all people in the ancient world, however, lost the ability to metabolize milk and milk products beyond age 3 or 4 because their bodies stopped making the necessary enzyme (called lactase). Thus, nine thousand years ago, every adult was lactose intolerant. Between five and nine thousand years ago, probably in northern Europe or in the MENA, the first mutation occurred, creating lactose-tolerant adults. This must have proved a great advantage because, by the standards of genetic mutations, it spread like wildfire among populations with access to cattle, goats, camels, and other milk-giving livestock.[15] Parallel mutations took place later in Africa, where adult lactose tolerance rates are very high among two subpopulations, and perhaps in Central Asia, where most adults can digest yogurt and cheese—if not milk. Overall, about a quarter of the world's population today retains the ability to digest milk into adulthood. They are found mainly in northern Europe (and zones where northern Europeans settled), the MENA, Central Asia, and two regions in sub-Saharan Africa. These are all lands where the cultural trait of livestock-keeping and the genetic trait of adult lactose tolerance coevolved over the past few millennia. Within the MENA, different populations have different rates of adult lactose tolerance. The Bedouin of the Arabian Peninsula have the highest rates, while Lebanese have among the lowest. (Within Europe, Scandinavians and Britons have the highest rates, Sicilians the lowest; within India there is a north–south gradient from moderate to very low rates.) Ancient populations' animal husbandry practices thus made more recent populations biologically distinctive, different from people in East, Southeast, and most of South Asia and from most Africans, Amerindians, and Pacific Islanders as well. MENA peoples, like northern Europeans, are among the eccentric ones, thanks to their ancestors' easy access to grass and milk-giving herbivores.[16]

The patchwork of arable lands and grasslands in the MENA meant that the complementary economies of protein-producers and carbohydrate-producers existed in tighter harness than elsewhere. Pastoralists and farmers needed one another nutritionally and economically, and their relations included regular trade, seasonal labor, occasional intermarriage, and much else. But pastoralists usually needed the products of farm and city more than farmers and city-dwellers needed the products of the grasslands. After all, they could raise some animals on their own lands, even if they usually could not afford to devote good land to livestock. The near self-sufficiency of a farming village in medieval England or Japan was feasible in most MENA agricultural settings, but it was comparatively suboptimal, and therefore less common, because of the nearby presence of plentiful grass, livestock, and protein. Put another way, the rewards of exchange, of producing surplus for sale, were higher in

the MENA than in most other places. This, combined with the good transport opportunities afforded by the interpenetration of sea and land, and with the abundance of pack animals and the related human skills of muleteers and camel-drivers, encouraged commercial development very early in the region's history.

The potential for conflict between farmer and pastoralist was also higher in the MENA than elsewhere. Such conflict is, again, routine wherever farmers and herders coexist. They could easily have incompatible ambitions for the use of land and water (although they obviously need not). More importantly, if they did not like the terms of trade, pastoralists could easily resort to violence and had little to fear in the way of consequences. For the last four thousand years in Africa and Asia, political history evidences frequent conflict between farmers and herders, just as economic history demonstrates trade and cooperation between them. Once they mastered the arts of horseback riding and archery, steppe pastoralists became a formidable foe. Beginning on the western steppe around the tenth century BCE, they inaugurated a pattern of irregular mounted raids upon farming villages. Their mobility allowed them to choose when and where they might fight settled folk, and to retreat at no cost when the odds seemed unfavorable. When attacking farmers, they could also engage in wanton destruction and human slaughter with little fear that revenge would be exacted. Steppe and desert warriors' own women, children, and herds remained safe, hundreds of kilometers away. They had no immobile property for which they had to stand and fight. Literate chroniclers typically regarded the occasional brutality of pastoralists as inherent to what these writers described as these people's savage and bellicose nature, rather than a function of impunity borne of ecological circumstance.[17]

Agrarian states spasmodically attacked pastoralists in punitive raids and genocidal campaigns. The first such efforts in the historical record are those of Darius against the Scythians as described by Herodotus in the fifth century BCE. Chinese armies ventured out onto the steppe from time to time from at least 129 BCE. But armies had very limited shelf lives on the grasslands before they starved or died of thirst. Without wagons, they could travel for five days on the steppe—assuming they could find water—before they would have to head back to farmland. With wagons, they might double their range. If they could not find water and had to bring it with them, thirst would constrict their range by about 80 percent. They could almost never inflict crushing defeat on pastoralists, but when they got the chance they often spared no one. These logistical limitations contrasted with pastoralists' mobility made life for frontier farming folk dangerous, made farmers eager for the protection of states, and made frontier zones unstable.[18]

Such conflicts existed from Manchuria to Morocco and beyond, but they led to different results in different places. In East Asia, from the time of the Qin Unification (221 BCE), big agrarian empires recurred with regularity as a means of resisting pastoralists' incursions. In turn, pastoralists often built large confederacies in order to resist the pressure from Chinese empires (or to mount credible threats through which to extort payment). The geographical segregation of arable land and grassland, of farmer and pastoralist, encouraged this scaling-up of polities in response to one another. In India, roughly the same pattern held, although on a smaller scale. As in China, all the big empires in South Asia originated in the north, in proximity to pastoralists. Big empires provoked big pastoralist confederations, although none as large as what evolved on the Chinese/Mongolian Steppe. In the MENA, the fragmented pattern of grassland and arable land encouraged the emergence of militarized states but made it hard for them to grow to the same spatial scale as occurred routinely in China and fairly frequently in northern India. Until the Ottoman Empire, the big empires usually fragmented within a century or two. Those that lasted best, like the Ottomans, incorporated pastoralist peoples and lands within their ambit, controlling both carbohydrate-producing and protein-producing zones, and the transit routes among them. The comparative rarity of huge empires in the MENA reduced the logic for pastoralists to build giant confederations of the sort more common on the larger grasslands of Central Asia and Mongolia.

All this is not to say that ecology and geography governed the political patterns of world history. Rather, it is to say that, first, the presence of grasslands and suitable livestock—especially horses for mobility—raised the probability of large agrarian empires emerging, which in turn raised the probability of large pastoralist confederations. Second, where the grasslands and arable lands existed in discrete spaces the scale of empires and confederations was likely to be larger, and where the grasslands and arable lands existed in a mosaic pattern the scale was likely to be smaller. Of course other things matter, and big empires could emerge and cohere, at least briefly, in places without pastoralist neighbors. The Inka in Peru and the Khmer in Cambodia are examples. But in the great majority of cases, big agrarian empires arose where arable lands and grasslands met; they coevolved with pastoralist polities.[19]

The eventual eclipse of pastoralist power also carried deep consequences for the MENA. From the time of mounted archery until the eighteenth century, pastoralists enjoyed some military advantages over settled populations—hence the incentives for farmers to band together under the rule of big states. But between 1700 and 1890, agrarian states around the world gained the upper hand and ultimately destroyed the political power and independence

of pastoralists. This worldwide historical shift (rarely if ever recognized as such) was based on the growing logistical and technological power of agrarian states, as well as, in some cases, their epidemiological advantage over pastoralists (in the form of greater resistance to certain infectious diseases). The Qing Empire in China, which destroyed the last of the great Mongol confederacies in the middle of the eighteenth century, exhibited all of these advantages. Its generals figured out how to supply big armies on the grasslands with food and water and how to coordinate movements over vast distances so as to entrap their enemies. They increasingly exploited the potential of firearms to allow infantry to withstand and defeat cavalry. Fortuitously—and fortunately for the Chinese—smallpox epidemics battered the Mongols while leaving the Chinese unscathed (more on this follows).[20] At approximately the same time as Qing forces finally eliminated the Dzungar Mongols, the Russian state "pacified" the Pontic Steppe.[21] Soon the Chinese, Russians, Qajar dynasts in Iran, and a few like-minded agrarian states had extinguished pastoralist power in Asia.

Meanwhile, in North America a loosely parallel evolution took place. The introduction of horses by Spanish conquerors led to the rise of mobile equestrian warrior states such as the Comanche and the Sioux between 1710 and 1750. They dominated the broad grasslands from Texas to Saskatchewan and frequently raided nearby farming communities for food and slaves. Unlike the kings of the Afro-Asian grasslands, they were not pastoralists on any scale, but rather bison hunters. The farmers they traded with and raided did not have time to band together into imperial agrarian states before the U.S. Army (perhaps in this context to be understood as serving an imperial agrarian state) obliterated the equestrian empires of the Comanche and the Sioux. The last stand of autonomous semi-nomadic (not, strictly speaking, pastoralist) power in American history took place at Wounded Knee in North Dakota in 1890.[22]

The extinction of pastoralist power affected the MENA fundamentally. The Ottomans, who in their early centuries had encouraged pastoralism (especially in frontier districts), changed their policy by the 1690s. Henceforth they often tried to settle nomads and encourage farming. They wanted, as most states usually do, to be able to tax and conscript people more easily. For more than two centuries they worked at it, registering, counting, describing pastoralists in Ottoman lands, and cajoling or forcing many of them into surrendering their autonomy and mobility. Ottoman officials developed the standard prejudices against mobile pastoralists, viewing them as uncivilized, primitive, and savage—little better than animals. Their objections included the notion that pastoralists' animals damaged agriculture and degraded environments, a common

refrain wherever pastoralists went.[23] The Ottomans conducted military operations against pastoral tribes. But in the absence of giant confederations of pastoral tribes, the Ottomans could not deliver a smashing blow as the Qing did to the Mongols in the 1750s. Instead, for centuries, the government in Istanbul might bribe chiefs or defeat a tribe or two, but they often would not stay bribed and defeated for very long.

But by the 1860s, the Ottomans were meeting with more success and within 30 years had settled almost all mobile pastoralists in Anatolia, their remaining Balkan territories, Syria, and Kurdistan. They never managed to achieve their goal in Libya and the Maghreb, where pastoralists retained autonomy and formed important parts of the resistance to Italian and French power into the early twentieth century (although the French had broken the big pastoralist confederacies in Algeria by the 1870s). The vastness of the Sahara made the extinction of pastoralist power there an especially difficult task.[24] Chapter 6 makes clear how easily the Turkmen tribes resisted attempts by Qajar Iran to destroy their power and autonomy into the middle of the nineteenth century. The Turkmen never formed any large confederacies; while this made it unlikely they could conquer Iran (which Arash Khazeni says they never wished to do), it also meant their fighting forces could not be trapped and crushed like the Dzungar Mongols.

In some ways, the suppression of pastoralists' autonomy in the MENA resembles a more difficult version of the suppression of piracy and privateering in the Caribbean. Privateers preyed on shipping and port cities on behalf of a monarch; pirates did it on their own account. One could be a privateer one month and a pirate the next. The line between the two was fuzzy, just as was the line between *akıncı* and *haydut* (or *armatole* and *kleft*) in the Ottoman Empire. The plantation societies of the West Indies (based on a very eccentric grass, sugarcane) proved vulnerable to pirates and privateers, whose mobility allowed them to swoop in, raid, pillage, and disappear quickly. The built environment of plantations and ports was easily destroyed, like the irrigation systems of MENA farmers. This vulnerability made it easier for pirates and privateers (like mobile pastoralists) to exact protection rent and ransoms from settled folk. In both cases it took concerted and sustained state action to suppress the threat, and that action was often as much diplomatic as military. Britain, which led the effort to end Caribbean piracy in the early eighteenth century, not only needed cooperation from other European powers such as France and Spain but from pirates who could be seduced into switching sides. The British appointed an ex-privateer and pirate, Henry Morgan, as lieutenant governor of Jamaica in 1675, just as the Ottomans appointed Yeğen Osman, a former bandit, as governor of Afyon in 1687. By 1730 piracy was on the wane in the

West Indies, although not fully suppressed. The attitude of the states involved was more uncompromising than that of the Ottomans with respect to independent pastoralists, and the scale of the project much smaller.

The interdigitation of grassland and arable land might also have affected the role of infectious disease in the political history of the MENA. The extinction of pastoralist power on the eastern steppe, accomplished by the Qing in the 1750s, was helped along by smallpox.[25] A Chinese chronicler wrote that in the final campaigns, 40 percent of the Mongols succumbed to smallpox, 30 percent were killed by Qing forces, and 20 percent escaped to Russian lands.[26] The Chinese suffered far less from smallpox, because most of them had survived it in childhood (when it is typically less lethal) and were thus immune as adults. In North America, the Comanche lost half their population to smallpox in 1780–1782 and more of their number to other epidemics in the nineteenth century.[27] Recruits in the U.S. Army and settlers on the prairies were usually immune to smallpox (and more resistant than the Comanche or Sioux to a host of other infections). The Ottomans and the French in Algeria, on the other hand, had no such help from pathogens. By the eighteenth and nineteenth centuries, if not well before, the pastoralists of the MENA had acquired approximately the same portfolio of disease immunities as settled folk. Since farmers and pastoralists interacted so regularly in the MENA, they shared infections liberally and developed antibodies against the same diseases. This might help explain why the extinction of pastoralist autonomy came later and slower in the MENA than it did in East Asia or North America.

It could well be that the origins of the Ottoman Empire also owed something to the interaction of disease and the settlement geography of the MENA. In the early fourteenth century, the Ottomans drew most of their manpower from pastoralist tribes in northwest Anatolia. They were not yet at all urbanized. But their main rivals—the Byzantines and several Turkic principalities such as Aydın, Karası, and Karaman—were either coastal settlements or closely connected to port cities. As such, they probably suffered much more acutely from the plague beginning in 1347 than did the Ottomans.[28] Unlike smallpox, plague is a vector-borne disease. The vector in question is rat fleas, which will cheerfully bite humans when rats are scarce. Thus plague is a disease confined to certain environments, especially those where grain is stored and rats congregate. Its usual pattern—noted by Procopius during the plague of Justinian in the sixth century and by many commentators since—is to hit port cities hardest, cities hard, villages less hard, and mobile populations least of all. Early Ottoman sources apparently make no mention at all of the plague—in sharp contrast to Byzantine accounts. The Byzantine Empire

reeled under the impact of plague beginning from 1347. It recruited Ottoman help in its campaigns in the Balkans; from that time onward the Ottomans were a significant force in regional politics. For more than a century, their successes took place mainly in the southeast Balkans and northwest Anatolia, landscapes severely depopulated by plague. The existing political formations in these areas probably suffered much more in the way of manpower loss than did the Ottomans themselves. This suggests that the mobile pastoralism of the Ottomans shielded them from the worst of the plague, raising the odds that they would be militarily and politically successful in the fierce competitions that would occur in Anatolia and the Balkans in the late fourteenth century. In this instance (if these speculations have merit), disease helped mobile folk against settled folk, the opposite of the pattern in cases where smallpox did the deadly honors.[29]

Much of the foregoing is speculation that cannot be tested or verified. We will almost certainly never uncover data about the differential impact of the Black Death on Ottoman versus Byzantine manpower. But given what we do know about the ways of life of these populations, the habits of rats, and patterns of mortality in subsequent plague outbreaks, these are, I hope, plausible partial explanations for the lightning success of the Ottomans from 1347 onward—at least until they captured Constantinople in 1453. These suggestions might supplement traditional arguments about ghazi motivation, Beyazıt's talents, the restless state of Balkan peasantries, and so forth.

My suggestions about the eccentricities of grass in the history of the MENA flow from two geographical features. First, in the MENA there has long been more grassland and less forest than in either more temperate or more tropical zones. Second, unlike most steppe and steppe/desert zones, grassland and arable land exist, and have long existed, in a more fragmented mosaic in the MENA than is the pattern in East Asia, north India, or North America, which has resulted in a long history of pastoralist and farmer being in closer, more frequent contact. This then predisposed the MENA toward eccentric economic, political, and epidemiological tendencies that were not widely shared around the world.

Eccentricities of Energy

A third eccentricity of the MENA in global historical context is its relationship to energy. In Chapter 2, Richard W. Bulliet discusses the role of cheap animal power resulting from abundant forage, and how that nudged the MENA into an energy technology cul-de-sac. Incentives to develop new and different

energy technologies were weak, because animal power was so cheap—both for transport and for milling. This idea bears a cousinly resemblance to Mark Elvin's explanation of the technological stagnation of late imperial China, his so-called high level equilibrium trap.[30] Elvin argued that by the late seventeenth century China had achieved great efficiency in its markets, had filled up all its suitable agricultural land, and had enormous reservoirs of cheap labor (human energy). This arrangement, Elvin, continues, discouraged investment in labor-saving technologies. Both arguments seek to explain why certain regions (the MENA and China) did not keep pace with Europe (mainly England) in the development of energy-intensive technologies that ultimately led to full-scale industrialization. Both also point to the importance of energy systems in world history.

The MENA's grasslands and domesticates (camels, horses, and donkeys in particular) endowed it with an eccentric history of energy, as Bulliet argues. This had implications for transport and the early and widespread development of markets, as noted above. Caravan routes, together with the Nile, the Tigris-Euphrates, a few lesser rivers, and the MENA's saltwater peninsulas knitted the region's centers together. China too showed precocity in the development of markets, based on its network of rivers gradually supplemented by its canals. In both cases, energy systems based on animal, human, and wind power undergirded regional economies as productive and commercialized as any in the world—until the emergence of fossil fuels.

In this final section I will underscore the obvious: the MENA has almost no coal but lots of oil. As the world shifted overwhelmingly to fossil fuels after 1800, these facts powerfully shaped the MENA's historical experience. I will treat this theme because it is so important, but briefly because it is nearly self-evident.

Until 1800, the entire world relied overwhelmingly upon an organic energy regime. In a few places, wind or waterpower added significantly to the energy harvest. For a century or more, Song China had a sizable iron industry based on coal. But these (and lesser) exceptions aside, usable energy for human purposes came in the form of chemical energy contained in biomass. Humans could eat some of it and thereby convert it into different forms of chemical energy, kinetic energy, and bodily heat. Their domestic animals could also eat some of it. And humans could burn some of it directly for heat. But to get things done, they had to rely on human or animal muscle.

This energy regime constrained human ambitions tightly. All energy ultimately came from the sun, which was inconvenient. Humans harvesting the energy from biomass were only able to tap—and very inefficiently—the annual flows from the sun, refracted through photosynthesis and one or two trophic

levels. When burning fuelwood or charcoal, people could tap the energy stocks of a century or two. But this was the only good way to stockpile or store energy for future use, and it was good only for heat energy. It was hard to amass kinetic energy except by amassing humans and animals. The average pharaoh, emir, or sultan had less energy at his command than has a modern bulldozer operator.

After 1800, the exploitation of fossil fuels shattered the constraints of the organic energy regime. Coal and oil together contain a supply of about five hundred million years of stockpiled sunshine.[31] Since 1888 the world has burned fossil fuels at an annual rate greater than the net primary productivity of the Earth (in other words, the amount of energy that photosynthesis can store in biomass). It takes about 90 tons of ancient biomass to make the oil needed for a gallon of gasoline. So fossil fuels represent very inefficiently stored sunshine, and we have been burning up the total stock quickly. This abundance of energy, more than anything else, makes modern times different from earlier human experience.

To convert the frozen sunshine of fossil fuels into kinetic energy required an engine. The first steam engines lost 99 percent of their energy as dissipated heat. Nonetheless, by 1800 a single steam engine could do the work of two hundred men (and it still wasted 95 percent of its energy input). By 1900, an average steam engine could do the work of six thousand men. To feed steam engines, one needed coal. From 1800 onward, coal gradually replaced biomass in the world's energy system. By 1890, more energy came from coal than from biomass.

As world regions go, the MENA is thin on biomass, but it is far poorer in coal. From 1800–1950, this was one of the worst deficiencies a region could have in terms of global competition for wealth and power. In environmental terms, given the effects of coal mining and coal combustion, having little coal might be considered a blessing. In economic and political terms, it was a curse for a century and a half. In the nineteenth century, when Europe, North America, South Africa, Australia, Japan, and even some places where labor was very cheap (Bengal, for example) had begun to substitute coal and steam for biomass and muscle, the MENA remained dependent on grasses and animals for its energy harvest. Anatolia had a little coal, and so did Iran. But the quantities were tiny by the standards of other parts of the world. Since 1980, the MENA has accounted for only 0.025 percent of world coal production—one out of every four thousand tons.[32] It was not alone in this economic misfortune: tropical Africa and South America outside of Colombia lacked coal as well. But the big centers of population—China, India, Europe (and by the nineteenth century, eastern North America)—all had plenty.

Moreover, what little coal the MENA had could not be cheaply transported to cities. Moving it via animal transport was prohibitively expensive. So very little was used until the era of oil-powered machinery and transport. This put the MENA in an extremely unfavorable situation compared to Russia, where coalfields lay athwart the Don River, or Great Britain, where coal lay near the sea in South Wales, Tyneside, and elsewhere. If MENA industrialists needed coal, they had to buy it from afar and pay accordingly.

Deficiency in coal led people in some parts of the world to seek alternative bases for industrialization. When turbine technology emerged in the late nineteenth century, entrepreneurs and engineers here and there tried to exploit "white coal"—hydroelectricity—to power factories and railroads. In some locations—around the Alps or Quebec's St. Lawrence Valley, for example—this strategy worked because reliable swift-flowing water existed. Bavaria, Lombardy, and Quebec built industrial economies substantially on white coal between 1890 and 1940. But only a few places around the world could match this record. The MENA had precious little white coal. What hydroelectric potential it had generally remained unharnessed until the 1970s.

The organic energy regime had been good to the MENA in the sense that its endowments of grass and animals did not handicap its economic development or political power. Indeed, if anything, the reverse was true. But in general economic terms, the organic energy regime did not generate big differences from one region of the world to the next. Every place got some sunshine, and all but the driest deserts and coldest taiga produced biomass in abundance. In political terms, the MENA's grass and animals were an important source of military power, wielded sometimes by pastoralist tribes, but sometimes by agrarian empires employing tribesmen as fighters. But when coal became king, the MENA's economic and political position plummeted vis-à-vis other parts of the world.

Oil took away king coal's crown by about 1965 and has kept it ever since. We use about 20 percent more oil than coal (in energy content) today. In parts of the MENA the oil age dawned early in the twentieth century, but it revolutionized life only in the middle of the century and, even then, only in the oil-producing countries. But since the 1960s, the size of the oil industry and the sums of money involved have been so great as to reverberate almost everywhere throughout the MENA. Oil, as every reader of this book will know, has proved a source of both unprecedented wealth and unusual disruption in the MENA. It has empowered several MENA states politically and militarily far beyond what they could plausibly have achieved in recent decades without oil. It has opened up chasms of inequality within MENA societies and, as oil production has everywhere, fouled the environment in and around the oil fields themselves.

But its impacts will be short-lived. King coal reigned for about seventy-five years; king oil has lasted for forty-five. Soon, whether with bangs or whimpers, the world will shift away from oil as its main fuel. Perhaps coal will regain its crown. Perhaps new technologies will install solar power on the throne. No one knows. But everyone knows oil exists in finite supply and sooner or later will become too expensive for routine use. Soon the oil age will appear a fleeting aberration in the MENA's—and the world's—history.

Conclusion

Every region of the world has its peculiarities. This chapter aimed to identify some of those in the material environmental history of the MENA, specifically regarding water, grass, and energy. They are all, of course, linked. Availability of freshwater helps determine vegetation. Vegetation provides chemical energy that animals (including humans) can transform into movement and heat. But it helps to first see these eccentricities separately in order to make isolated comparisons to situations in other parts of the world.

The eccentricities of the MENA with respect to water include both the obvious constraint of limited fresh water in much of the region, and the less-noticed convenient geography of saltwater seas, gulfs, and bays. Both are shared with some other parts of the world. But no other sizable part of the world shares both. The configuration of land and sea helped in the precocious commercialization of the MENA, from Sumerian times if not before. It also helped stimulate caravan traffic where rivers did not serve as transport arteries (in other words, in lands other than Egypt and Iraq). The MENA's seas, while convenient for commerce, provided paltry quantities of fish protein. In comparison to other parts of the world, MENA populations had to raise more animals per person or suffer from protein deficiency. And MENA navies (except that of the Ottomans) had to find their crews without the useful reserve army of fishermen that typically existed where fisheries flourished. The scarcity of fresh water should be understood not merely as a background condition of life in much of the MENA, but also in relation to climate change—a concern that historians are with some hesitation beginning to take seriously. Above all else, even modest changes in rainfall regimes, whether over years or centuries, carried particularly significant consequences in the MENA, either enlarging or shrinking human possibilities. Equal changes in rainfall regimes in well-watered lands were far less consequential because none of their communities stood at the margin where rainfall agriculture, or even irrigation agriculture, was barely practical.

The eccentricity of grass in the MENA derived mainly from the fact that grasslands existed in a crazy quilt pattern rather than in huge expanses. Arable land, grass, and scrub stood side by side in (by the standards of other parts of the world) little patches. So herders and farmers lived almost cheek by jowl, raising the probability of systematic interactions between them, both warlike and peaceful. In contrast to the Pontic and the Mongolian steppelands, where big blocks of grassland encouraged the emergence of large pastoralist confederations in response to big agrarian states, the MENA's political landscape differed. Smaller polities were the rule, both in size and in population. There were of course exceptions, at least in the form of agrarian empires that lasted a century or two (and the Ottomans, who lasted roughly six). But the contrast to the situation in East Asia, where big agrarian states—in the form of successive Chinese dynasties—and big pastoralist confederacies were routine, is striking.

The eccentricities of energy in the MENA reside in its long reliance on biomass and animals, its minimal recourse to coal, and its near-total refashioning in the age of cheap oil. Most parts of the world relied on biomass and animals for most of human history; in this respect, the MENA is as normal in its energy history as it could be. Only in the nineteenth century did its energy path come to conform less fully to the global average. But until 1920 or so, the use of coal was itself an eccentricity, confined to a few parts of the world. The MENA, in relying minimally on coal, was still in the company of almost all of Africa, South America, and South and East Asia. Only a few pockets in these lands had turned to coal on any scale. So the MENA's energy pathway may appear eccentric when viewed through the lens of Europe, Russia, Japan, or North America (and those few pockets elsewhere), but if seen through the lens of India, China, Africa, or Brazil in 1920, it would look normal. That changed radically with the development of cheap crude oil beginning early in the twentieth century and exploding from the late 1940s on. From this point forward, the MENA's experience with energy looks highly eccentric compared to almost anywhere else. When the oil grows scarce, or a new energy regime displaces it, the MENA's experience will be eccentric again, in new ways and for new reasons.

Notes

1. In a parallel exercise I tried to isolate distinctive features of Chinese environmental history in J. R. McNeill, "Chinese Environmental History in World Perspective," in *Sediments of Time: Environment and Society in Chinese History*, ed. Mark Elvin and Liu Ts'ui-jung (Cambridge: Cambridge University Press, 1998), 31–52.

2. Note, however, that some of this book's chapters offer comparative perspectives from time to time.

3. By this I mean the Mediterranean east of a line between Cyrenaica and Rhodes.

4. On Pompey's campaign and Mediterranean piracy, see Philip De Souza, *Pirates in the Graeco-Roman World* (Cambridge: Cambridge University Press, 2002); Jules Sestier, *La Piraterie dans l'antiquité* (Paris: Marecq, 1880). About piracy in other regions, see Robert Anthony, *Like Froth Floating on the Sea: The World of Pirates and Seafarers in Late Imperial South China* (Berkeley: Institute of East Asian Studies, 2003); Kris Lane, *Pillaging the Empire: Piracy in the Americas, 1500–1750* (Armonk, NY: M. E. Sharpe, 1998).

5. On Lepanto and its aftermath, see Niccolò Copponi, *Victory of the West: The Great Christian-Muslim Clash at the Battle of Lepanto* (Cambridge: Da Capo Press, 2007), 299–303; Mehmet Kuru, "The Relations between Ottoman Corsairs and the Imperial Navy in the 16th Century" (Ph.D. diss., Sabancı University, 2009); İdris Bostan, *Osmanlı Bahriye Teşkilâtı: XVII. Yüzyılda Tersâne-i Âmire* (Ankara: Türk Tarih Kurumu Basımevi, 1992), especially 188; Colin Imber, "The Reconstruction of the Ottoman Fleet After the Battle of Lepanto, 1571–1572," in *Studies in Ottoman History and Law*, ed. Colin Imber (Istanbul: Isis, 1996), 85–101. The manpower of the Ottoman navy included oarsmen, who needed no knowledge of the sea and were recruited from inland districts of Rumeli and Anatolia, and true sailors, who came from the Black Sea, Sea of Marmara, and Aegean coasts. Experienced sailors were scarce and often the limiting factor in early modern navies.

6. Simone Riehl, "Climate and Agriculture in the Ancient Near East: A Synthesis of the Archaeobotanical and Stable Carbon Isotope Evidence," *Vegetation History and Archaeobotany* 17 (2008): 43–51; M. Magny, B. Vanniere, G. Zanchetta, and E. Fouache, "Possible Complexity of the Climatic Event around 4200–4000 cal. BP in the Central and Western Mediterranean," *The Holocene* 19 (2009): 823–833.

7. A recent reflection on aridity and water management is Edmund Burke III, "The Transformation of the Middle Eastern Environment, 1500 B.C.E.–2000 C.E.," in *The Environment and World History*, ed. Edmund Burke III and Kenneth Pomeranz (Berkeley: University of California Press, 2009), especially 83–88.

8. Karen J. Cullen, *Famine in Scotland: The "Ill Years" of the 1690s* (Edinburgh: Edinburgh University Press, 2010); Michael Flinn, *Scottish Population History from the Seventeenth Century to the 1930s* (Cambridge: Cambridge University Press, 1977); Eino Jutikkala, "The Great Finnish Famine in 1696–1697," *Scandinavian Economic History Review* 3 (1955): 48–63.

9. An attempt which leaves room for improvement is Arie S. Issar and Mattanyah Zohar, *Climate Change: Environment and Civilization in the Middle East* (Dordrecht: Springer, 2004). For comparison, see Emmanuel Garnier, *Les dérangements du temps: 500 ans de chaud et de froid en Europe* (Paris: Plon, 2010); Emmanuel Le Roy Ladurie, *Histoire humaine et comparée du climat*, 3 vols. (Paris: Fayard, 2004–2009); Rüdiger Glaser, *Klimageschichte Mitteleuropas: 1200 Jahre Wetter, Klima, Katastrophen* (Darmstadt: Primus, 2008); Franz Mauelshagen, *Klimageschichte der Neuzeit, 1500–1900* (Darmstadt: Wissenschaftliche Buchgesellschaft, 2010).

10. Issar and Zohar, *Climate Change*, 212–222.

11. I will use this phrase where other authors use "nomadism" because true nomadism was rare and many of the herders I write about were semi-nomadic or transhumant. Moreover, these herders may have changed their patterns of mobility from time to time.

12. A helpful introduction to early steppe pastoralism is David Anthony, *The Horse, the Wheel and Language: How Bronze-Age Riders from the Eurasian Steppes Shaped the Modern World* (Princeton, NJ: Princeton University Press, 2007). See also Nicola Di Cosmo, *Ancient China and Its Enemies: The Rise of Nomadic Power in East Asian History* (Cambridge: Cambridge University Press, 2002). And for what is now upper Egypt and northern Sudan, see Karim Sadr, *The Development of Nomadism in Ancient Northeast Africa* (Philadelphia: University of Pennsylvania Press, 1991).

13. Reşat Kasaba, *A Moveable Empire*: *Ottomans, Nomads, Migrants and Refugees* (Seattle: University of Washington Press, 2009), 18.

14. Vaclav Smil, *Energies: An Illustrated Guide to the Biosphere and Civilization* (Cambridge: Massachusetts Institute of Technology Press, 1999), 118.

15. The advantage consisted of supplies of high-quality nutrition in the form of milk, yogurt, and cheese. It may also have consisted of healthier liquids. Cattle and camels can produce healthful milk from polluted or brackish water and can take in moisture from the vegetation they eat. Thus, they can convert liquids that are unhealthful or unavailable to humans into helpful ones. This capacity would have been especially advantageous in places where good water was scarce—as in arid environments.

16. Clare Holden and Ruth Mace, "Phylogenetic Analysis of the Evolution of Lactose Digestion in Adults," *Human Biology* 81 (2009): 597–617; Pascale Gerbault et al., "Evolution of Lactase Persistence: An Example of Human Niche Construction," *Philosophical Transactions of the Royal Society B* 366 (2011): 863–877; S. S. Hijazi, A. Abulaban, Z. Ammarin, and G. Flatz, "Distribution of Adult Lactase Phenotypes in Bedouins and in Urban and Agricultural Populations of Jordan," *Tropical & Geographical Medicine* 35 (1983): 157–161.

17. A study of ancient Chinese texts and their conceptions of pastoralists (and other foreign peoples) is Di Cosmo, *Ancient China and Its Enemies*, 93–158. See also Romila Thapar, "The Image of the Barbarian in Early India," *Comparative Studies in Society and History* 13 (1971): 408–436.

18. Herodotus, *The Persian War* (New York: Modern Library, 1942), 4.121–128. Interesting calculations on the logistics of armies in steppe and desert terrain appear in the following: Kenneth Chase, *Firearms: A Global History to 1700* (Cambridge: Cambridge University Press, 2003), 16–18. The tendencies of pastoralists and farmers to demonize one another and exterminate one another in war are well attested. See, for example, Christopher I. Beckwith, *Empires of the Silk Road: A History of Central Eurasia from the Bronze Age to the Present* (Princeton, NJ: Princeton University Press, 2009).

19. These generalizations are based on Peter Turchin, "A Theory for Formation of Large Empires," *Journal of Global History* 4 (2009): 191–217. Turchin identifies 60 empires of larger than one million square kilometers before 1800; all but four, including the Khmer and Inka, were located in lands in regular contact with the steppe pastoralists of Morocco to Manchuria.

20. Peter C. Perdue, *China Marches West: The Qing Conquest of Central Asia* (Cambridge, MA: Harvard University Press, 2005).

21. Willard Sunderland, *Taming the Wild Field: Colonization and Empire on the Russian Steppe* (Ithaca, NY: Cornell University Press, 2004).

22. Pekka Hämäläinen, *The Comanche Empire* (New Haven, CT: Yale University Press, 2008); Robert Utley, *The Last Days of the Sioux Nation* (New Haven, CT: Yale University Press, 2004).

23. This was also the case among French officialdom in the Maghreb. See Diana K. Davis, *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa* (Athens: Ohio University Press, 2007).

24. Kasaba, *A Moveable Empire*, 53–122; Benjamin Claude Brower, *A Desert Named Peace: The Violence of France's Empire in the Algerian Sahara, 1844–1902* (New York: Columbia University Press, 2009); Osama Abi-Mershed, *Apostles of Modernity: Saint-Simonians and the Civilizing Mission in Algeria* (Stanford, CA: Stanford University Press, 2010).

25. In addition to Perdue, *China Marches West*, see also Jiafeng Zhang, "Disease and Its Impact on Politics, Diplomacy and the Military: The Case of Smallpox and the Manchus, 1613–1795," *Journal of the History of Medicine and Allied Sciences* 57 (2002): 177–197. The Manchu feared smallpox greatly and managed to contain its ravages within their ranks while they conquered China, ruled China, and then conquered the Mongols.

26. Wei Yuan, cited in Peter C. Perdue, "Fate and Fortune in Central Eurasian Warfare: Three Qing Emperors and their Mongol Rivals," in *Warfare in Inner Asian History*, ed. Nicola Di Cosmo (Leiden: Brill, 2002), 393.

27. Hämäläinen, *Comanche Empire*, 111; Adam R. Hodge, "Pestilence and Power: The Smallpox Epidemic of 1780–1782 and Intertribal Relations on the Northern Great Plains," *The Historian* 72 (2010): 543–567.

28. Whether or not the pandemic of 1346–1352 was plague, plague and other infections, or only other infections is in dispute, although the weight of expert opinion plunks for plague. On the difficulties of retrospective diagnosis in the MENA, see Sam White, "Rethinking Disease in Ottoman History," *International Journal of Middle East Studies* 42 (2010): 549–567.

29. My prior speculations on this subject have been superseded by those of Uli Schamiloglu. See J. R. McNeill, "Ecology and Strategy in the Mediterranean," in *Naval Policy and Strategy in the Mediterranean: Past, Present, and Future*, ed. John Hattendorf (London: Frank Cass, 2000), 376–377; Uli Schamiloglu, "The Rise of the Ottoman Empire: The Black Death in Medieval Anatolia and Its Impact on Turkish Civilization," in *Views from the Edge: Essays in Honor of Richard W. Bulliet*, ed. Neguin Yavari, Lawrence G. Potter, and Jean-Marc Oppenheim (New York: Columbia University Press, 2004), 255–279. Metin Kunt suggested the Black Death might have helped the Ottomans, but on the implausible argument that their Central Asian origins provided them immunities that Greeks and Serbs did not have. Metin Kunt, "State and Sultan up to the Age of Süleyman: Frontier Principality to World Empire," in *Süleyman the Magnificent and His Age: The Ottoman Empire in the Early Modern World*, ed. Metin Kunt and Christine Woodhead (London: Longman, 1995), 3–19.

30. Mark Elvin, *The Pattern of the Chinese Past* (Stanford, CA: Stanford University Press, 1973), especially 298–315.

31. Useful perspectives can be found in the following: Charles Hall et al., "Hydrocarbons and the Evolution of Human Culture," *Nature* 426 (2003): 318–322; J. S. Dukes, "Burning Buried Sunshine: Human Consumption of Ancient Solar Energy," *Climatic Change* 61 (2003): 31–44.

32. "Middle East: Total Primary Coal Production," *Titi Tudorancea Bulletin*, October 21, 2010. http://www.tititudorancea.com/z/ies_middle_east_coal_production.htm (accessed June 18, 2011).