ECOLOGICAL DEGRADATION AND ENVIRONMENTAL CRISIS IN CHINA, 1800-1950

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[Note: Material in this paper is excerpted from a larger project entitled *China: Its Environment and History* that spans several millennia from the Neolithic to the present, but has been framed for the seminar. I hope that book will reach a broad audience, and is so composed. Some passages in this paper refer to sections of that manuscript. Graphics noted in the text have not been included because the file sizes are too large to email, but some will be used at the seminar.]

From 1400 to 1800, China was the most populous political entity on earth with between one-quarter and one-third of the world's total population, and it had the largest economy, in terms both of agriculture and of industrial production, as well. Moreover, China's agricultural productivity and rural standard of living, at least in its most developed regions such as the lower Yangzi delta region, were broadly comparable to the wealthiest regions of Western Europe. During those centuries, which some historians term the early modern world, China's vast consumption and production constituted a major engine of global economic activity.[1] In the nineteenth and early twentieth centuries, some parts of the world escaped from the constraints imposed by a biological old regime of energy derived largely from biomass, while China (and much of the rest of the world too) remained within that organic world. As a result, I argue, deteriorating environmental conditions contributed to China's rural impoverishment and social disruptions in the nineteenth and twentieth centuries.

There is much scholarly debate about the state of rural China in the nineteenth and first half of the twentieth century. Below the relatively calm surface of the standard political narrative of dynastic decline intensified by imperialist pressures roil debates about whether the rural population was getting poorer, agricultural output rising or falling, rural incomes growing or shrinking, and the rural economy commercializing or

stagnating and involuting.[2] These debates are implicated in explanations of the Chinese Communist revolution and victory in 1949. Much of this debate involves substantial econometric modeling of China's rural economy, and rigorous comparisons with parts of Europe based largely on analyses of China's lower Yangzi delta, usually glossed as China's most developed economic region.[3] But China was not the lower Yangzi, and while I have contributed to the quantitative analysis of the performance of the rural economy elsewhere,[4] the purpose of this paper is more modest: to survey the secondary literature for what it can tells us about environmental conditions in China in the nineteenth and twentieth centuries.

The connections among agricultural systems and the environment are many, as are their intertwined histories. In China, settled agriculture was one of the driving forces of deforestation, while Han farming practices created agro-ecosystems of varying degrees of sustainability. Moreover, because grain prices affected demand for industrial products and choices families made about family size, questions about the environment are broadly relevant to much that is important to know about the dynamics of Chinese history.

China's early modern wealth and power were based in large part on the exploitation of China's environmental resources. Over previous millennia, the Chinese empire had expanded to the north, south, and southwest, in part pushed at various times by military pressure from nomadic peoples, and at others pulled by the attraction of strategic materials and other resources. As the empire expanded its grasp, its various states sent Chinese families to transform the local environments into tax-paying farms, along the way encountering other peoples and their ways of relating to nature. That strategy of expansion—which we can only call colonialism because of the various peoples who were incorporated into the empire[5]—worked as long as the empire could expand. During the Ming but especially the Qing, the empire reached its limits. In part, limits were set by encounters with other powerful states—the Vietnamese who resisted Ming China's expansion in the early fifteenth century, or Russia in the late seventeenth century. [6] But the limits of empire also had an environmental component, as with the tropical diseases encountered in the south and the southwest.[7]

To be sure, in the eighteenth century Qing colonial projects in the southwest and the northwest sent millions of Han Chinese migrants from neighboring core regions, but by the nineteenth century mostly only the Manchu homeland in the northeast remained to draw Chinese migrants, and they came in increasing numbers in the late nineteenth and first half of the twentieth century.[8] In addition, populations that might have migrated to the frontier started to exploit inner frontiers—highlands that could not be easily settled or populated before New World crops made that economically feasible.

The centuries of deforestation and destruction of wildlife habitat detailed in the previous chapters did not go unnoticed by Chinese observers. As discussed in chapter 4, China's officials were quite aware of the mounting hydrological problems they were facing, as well as the consequences of deforestation in the mountains above their major river valleys.[9] Perhaps even more interesting, by the early nineteenth century there is

evidence that both the idea and reality of species extinction had come to at least one official.[10] As Han Chinese captured more and more solar energy for agriculture, the energy available to other life forms—indigenous peoples, forests, tigers, and elephants alike—declined, sometimes to the point of being insufficient for those species to survive. Tigers disappeared from south China forests by the early nineteenth century, although a few score hung on in remote corners of forests until the twentieth century.[11] At the same time far to the north, after 1822 Manchu Bannermen no longer sent bears and leopards from Manchuria to Beijing, although China's Manchu rulers continued to use Amur tigers after that for military training exercises.[12]

The removal of forest for farms and the consequent simplification of China's ecosystems into agro-ecosystems led to more than the loss of biodiversity. By the nineteenth century, these processes were also leading to the widespread degradation of the environment. Degradation differs from the loss of biodiversity in that a degraded environment is so changed and depleted of the nutrients needed to support life that ecosystems seldom have the ability to regenerate themselves. Instead, the environment is altered at lower levels of energy, increasingly unable to support more complex life-generating ecosystems. Such a degraded environment creates a crisis for those species whose existence depended on a particular ecosystem, leading to local extirpation or extinction. Because humans are embedded in ecosystems, human institutions have environmental underpinnings that when weakened can precipitate social, economic, and political crises.

As Blaikie and Brookfield point out, land degradation is neither an objective phenomenon, nor natural. Rather, what constitutes degradation depends to a certain extent on what values a society places on the land; in that cultural context, deleterious human interference of natural processes constitutes land degradation.[13] From a Han Chinese point of view, then, deforestation that made way for more valuable farmland did not necessarily degrade the land, but "improved" it. But erosion of mountainsides and a decline in the productivity of lowland farmland, both of which will be taken up in the next section, do constitute land degradation.[14]

Blaikie and Brookfield further argue that not all land is equally susceptible to degradation, and that some land is more easily restored and repaired while other land can be irretrievably degraded. They use the concepts of "sensitivity" and "resilience" to capture this variability of the susceptibility of land to degradation. For instance, land that has low sensitivity to human interruption and can easily bounce back from that impact is more amenable to repair under good human management practices. An example might be wetlands. On the other hand, a land system that is highly sensitive to human alteration and does not easily repair is likely to degrade quickly and to be very difficult to restore; an example is the arid steppe.

In this paper, I want to focus on the evidence of deforestation, the consequent river valley flooding in various parts of China, and the ways in which land systems in China deteriorated and degraded.

[Fig. 6.1 China's Forests ca. 1930]

Northwest China. As early as 1850, but certainly during the first half of the twentieth century, the removal of north China's forest cover led to clear signs of environmental degradation in the Wei River valley and the loess lands to its north and east. Although forests remained in the more inaccessible parts of the Qinling Mountains until the 1930s, [15] in the Wei River valley itself, "trees are scarce." [16]

To the east in Shanxi province, an early-twentieth study observed: "Nowhere is the havoc wrought by deforestation more evident than in [Shanxi province]. Around Taiyuanfu all the once-wooded mountains are bare and bone dry. Down through the province one sees no trees on mountain or foothill save those about temples….Once the tree cover is removed, the rains wash the soil from the hillsides and with it fill the watercourses and choke the valleys. Wherever a brook or a creek debouches into the valley of the Fen it has built with this wash a great alluvial cone....This cone has covered under silt and sand and gravel from a few score acres to several square miles of the former rich bottom lands, and they can never be recovered."[17]

The rather astounding photographs in Fig. 6.2a-b show the effects of the siltation: "Since the bridge was built, 20 feet of wash from deforested hills has been dropped in that watercourse, and the stream, no longer fed from spongy wooded slopes, is a trickle…."[18] The silt came from the loess plateau, which had been steadily eroding since the Han dynasty, but which became increasingly eroded in the nineteenth and twentieth centuries (Fig. 6.3). "From Hankou to Beijing," the German geographer von Richthofen reported in the 1870s, "all mountains and hills are destitute of tree and shrubs and offer a most desolate aspect….If it were not for the [water-storing capacity of the soil formation called] loess, Northern China would already be a desert."[19]

Fig. 6.2a-b. Siltation in Shanxi Province ca. 1910
Source: Norman Shaw. *Chinese Forest Trees and Timber Supply* (London: T. Fisher Unwin, 1914), plate facing p. 126.

Fig. 6.3. Erosion on the loess plateau.
Source: Buck, *Land Utilization in China*, plate facing p. 186.

The Huai River Valley. According to David Pietz, before the southern shift of the Yellow River in the twelfth century (see chapter 4), the Huai River valley had been prosperous and economically advanced. A vast irrigation and canal system made it possible to grow rice in a region described as early as the Han dynasty as "teeming with fish, clams, and grains," and having a dense marketing system.[20] Forests had disappeared before the plow. With the twelfth-century shift of the Yellow River to a course south of the Shandong massif, the Yellow, Huai, and Yangzi River systems became intertwined, to the disadvantage of the Huai River valley. With the mouth of the Huai River blocked by the Grand Canal and the Yellow River, "flood water rolled out onto the agricultural plain. Farmers could only wait for evaporation and seepage to dry their lands."[21]

Despite late-sixteenth century attempts to devise new methods for improving the flow of water through the combined Yellow River/Huai River valley system, between 1400 and 1900 there were 350 large floods in the Huai valley. The increasing deforestation of the region meant that instead of depositing nutrient-rich alluvium, increasingly the floods deposited sterile sand, sometimes seven to eight meters deep. Counties that in the Han had been known for their surplus of rice and fish were now "completely abandoned because of salinization—there is not an area which is not a wilderness of weeds and thistles."[22] Plagues of locusts followed.[23]

Not surprisingly, the Huai River valley became progressively poorer and less populated, leading to the endemic peasant unrest described by Elizabeth Perry.[24] Land holding became increasingly concentrated in the hands of a few wealthy families, and even educational and cultural levels declined.[25] Without irrigation, cropping settled on a few hardy crops—winter wheat, sorghum, and soybeans—and with shrinking markets, there were few opportunities to make money. By the nineteenth century, most inhabitants existed barely above "minimal subsistence."[26]

The Yellow River and Grand Canal Region. The North China plain was basically flat—it dropped only a foot or so every mile and was described as "flat as a billiard table"[27]—so that water flowed very slowly eastward toward the ocean under any circumstances. Left unrestrained from where the Yellow River leaves the mountains just to the west of present-day Zhengzhou, the River would have meandered all over the North China plain. As it was, Chinese efforts from at least the Zhou period in the eighth-century BCE had progressively diked the river to prevent flooding and to open up land for farming. The diking in itself would not have been too problematic had it not also been the case that the Yellow River carried increasing amounts of silt. From its point of origin, the upper reaches of the Yellow River flows through the loess soil region, and as agriculture from Zhou times on removed the rather thin cover of natural vegetation, the amount of yellow silt eroding into the river increased, as did flooding. When "the River" became known as the "Yellow" River—in the Han or only later in the Tang—is a matter of some dispute.[28] As the Yellow River entered the North China plain, it slowed and the silt settled out, raising both the riverbed and the dikes built ever high to prevent flooding.[29]

Having been heavily deforested as early as the Han dynasty (see chapter 3), by the turn of the twentieth century, "the plain was entirely free from any tree or shrub, every available inch being taken up by the cultivation of cereals."[30] As we saw in chapter 4, in the twelfth century, political instability and warfare between Song troops and northern invaders led each side to breach the dikes for their own tactical advantage, with most of the river shifting south after 1194. Some water continued to flow north through a channel then called the Daqing River, but the Mongol decision to extend the Grand Canal more or less straight north to their new capital of Dadu (present-day Beijing) meant that after 1288 even that river water was harnessed to canal duty. In the mid-Ming, all remaining Yellow River water was directed south into the course of the Huai River.[31]

Fig. 6.4a-b. Dike Repair on the Yellow River. Source: "Charles K. Edmunds, "Shan-tung—China's Holy Land," *The National Geographic Magazine*, vol. 35 no. 3 (Sept. 1919), pp. 237-38.

The second problem thus was that the Yellow River, flowing slowly across the flat and deforested North China plain to begin with, was bisected by the Grand Canal, forming an immensely complicated intersection near the city of Huaiyin, taking over the lower course of the Huai River, "crowding out and diverting the Huai waters into Hongze Lake and the lakes and marshes that extend from Hongze southward to the Yangzi River."[32] The Grand Canal slowed the flow of an already slow Yellow River, backing up the waters of the Huai River further upriver into the Huai River valley; the silt-laden waters of the Yellow River had a hard time pushing through to the sea, a problem which only worsened with time and the deposition of more silt at the mouth of the river and was tackled only in the 1950s.

This combination of a flat North China plain, the meandering and diked, silt-laden Yellow River, and the construction and maintenance of the strategically essential Grand Canal, [33] also had significant ecological consequences for the entire region. The canal slowed the drainage of all north China rivers, large and small alike, with increased sedimentation leading to periodic flooding and then water logging because the waters could not drain. And because fresh water contains dissolved salts (that mostly get flushed out to sea), waterlogged land could easily become saline and less productive, or even useless. "The worst areas become marshes, which in turn become breeding grounds for locusts."[34]

Because the Chinese state had such a huge vested interest in the Grand Canal, it invested vast human, material, and monetary resources to maintain the hydraulic system that was the Yellow River-Grand Canal ecosystem, centering on the region where the Yellow River, Grand Canal, and Huai River/Hongze Lake all converged in Jiangsu province north of the Yangzi River.[35] That system inexorably degraded in the nineteenth century, as Jane Kate Leonard's study of the Grand Canal crisis of 1824-26 documents.[36]

The problem was silt building up in the complex of waterworks in the junction region of the Yellow and Huai Rivers, Hongze Lake, and the Grand Canal. By the eighteenth century, several centuries of diking the Yellow River had raised it several meters above the southern section of Grand Canal (known as the Huaiyang Canal), flowing from Hongze Lake south to the Yangzi River, and with its silt content, was constantly threatening to get even higher. Until the late sixteenth century, the waterworks were managed under a theory of "dividing the channel" of the Yellow River into several smaller ones to disperse floodwaters. All that did, though, was to slow the river and increase the silting.

The approach begun in late sixteenth century scoured the bed of the Yellow River by building narrow dikes to speed the flow, and directed clear water into the Yellow River.[37] The source of the clear water was Hongze Lake, created in 1579 by the

construction of the Gaojiayan dike across the Huai, which captured more-or-less silt free water from the Huai and two other smaller rivers. Hongze Lake was diked on its eastern shore, and that dike was continually raised so the lake level would be above the Yellow River.[38] That was a recipe for disaster. To make sure that floodwaters did not destroy the system, the Gaojiayan dike was reinforced by a strong rock wall, with several floodgates built into the dike. Further south, five additional gates were installed to spill floodwaters into the Yangzi River.[39]

Over time, Hongze Lake began to silt up, not just from the small amount of silt carried by its tributaries, but also by periodic flooding of the Yellow River which found its way into those tributaries and thus into Hongze Lake; backfilling of Hongze Lake with Yellow River water also contributed to the build up. Dredging took care of some of the silt, but as both Hongze Lake and the Yellow River silted and their beds rose, the only way to keep Hongze Lake above the Yellow River was to continually raise its eastern dikes. In Kate Leonard's words, "In spite of the scale and complexity of the canal's water-control network, and advances in the bureaucratic management of the system, the Qing state was losing its battle against the silt [by the late eighteenth century]. The canal, lakes, rivers, and drainage canals were all silted and their beds upraised, and overflow gates were mired in mud."[40] Hongze Lake was "perilously high," and when torrential rains in late 1824 "tore two huge breaches in the dike wall," floodwaters cascaded eastwards into the Grand Canal and beyond that into the flat, low-lying, flood prone eastern part of Jiangsu province. Leonard details the immense effort, led by the Daoguang emperor, to stem the flood and restore the Grand Canal.

It may have looked like a disaster had been averted. But no amount of human effort could stop the Yellow River from its meanders and ultimate shift back north, flowing through channels where it been prior to 1194. "The final shift occurred between 1851 and 1855, with the main branch of the river moving north in 1852. Devastating floods continued for the rest [of the nineteenth century] as this mighty river established its new bed" to the north of the Shandong massif.[41] The shift north had devastating effects on the North China plain, inaugurating a century of floods, misery, rebellions, and uprisings. Because the imperial state was also dealing with a new kind of threat posed by militarily superior European, Japanese, and American powers, its treasury was strained and its attention taken away from the Grand Canal, which was rendered inoperable and never restored. The nineteenth-century flooding also caused "a large-scale epidemiological disaster," in James L. Webb's estimation, spreading malaria infections and deaths.[42]

And although the Yellow River left the Huai River valley after 1855, according to David Pietz "the damage it wrought was complete."[43] The Huai was completely cut off from its former bed (the one abandoned by the Yellow River), and because that bed was higher than the Huai itself, the Huai continued to pour into Hongze Lake and to seek access to the sea via an outlet in the southeast corner of Hongze Lake that led to the Yangzi River. Because that was inadequate for the volume of water carried by the Huai, the region was constantly inundated. The only solutions were the dredging of the Huai's former riverbed, or widening the channel to the Yangzi River, neither of which happened

because the imperial state was no longer interested in the region, and local leaders lacked the resources.[44] Only after the Chinese Communist victory in 1949 did the state have sufficient manpower, capital, and expertise to attempt to rectify the ecological disaster caused by the Huai River's lack of an adequate outlet to the sea, as we will see in chapter 7.

Before that, the Yellow River shifted course once more. War between China and Japan broke out in July 1937 after Japanese armies moved against Chinese troops. Within months, Japanese troops took Beijing, the Japanese army began moving south toward Wuhan, the wartime capital of Jiang Kaishek's Guomindang government, and toward Zhengzhou.[45] To slow the Japanese advance, on June 9, 1938, Jiang Kaishek had his army breach the Yellow River dikes just northeast of Zhengzhou, producing a 70,000 square kilometer flood that spread down the Huai River valley to Hongze Lake and the Grand Canal. The Yellow River dikes were so large and stout that two attempts to breach them using explosives failed, and only by furiously excavating down was the dike finally undermined and breached. Nearly a million people drowned, and at least two million more fled. Japanese tanks and troops were slowed for a while, but their advance continued. For years, the course of the Yellow River continually shifted, according to American Jack Belden: "In its unpredictable journeyings, the new river has gone on a rampage through eleven counties and three provinces."[46] Hundreds of thousands of villages were washed away, and millions of acres of farmland covered with silt or waterlogged. When the floodwaters subsided under the parching sun, "the ground turned as hard as brick, and there was no way to plant crops."[47] This war-induced, man-made environmental disaster was immense: over four million victims, millions in need of relief, and millions of refugees.[48]

The North China Plain. With the late-nineteenth century abandonment of the Grand Canal, the entire region of the North China plain that had been considered strategically central to the imperial state for two millennia entered a period of economic, demographic, and environmental decline. Kenneth Pomeranz calls this process "the making of a hinterland"[49] from the second half of the nineteenth century into the twentieth century, as the concerns of the imperial state shifted from traditional statecraft to the threats posed by Western powers along the China coast.

Prior to the shift of the Yellow River and the end of Grand Canal transport, and because of the strategic importance of the area to the maintenance of the Grand Canal, the region of North China Pomeranz calls "Huang-Yun" (named for the Yellow River and Grand Canal) received building materials and fuel from elsewhere that it could not produce itself. Family farming with few opportunities for marketing led to a large and fairly dense population that consumed more fuel than it could gather from the surrounding countryside. Stone for reinforcing the dikes also came from outside; the imperial state imported all of these resources into Huang-Yun to maintain the Grand Canal.

After 1855 and the abandonment of the Grand Canal, stone and fuel in the form of sorghum stalks both became scarce, leading to more and more devastating floods, and to less or even no fuel for heating and cooking. Naturally, "people took from ecologically

crucial areas outside the villages—riverbanks, hillsides, wastelands, and former forest lands,"[50] stripping an already bare environment of sources of soil nutrients and sending crop yields plunging. "As peasants ran through not only wood, but chaff from their crops, and twigs, roots, and grass from the surrounding land, they were forced to burn dung—an inefficient fuel and a desperately needed fertilizer."[51] By the early twentieth century, "both foreign and Chinese observers were noting that Shandong had no forests left, even on hillsides."[52] As Lowdermilk observed in the 1920s of Shandong's hills, "Each winter, the poor of the villages go into the hills after the grass cover is cut, to dig…out the roots of the summer's growth of grass" for their fuel.[53]

Perversely, in Pomeranz's view, the mounting ecological crisis on the North China plain was not simply caused by population pressures, nor by the environmental problems brought on by the Grand Canal; rather, "it was the abandonment of the old hydraulic system"—i.e. the state-maintained Yellow River/Grand Canal/Huai River/Hongze Lake complex—"that hurt" the region.[54] That is, the imperial state abandoned traditional statecraft concerns with maintaining the Grand Canal to meet greater threats from Western powers. Moreover, without markets and the possibility to specialize and trade cash crops like cotton (or even opium) for the necessities of life, the ecological impoverishment of North China led to human suffering as well.

Another analysis of North China by Lillian Li, though, suggests that even if the imperial central state had devoted all the resources it could to the problems of the Huang-Yun region, the same ecological problems would have cropped up. Around the capital city of Beijing, intense central government concern for maintaining the waterways and preventing flooding nonetheless proved ineffective, and by the turn of the twentieth century the Hai River basin, including the Yongding River which flowed just past Beijing, was no better off than Huang-Yun or the Yellow River/Grand Canal junction region, all of which shared basic geographical and ecological characteristics.[55]

For nearly 200 years of the Qing dynasty, from around 1700 to 1900, successive emperors and provincial governors expended huge amounts of money and manpower to stabilize the rivers in the capital region by diking, channeling, and dredging out the silt. Li details those efforts in a recent book, and reproduces an impressive mid-eighteenth-century Chinese map that glosses the myriad engineering projects launched to ensure that the rivers did not flood.[56] The end result, though, was that "Altogether in the Qing—during the Kangxi, Yongzheng, and Qianlong eras [1661-1795]—more than 10 million taels of public and private funds had been spent on river construction, and yet catastrophes could not be prevented."[57] Then, from the late nineteenth century through the first half of the twentieth century, "the continued deterioration of [the region's] rivers, compounded by unusually heavy precipitation, produced seemingly endless catastrophes." As was true elsewhere on the North China plain, the silt built up, coming in larger quantities as ever more natural land cover and forest was removed for farms; floods were frequent and large. In one of the floods around the turn of the twentieth century, a Western missionary reported: "The area is a vast sea—of which the limit cannot be seen….There is no prospect of water flowing out for more than a year."[58]

Water logging and subsequent salinization plagued not just the capital region, but also most of the North China plain.

One of the Beijing-area projects that sought to solve the silting problem channeled rivers into two huge wetlands called "Eastern Swamp" and "Western Swamp" stretching some 80 miles between the cities of Tianjin and Bao'an, and another 20 miles or more north and south, where the silt would drop out, and the (hopefully) clearer river waters would flow out of the swamp. Hydrologically, of course, the swamps were a catchment basin for annual floods waters, expanding like a great lung when needed. But to the water engineers of the late imperial Chinese state, these swamps were "solutions" to the problem of siltation in the rivers, and the silt-laden rivers were directed to the swamps. But the swamps were of course extensive, biologically rich ecosystems. Indeed, those swamps may have held the greatest biodiversity of any place on the North China plain since it had first been settled three thousand years earlier. Certainly there were herds of various kinds of Chinese river deer, including sika and musk deer. There may even have been herds of what became known as Peré David's deer, the last surviving members of which were kept in the enclosed Qing imperial hunting grounds just north of the swamps. With deer come predators—wolves, large cats, perhaps even tigers. One can only imagine the different kinds of waterfowl, including the now-endangered swans, along with pheasants and other swamp-loving birds like red-winged black birds and orioles. With such a huge water surface, the East and West swamps no doubt also served as way stations on the flyways of migratory birds. In the waters of the swamps, mollusks, fishes, and turtles of all kinds must been at home there too.

As the swamps silted up, peasant farmers "reclaimed" them as farmland. Indeed, by the late nineteenth century, wealthy families in the region claimed and farmed the nutrient-rich former bottomland, and the swamp had shrunk to one-third of its previous size. A provincial official predicted that it would eventually disappear, and it did. Today, in fact, little water at all flows through any of the rivers around the capital, most of it being captured and retained upstream in reservoirs for the city of Beijing, and even that is insufficient, prompting construction of the massive South-to-North-Water-Transfer Project.[59] "Such is the conclusion," Lillian Li says, "of a long process of environmental change over the centuries."[60]

The North China plain, including the Huai River valley, of course, had been heavily farmed since the Han dynasty and even the hills had been deforested by the Song, so it is not too surprising that it would have been among the first parts of China to exhibit clear signs of environmental degradation. Certainly, the human attempts at "water control" eventually backfired in one way or another, arguably creating larger environmental problems and ecological damage than if the rivers and the riparian ecosystems had been left alone. Where the north China plain once had hundreds of lakes and swamps, by the 1980s only 20 remained. The Qing imperial hunting ground south of Beijing contained 117 springs and 5 large lakes in the Qianlong era (ca. 1771); today there are none.[61]

The environmental deterioration of the North China plain had social, economic, and political repercussions. Let us start first just with the loss of those swamps. Certainly, the wildlife and the region's biodiversity suffered. But people too relied directly on those swamps, or more directly, on the animals and plants as sources of food and medicine. Deer and fish had been important sources of nutrients for people. But with the loss of these swamps, as was the case everywhere else in China where natural ecosystems were simplified into farms, the human population too lost a natural source of dietary protein that in the best of times would have provided variety and additional nutrients to peoples' diets. As it was, the human population of north China became increasingly tied to food from their farms, and when those harvests failed—as they did with the increased frequency of floods and droughts across the North China plain—people experienced food shortages and entire regions became famine stricken. The largest of those famines—with millions of causalities—struck in 1876-79, 1917, 1920-21, and 1928-30,[62] intensified by a series of strong ENSO-induced droughts.[63]

Not surprisingly, banditry was endemic. At various points, that banditry merged with other local and national events to produce rebellions; the largest that originated on the North China plain were the Nian (1851-63), the Boxer Uprising (1899-1900), and the Red Spears (sporadically from 1911 to 1949). Moreover, the Chinese Communist party established a base area there in the 1940s to resist Japanese invaders and then to do battle in a civil war (1945-49) after Japan's defeat.[64] Indeed, ecological degradation contributed significantly to rural poverty, and it should not be too surprising that the poorest parts of rural China provided substantial support to the Communists.[65]

Environmental conditions on the North China plain alone did not cause social disorder, rebellion, and revolution. But as Elizabeth Perry and Joseph Esherick have suggested, those social movements cannot be understood or explained without examining the underlying environmental conditions and the processes of ecological degradation.

Yangzi River Valley. In chapter 5, I examined the ecological changes and challenges in central China and in the lower Yangzi region and so will not repeat that material here. To summarize, deforestation of the highlands led to erosion and the filling in of swamps in the Dongting Lake region, followed by increasing lowland "reclamation" of land along the shores of Dongting Lake, decreasing its surface area and volume of water held so that it could no longer contain the periodic (and predictable) Yangzi flood waters.

To the north of Dongting Lake on the Jianghan plain between the Yangzi River and its tributary the Han River, long-term hydrological changes also were causing severe ecological problems (part of the story of this area was told in chapter 5). Originally a vast marsh that was slowly filled with sediment from the Han and Yangzi Rivers, by the Song it had become "studded with thousands of lakes and small marshes." Diking and poldering transformed the region into highly productive rice producing and exporting farms. But because the land that was reclaimed for the rice paddies originally had been marshland and was lower than the rivers, dikes and polders had to be built higher and higher as sediment raised the river beds, and farming communities faced mounting

difficulties in draining off annual flood waters. Increasing breaks in poorly maintained dikes exacerbated flooding. By the eighteenth century, some fields were becoming permanently waterlogged, and during the nineteenth century water began to reclaim large portions of the region, turning it back into a swamp. In response, peasant farmers began growing aquatic plants or others that could be harvested before the floods; many abandoned farming altogether for fishing.[66]

Further down river, deforestation of the highlands above the southern bank of the Yangzi sent increasingly sterile sand and gravel downhill into the rich rice paddies; to protect those resources, officials prohibited any further upland reclamation, but with dubious results. Similar dynamics unfolded all the way down to Hangzhou and its lakes and highlands.[67] The story of Xiang Lake on Xiaoshan plain just south of the Yangzi River is more emblematic than exceptional. As noted in chapter 4, rice production there had begun in the highlands, and moved into the marshy plains only as growing populations and accumulations of capital made poldering possible. In the Song, the area sported 217 lakes, "the greatest density of lakes in all China," according to Keith Schoppa. In the late Song, a reservoir called Xiang Lake was built to catch, retain, and regulate water supplies flowing from the hills for use in the rice paddies.

Over the succeeding centuries, a dynamic unfolded involving the silting in of Xiang Lake, its periodic dredging by various governmental entities, and encroachments on the lake by wealthy and powerful landlords who wanted to create more farmland. Already stressed by the eighteenth century, in the mid-nineteenth century this "remarkably fragile" system broke down in the wake of social disorders and population loss occasioned by the Taiping Rebellion (1850-65), followed by floods that damaged sluice gates and dikes. In Schoppa's estimation, Xiang Lake might have been saved had there been public-minded officials who wanted to expend the energy to do so, or money for reconstruction. There was neither, and so rice paddies sprouted on the former marsh *cum* lakebed; by 1937 "houses and sheds stood where once the water had been fifty feet deep."[68]

South China. Paradoxically, some of the most degraded of China's lands are in its tropical and semi-tropical regions. As in the hills south of the Yangzi, from the mid-sixteenth century on, upland specialists armed with New World crops, especially maize, migrated into and throughout the hill and mountain regions of south China. Some, especially the Hakka, were more mindful of the fragility of highland environments and took more care to replant trees that had been cut for timber sales down river, while more recent Han migrants, pushed by population pressure out of the lowland valleys, cut down trees and planted nutrient-demanding crops like maize and tobacco. In the Nanling mountains in northern Guangdong, for instance, according to the 1819 Nanxiong county gazetteer, tobacco had begun to be planted "40 or 50 years ago….The profit obtained is much greater than rice. But the tobacco is all planted on the hilltops. As soon as the land is opened, the soil deteriorates and erodes. Any heavy rain silts the rivers and there is fear of imminent flooding. But because of the large profit it is tolerated. The locals [now] are forbidden to open any new land so as to correct the situation."[69]

That official proscription did little to halt the deforestation and land degradation, as peasant farmers throughout south China "habitually fire most the burnable slopes in the vicinity of the homes during the dry season each year. The continuation of this practice tends to destroy the majority of species of woody plants and change the aspect of a once richly forested country to that of a hilly or mountainous grassland."[70] Western observers thought that the mountains were fired to bring ash and nutrients down into their fields, but the peasant farmers told the researchers that they burned the fields to deprive snakes, tigers, and thieves of their dens, while Chris Coggins found in Fujian that the practice encouraged the growth of an edible fern that was prized in times of famine.[71] Once the forest cover was removed, especially in the hills and mountains of southern Zhejiang, throughout Guangdong, and in southern Yunnan, heavy monsoon rains quickly leached whatever nutrients remained in the soil, rendering the natural regrowth of forest unlikely. [72] Additionally, the burning off of tropical and subtropical forests unleashed the very tough cogongrass that stifled any other vegetation, turning mountainsides green, but devoid of forest.[73] Even the cogongrass cover did not stop massive slumping after periods of heavy rainfall, where huge parts of hillsides cleaved off and slid downhill.

Southwest China: Yunnan. Parts of the story of the transformation of the environment in China's southwest provinces of Yunnan and Guizhou have been taken up in the previous chapter, and will be continued in more detail in the next chapter with a consideration of the building of hydroelectric dams on many rivers in the southwest. Here I want to make a few observations about war and the disease environment, in particular malaria.[74] As noted earlier, in the eighteenth century, malaria had foiled Qing military campaigns against Burma. The Japanese invasion of Manchuria in 1931, the civil war between Communists and the Guomindang, coupled with flooding in the lower Yangzi in 1932 led to a 60 percent malaria infection rate there, and 300,000 deaths. In 1933, 30,000 malaria deaths were recorded in a single Yunnan county.[75] After Japan's 1937 attack on China and the entrance of the U.S. into the Pacific War in 1942, the U.S. became committed to keeping the Guomindang in the fight against Japan by supplying war material to Jiang Kaishek's government (which had retreated inland to Chengdu in the Sichuan basin) by building the "Burma Road" from northeastern Burma through Yunnan.

American personnel then encountered malaria in Yunnan, with 50 percent rates of illness and an unknown number of deaths death. In other parts of the Pacific theater, malaria was felling more U.S. troops than enemy fire, so General MacArthur formed teams to combat malaria.[76] One of those teams was sent to the Chefang Valley in Yunnan (Fig 6.5a). That valley looked like a typical south China rice paddy environment (Fig. 6.5b), with the addition of anopheles mosquitoes and malaria. U.S. personnel distributed soap to villages because the suds kept streams "free of mosquitoes for about 100 yards" (Fig. 6.5c), they dug drainage ditches, sprayed oil on stagnant water, and introduced gambusia minnows into the paddies to eat the mosquito larvae. Additionally, the Americans noted that "the hills are high and out of the mosquito areas," apparently driving some of the locals to begin terracing hillsides to get above the deadly mosquitoes (Fig. 6.5d).[77] Whether that worked, or whether transforming the wooded hillsides into rice paddies merely spread mosquitos and malaria is not known. Nor is it known whether

those doing the terracing might have been recently arrived Han Chinese fleeing the Japanese invasion who had no experience with malaria.[78]

Fig. 6. 5a-d. The Chefang Valley in Yunnan. Source: Library of Congress Prints and Photographs Division in a collection entitled "Malaria Control in India and China, 1929-40," call number LOT 1786 (M) [P&P].

West China: Sichuan. Several additional examples of environmental degradation following in the wake of the successive waves of deforestation prior to 1949 could be cited.[79] Even the lush rice paddies of the lower Yangzi and the Pearl River delta experienced problems when tons of increasingly sterile sand and not nutrient-rich alluvium flowed down the hills and mountains, obstructing river channels and flooding the lowland paddies. About the only reference I have found to a human-altered agro-ecosystem that was *not* degrading was in the Red Basin around Chengdu in Sichuan province (see Fig. 6.6). According to an early-twentieth-century report on the effects of deforestation in China:

> This portion is densely populated and carefully cultivated, this cultivation not being confined to agriculture alone, but extending to the planting of useful and ornamental trees such as the bamboo, tung, mulberry, cypress, varnish…and a variety of fruit-trees. The most important part of the Red Basin is the Cheng[du] plain, which has been described as the most densely populated area of the earth's surface. The vegetation is in most parts of the basin of almost tropical luxuriance owing to the extreme dampness of the climate, which permits, in the Cheng[du] plain, an admirable system of irrigation. Seen from a height, the plain looks like a forest, for every farm has its grove of bamboo, cypress, palms, and fruit orchards while tung and varnish trees abound. The country along the Min [River] between Kiating and Chungking is also rich in trees, which are described as 'of living green, free from insects, and without blight or deformity,' thus rendering this part of [Sichuan] an object lesson to regions farther east.[80]

It is somewhat curious that the Red Basin of Sichuan was not experiencing significant problems from silt carried down from rivers flowing out of the mountains to the north and west that formed the eastern portion of Tibet, for as we will see in the next section, large parts of Tibet and the mountainous regions of northern and western Sichuan inhabited by Tibetans in fact had been deforested. But farmers in Sichuan apparently did not have to cope with heavily silted waters, and the 2000-year-old Dujiangyan waterworks continued to function without silting or flooding.[81]

Fig. 6.6. Well-tended farmland in Sichuan. Source: Dr. Joseph Beech, "The Eden of the Flowery Republic," *The National Geographic Magazine*, vol. 38 no. 5 (Nov., 1920), p. 366.

[Section on the northeast/Manchuria omitted for this paper.]

Tibetan/Qinghai High Mountain Plateau.[82] In parts of the Tibetan highlands, in particular the Himalayan Mountains, the climate is too harsh and dry to sustain the growth of trees, but much of the Tibetan plateau not only could sustain birch or juniper forests, but as ecologists now conclude, probably did. That comes as somewhat of a surprise, for as long as most scholars or observers have been able to determine, vast stretches of the Tibetan plateau, as well as south-facing mountain slopes descending further down into Yunnan and Sichuan provinces, were covered not in forest, but in various kinds of meadows and grasslands that Tibetans used as pastures for their herds of yaks, sheep, and goats. Tibetans and other observers assumed that those treeless meadows had always been there. But those assumptions have been proven wrong: "huge areas in the Inner Himalaya [of Tibet] originally bore forests but have been deforested by humans and their livestock."[83]

Over the centuries, Tibetans removed the original forests, probably by fire, replacing the forests with combinations of lower-growing plants that compose useful pasture for their herds. "Regular grazing promotes species with high regenerative capacity like grasses or rosette plants and creeping plants or plants with creeping shoots."[84] Elsewhere, "under moderate grazing, a species-rich, about knee-high, meadowlike vegetation may develop, which we call *flower meadows*, because it is dominated not by grasses but by herbs. It is one of the most beautiful plant communities of the Himalayas."[85] Holzner and Kriechbaum think that Tibetans for centuries followed grazing practices that sustained their meadows and pastures. "This way of herding livestock requires much understanding of, or perhaps a feeling for, animals, vegetation, and the optimal rhythm of grazing and wandering, a knowledge that has been handed down from one generation to the next…."[86] In other words, although Tibetans probably removed the original forest on the plateau and mountainsides, their pastoral way of life promoted the establishment and maintenance of meadows, grasslands, and pastures that held the soil in place. Even woodcutting and the cutting of peat from bogs for fuel could have been sustainably managed. Nonetheless, the available evidence suggests that for centuries—maybe going back 2000 years when pollen analysis shows a sharp decline of forests[87]--Tibetans or other peoples on the high plateau have been transforming forests into the grassland environment preferred by their goats, sheep, and yaks.

In Tibetan areas closer to the Red Basin of Sichuan, in particular about a hundred miles north up the Min and Mao'er gai Rivers, Jack Hayes has found significant evidence of the Tibetan use of fire to alter and then maintain their pastures—even on the mountainsides above the Sichuan basin—in the late nineteenth century. Where foreign observers from Europe who thought that it was forests that were beautiful and a shame that Tibetans and Chinese removed them for pasture or farms, Hayes concludes that "Tibetans created an 'agro-pastoral regime' based on widespread fire use that lasted throughout the late imperial period even into the late 1930s and early '40s."[88] Thus even though forests had been removed, the mountain sides were not left open and barren, but instead were covered with pastureland for Tibetan herds, preventing excessive soil

erosion and ecological problems further down river in the Sichuan basin. Serious problems would develop in the late twentieth century, as we will see in chapter 7, when extensive logging with powerful equipment by state forestry bureaus so stripped mountains of forest in western and northern Sichuan that devastating flooding of the Yangzi River valley in 1998 prompted the premier of the People's Republic of China to order an immediate halt to any further logging of old growth forests.

[Section on Nutrient Cycles and Agricultural Sustainability omitted here to conserve space]

Resource Constraints, Environmental Management, and Social Conflict. Conflicts over water control and wrangling over the causes of flooding among various local interests, and between local and national leaders, were but one kind of social conflict that strains on the environment were causing. Migrations of people from areas already densely populated and intensely farmed to more peripheral areas in the southwest, the northeast, and the inland highlands may have alleviated tensions in the areas they left, but those migrations set off conflicts with the indigenous peoples the Chinese farmers encountered. Moreover, as even the inner upland regions filled up, conflicts between upland and lowland interests sharpened. And throughout the core areas of the empire, contests for control of ever-shrinking resources, whether those were land, water, or forests, sparked lineage feuds in the south and southeast, legal and other contests between local-place organizations, and suspicion of outsiders among villages finding cohesion through religious cult practices. By the second half of the eighteenth century, population growth, efficient markets, and state interests were propelling China toward more intensive use of existing natural resources, to conflict over the use of those resources, and toward the limits of empire. Even ocean fishery stocks were being depleted and fought over.[89]

Deforestation not only degraded the environment, but brought on shortages of timber and wood, critical issues in an agrarian economy still largely fueled by tapping energy stored in trees and other organic material. As early as 1850, there was clear evidence that China was experiencing resource shortages and environmental challenges brought on by the vast environmental changes that China had experienced over the preceding millennia, and that those environmental problems intensified over the next century. [90]

Paradoxically, additional evidence of the growing shortage of trees for timber comes from a study by Nicholas Menzies designed to show that, even in the midst of "the relentless destruction of what little forest remained…[under] certain sets of social, economic, and ecological conditions, forested land was protected, maintained, or managed, in the face of widespread forest clearance and conversion."[91] There is much that is significant about forest management in Menzies's book, but for our purposes what it also shows is that nearly all of the cases he cites as evidence of forest management (and the preservation of forests) collapsed by the late nineteenth century. The imperial Mulan hunting preserve in Manchuria was abandoned in 1820 and then encroached upon afterwards; at Buddhist monasteries in central and south China monks and abbots

conspired with timber merchants to sell their wood; even the most sacred spots found it hard to keep outside forces at bay, leading to extensive land clearance and forest loss. Additionally, "Village forests and clan forests have largely disappeared since the 1911 Revolution,"[92] and old growth stands would have been cut down except for their remote, inaccessible locations and hence high cost to log.

By the turn of the twentieth century, then, only the most extraordinary circumstances or protection allowed forests that otherwise would have been logged to remain standing, unless they already had an economic value. That some survived, in particular a few monasteries' forests, into the twentieth century is important, for as we will see, those relic forests provided ecologists with clues to what the forests of China had been before they were removed or replaced with secondary marketable stands of bamboo or the Chinese fir (*cunninghamia*).

Even so, there was a decreasing amount of fuel available for people to cook and heat with. Stir-frying emerged no later than the Song when wood for fuel around Kaifeng was in short supply; that method continued to be useful as there was even less wood for fuel in the nineteenth and twentieth centuries. Instead of wood, peasant farmers scoured the land for straw, grass, or animal dung to burn.[93] Trees that remained had limbs cut off up the point where people could not reach, and whatever leaf litter fell on the ground too was picked up to burn, thereby depriving the soil of organic nutrients, further degrading ecosystems.

So What?

In the century and a half prior to the Chinese Communist victory in 1949, the evidence (however anecdotal) points to widespread ecological degradation in China. The dynamics of population growth, commercialization, and the strategic and fiscal needs of the state sent waves of Chinese migrants into borderlands and inner peripheries where forests were removed and wetlands filled in to make way for farms, dramatically altering China's hydrology.[94] Deforestation in frontier areas led to increased siltation and flooding of river plains in core regions, loss of nutrients from the soil and of its ability to hold water, energy shortages, and constrictions of timber supplies for building.

Erosion and silting of rivers, in Lowermilk's estimation, "has without doubt reduced the aggregate productive capacity of land," especially in north and central China.[95] Despite practices that recycled nutrients back to the farm (see chapter 4), by 1949 nearly all of China's cultivated land was deficient in nitrogen.[96] By the time the Communists came to power in 1949 there was not much farmers could do to increase the input of nitrogen to their fields to increase the food supply, and hence either to produce a surplus to finance industrialization, to raise the standard of living of the existing population, or even to provide sustenance for a growing population from the existing stock of farmland.[97] Indeed, evidence from the first half of the twentieth century indicates that food supplies were inadequate to sustain the population: as much as 15 percent of the male population was so poor that they could not marry, and they died without reproducing.[98] Competition for increasingly scarce resources on both land and water

occasioned more and increasingly sharp social conflict. Rural impoverishment stoked the enthusiasm of millions of China's rural people for change and for support for the Chinese Communists to do so, but the impoverished natural environment would not make that an easy task. Among other things, the Chinese Communists were to inherit a seriously degraded natural environment.

That degradation was less cyclical than conjunctural. In the nineteenth century, the Qing state faced internal rebellion, foreign aggression, political reaction, and declining state revenues, all of which environmental pressures vastly complicated. But the environmental problems occasioned especially by deforestation were very long in the making, and not easily reversed, as the environmental experience of the PRC was to make clear. The physical limits of the Chinese empire had been reached, and its dynamics led to the increasingly intensive use of a shrinking base of natural resources.[99] In 1750 about 25 percent of China's land surface was forested; by 1950 that had shrunk to 5-10 percent.[100]

Many elite Chinese in the nineteenth century understood the ecological problems they were facing, and often interpreted them as evidence of a growing shortage of resources and of the available land and water to sustain agriculture. Despite the concerns of officials, pressures on China's environment continued and intensified into the nineteenth and twentieth centuries. Spreading farms and tax-paying subjects to the furthest corners of the empire enhanced the power and reach of the Qing state. The need for tax-generating economic development more often than not trumped knowledge about impending ecological problems. Officials even knew that species were going extinct.

By 1800, tigers and elephants— "star species" that are indicators of healthy ecosystems—were pushed into the peripheries of the peripheries, and had been extirpated from most of China. That in itself is evidence of collapsing natural ecosystems and their replacement with agro-ecosystems. The south China tiger held on in a few mountainous redoubts, largely on the border between Guangdong and Jiangxi provinces and in the Fujian mountains. As humans encroached upon and destroyed their habitat, the number of tiger attacks on people surged in the eighteenth and nineteenth centuries, only to drop as the population of tigers dropped precipitously.[101] The Asian elephant was pushed further into remote areas bordering Yunnan and Burma.

Map 1.1. The Range of the Tiger. *Source:* The IUCN Red List of Threatened Species, "Panthera tigris," <http://www.iucnredlist.org/apps/redlist/details/15955/0>

One historian has called these disappearances the result of a "three-thousand year war on animals."[102] "War" is probably the wrong metaphor to describe what happened to the wildlife of China. To be sure, tigers and elephants (and other wild animals as well) were indeed hunted and killed, both for protection against their predations, and for their marketable body parts. But hunting is not what drove these species to the brink of extinction, and others into oblivion. The culprit rather has been the destruction of their

habitat, mostly to make way for farms and for increases in the size and distribution of the Han Chinese population throughout the space that the state could control. To that extent, the loss of China's wildlife has been more like a holocaust than a war.

Simultaneously, China's human population surged, almost tripling from 225 to 580 million between 1750 and 1950. Those growing numbers indicate that people in the Chinese empire had been able to capture increasing amounts of energy from their environment; agro-ecosystems to support humans replaced ecosystems that had supported other species. Not surprisingly, the resulting human population growth was not spread evenly. The core regions of central and eastern China saw very slow population growth, while frontier regions grew much faster. In part that faster growth came from relaxed controls on fertility within Han Chinese families, and in part from extensive migration from core regions.[103] Ten million or more migrated from central China to Sichuan, and 12 million migrated from north China into Manchuria, with millions more moving shorter distances. As Lee and Wang observed, "in the mid-eighteenth century, the six most popular provinces for frontier settlement (Sichuan, Yunnan, and Guizhou in the west and southwest; Liaoning, Jilin, and Heilongjiang in the northeast) accounted for only 5 percent of the national population. By the early twentieth century they accounted for 25 percent of all Chinese."[104]

But the dynamics leading to China's environmental woes were less Malthusian than Smithian, or what Wrigley has termed those of an "advanced organic economy." Based on his reading of classical economists, Wrigley distinguished "organic" economies, or those that derive their energy sources from capturing part of the solar energy flow reaching the earth, from "mineral-based" economies that tap stores of solar energy, in particular coal and oil. Organic economies faced inherent limitations, while those drawing on stores of coal and oil for energy could escape those limits. "All organic economies depended exclusively, or almost exclusively, upon their ability to capture some part of the flow of energy reaching the earth in the form of insolation, and to preserve a favourable balance between the energy spent in this pursuit and the energy made available by it."[105] The more efficiently those flows were captured, stored, and utilized, the more "advanced" the organic economy. Agricultural technologies and markets improved those efficiencies, and marked what Wrigley meant by an "advanced organic economy."

Moreover, even an advanced organic economy, by which he meant specifically England in the seventeenth and eighteenth centuries, and which Jack Goldstone has extended to apply to many parts of Eurasia, China and Japan included, inexorably confronted limits to growth. The necessities of life all came from the land, constituting what we now call biomass. Meeting those needs was always in competition for the use of land resources, and was limited "by the fact that the land was almost the sole source not only of food but of the great bulk of the raw materials used in manufacture….As growth progressed, the obstacles to further growth grew ever more pressing" because of the unavoidable diminishing returns to land (and labor) as the best land and best practices were used up, and inferior land brought into production. Manuring, specialization via markets, and improved knowledge of crops and animals might temporarily reverse or

slow the competition for the uses of land, but those limits would be reached, especially in the tension arising over the use of land for food or for fuel. In Wrigley's view, there was no internal dynamic by which an advanced organic economy would or could develop into another kind of economy that would keep growing (i.e. the modern industrial economy).[106] More likely was the continuation of the advanced organic economy toward what J. S. Mill termed a "stationary state."[107] To be sustainable and not enter a long period of declining standards of living and deteriorating ecological foundations for the society, such a state would require exquisite control over population size and distribution, consumption, and waste and nutrient recycling, among other adjustments to the strict limits to growth that it faced.[108]

China's environmental history in the nineteenth and twentieth centuries illustrates those dynamics. Population growth was stabilizing in core regions, and there is reason to think that it would have slowed in frontier regions too as ecological degradation limited economic opportunities, and families adjusted to those conditions. But whether or not that "stationary state" would have been sustainable cannot be known because the irruption of modern industry changed the dynamics of world history, ushering in instead China's "revolutionary state" in the second half of the twentieth century, a state that had no willingness or intention to live within the confines of an advanced organic economy.

Notes

[1] See Andre Gunder Frank, *ReOrient:Global Economy in the Asian Age* (Berkeley and Los Angeles: University of California Press, 1998); Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000; R. Bin Wong, *China Transformed: Historical Change and the Limits of European Experience* (Ithaca: Cornell University Press, 1997); Robert B. Marks, *The Origins of the Modern World: A Global and Ecological Narrative from the Fifteenth to the Twenty-first Century* (Lanham: Rowman & Littlefield, 2007).

[2] The debate between Kenneth Pomeranz and Philip Huang (among others) is in the *Journal of Asian Studies* vol. 61 no. 2 (2002), both of whom cite Li Bozhong's work on the lower Yangzi, *Agricultural Development in Jiangnan, 1620-1850* (New York: St. Martin's Press, 1998). Loren Brandt *Commercialization and Agricultural Development: Central and Eastern China 1870-1937* (New York: Cambridge University Press, 1989) and Thomas Rawski, *Economic Growth in Prewar China* (Berkekely: University of California Press, 1989) argue for rural economic improvement from the late nineteenth century to the beginning of war with Japan in 1937.

[3] For an insightful summary, see Daniel Little, "Eurasian Historical Comparisons: Conceptual Issues in Comparative Historical Inquiry," *Social Science History* vol. 32 no. 2 (Summer 2008), pp. 235-61.

[4] Robert B. Marks, *Tigers, Rice, Silk, and Silt: Environment and Economy in Late Imperial South China* (New York: Cambridge University Press, 1998). See especially chapter 8 and pp. 336-38. I argue that agricultural productivity and commercialization had severed grain prices from local or even regional harvests, leading to fewer subsistence crises in eighteenth-century south China than in England at the same time, and that low grain prices contributed to south China's proto-industrialization.

[5] The story of Han Chinese encounters with others is an important theme in China's environmental history, beginning perhaps as early as the second millennium BCE, but certainly taking form in the Han dynasty with the innovation of "military agricultural colonies," or *tun tian*. See also Laura Hostetler, *Qing Colonial Enterprise: Ethnography and Cartography in Early Modern China* (Chicago: University of Chicago Press, 2001).

[6] Peter C. Perdue, *China Marches West: The Qing Conquest of Central Eurasia* (Cambridge, MA: The Belknap Press of Harvard University Press, 2005).

[7] David A. Bello, "To Go Where No Man Could Go For Long: Malaria and the Qing Construction of Ethnic Administrative Space in Frontier Yunnan," *Modern China* vol. 31 no. 3 (July 2005), pp. 283-317.

[8] Han Chinese farming in those frontier regions had significant environmental consequences, but that topic is beyond the scope of this paper.

[9] For additional examples, see Eduard B. Vermeer, "Population and Ecology along the Frontier in Qing China," in Mark Elvin and Liu Ts'ui-jung eds., *Sediments of Time: Environment and History in Chinese Society* (New York: Cambridge University Press, 1997), pp. 272-77.

[10] Robert B. Marks, "People Said Extinction Was Not Possible: 2,000 Years of Environmental Change in South China," in Alf Hornberg ed., *Environmental History: World System History and Global Environmental Change* (Alta Mira Press, 2007).

[11] Marks, *Tigers,* ch. 10.

[12] David Bello, "The Cultured Nature of Imperial Foraging in Manchuria," *Late Imperial China* vol. 31 no. 2 (Dec 2010), p. 10.

[13] For an insightful discussion, see Dee Mack Williams, *Beyond Great Walls: Environment, Identity, and Development on the Chinese Grasslands of Inner Mongolia* (Stanford: Stanford University Press, 2002), ch. 4. *Wolf Totem* (New York: The Penguin Press, 2008), a fictional account based on author Jian Rong's experiences in Inner Mongolia in the 1960s and 1970s, provides additional insight into Mongol values as well as steppe ecological relationships and land degradation from the 1960s onward.

[14] Piers Blaikie and Harold Brookfield, "Defining and Debating the Problem," in Piers Blaikie and Harold Brookfield, *Land Degradation and Society* (New York: Methuen, 1987), pp. 1-26.

[15] For descriptions of the deforestation of the Wei River valley, see Eduard B. Vermeer, *Economic Development in Provincial China: The Central Shaanxi since 1930* (Cambridge and New York: Cambridge University Press, 1988), ch. 4.

[16] Norman Shaw, *Chinese Forest Trees and Timber Supply* (London: T. Fisher Unwin, 1914), p. 134.

[17] Shaw, *Chinese Forest Trees*, p. 125.

[18] Shaw, *Chinese Forest Trees*, pp. 128-29.

[19] Quoted in W. C. Lowdermilk, "Forestry in Denuded China," *The Annals of the American Academy of Political and Social Science*, vol. 152 (Nov. 1930), 138.

[20] David A. Pietz, *Engineering the State: The Huai River and Reconstruction in Nationalist China, 1927-1937* (New York and London: Routledge, 2002), p. 7.

[21] Pietz, *Engineering the State*, p. 10.

[22] Pietz, *Engineering the State*, p. 15.

[23] Elizabeth Perry, *Rebels and Revolutionaries in North China, 1845-1945* (Stanford: Stanford University Press, 1980), note p. 16. Locusts, of course, had long been feared as one of the scourges of farmers, with swarming masses periodically devouring the standing crop in county after county. Intensive study of locust behavior in the Ming dynasty finally led to the seventeenth-century publication of Xu Guangqi's *Treatise on Expelling Locusts*. Xu studied locust life cycles, and concluded that the threat could be minimized when the locusts were in the larval stage and wriggling or jumping on the ground. Human action should shift from damage control to prevention, he concluded, and the specifics of how to do that were published in his book. Later it was discovered that ducks especially could be useful in eating nearly all the locust larvae. But this approach to controlling locust outbreaks presupposed a society in which officials, local gentry, and commoners would work together to stem a locust threat. By the early twentieth century, local officials were scarce and "good" gentry had become just landlords. Farmers were left pretty much to themselves without the knowledge or organization to handle locusts, let alone floods or droughts. Tim Sedo, "Environmental Governance and the Public Good in Xu Guangqi's *Treatise on Expelling Locusts*," paper presented at 2011 AAS annual conference, Honolulu HI.

[24] Elizabeth Perry, *Rebels and Revolutionaries in North China, 1845-1945* (Stanford: Stanford University Press, 1980).

[25] Pietz, *Engineering the State*, pp. 15-16.

[26] Perry, *Rebels and Revolutionaries in North China,* p. 42.

[27] Quoted in Elizabeth J. Perry, *Rebels and Revolutionaries in North China, 1845-1945* (Stanford: Stanford University Press, 1980), p. 19.

[28] Heiner Rotz, "On Nature and Culture in Zhou China," in Hans Ulrich Vogel and Günter Dux eds., *Concepts of Nature: A Chinese-European Cross-Cultural Perspective* (Leiden: Brill, 2010), p. 203 n. 20.

[29] For an insightful history of the eleventh-century shift of the Yellow River north, and the environmental effects of that shift, see Ling Zhang, "Changing with the Yellow River: An Environmental History of Hebei, 1048-1128," *Harvard Journal of Asiatic Studies* vol. 69 no. 1 (2009), pp. 1-36.

[30] Quoted in Joseph W. Esherick, *The Origins of the Boxer Uprising* (Berkeley and Los Angeles: University of California Press, 1987), p. 1.

[31] XXX, "Sacrificing Local Interests: Water Control Policies of the Ming and Qing Governments and the Local Economy of Huaibei, 1495-1949," *Modern Asian Studies*, forthcoming.

[32] Jane Kate Leonard, *Controlling from Afar: The Daoguang Emperor's Management of the Grand Canal Crisis, 1824-1826* (Ann Arbor: Center for Chinese Studies, University of Michigan Press, 1996), p. 9.

[33] On his first "southern tour" in 1684, the Kangxi emperor was being transported down the Grand Canal and observed the massive flooding and human misery caused by the breakdown of the Yellow River/Grand Canal system, and asked the director- general of the river conservancy who was with him what it would take to fix the problems. "More than one million taels [ounces of silver]," the emperor was told. Or using corvee labor summoned by local magistrates, it "would certainly be over ten years before it was finished." Because of the strategic significance of the Grand Canal, the Kangxi emperor decided to proceed expeditiously. See Antonia Finnane, *Speaking of Yangzhou: A Chinese City, 1550-1850* (Cambridge, MA: Harvard University Press, 2004), pp. 149-50.

[34] Phillip C. C. Huang, *The Peasant Economy and Social Change in North China* (Stanford: Stanford University Press, 1985), p. 60.

[35] For descriptions of several of the incidents of Yellow River flooding, the role of "Confucian engineers," and execution of strategies to stem the flooding, see Randall Dodgen, *Controlling the Dragon: Confucian Engineers and the Yellow River in Late Imperial China* (Honolulu: University of Hawai'i Press, 2001), esp. chs. 4-5.

[36] The following is based upon Leonard, *Controlling from Afar*, chapter 1.

[37] The story of the Ming official Pan Jixun who developed these ideas is told in Pietz, pp. 11-15, and in Randall Dodgen, "Hydraulic Evolution and Dynastic Decline: The Yellow River Conservancy, 1796-1855," *Late Imperial China* Vol. 12 no. 2 (Dec 1991): 36-63. See also Dodgen, *Controlling the Dragon*, chs. 1-2.

[38] XXX, "Sacrificing Local Interests."

[39] In addition to Leonard, *Controlling from Afar*, see Finnane, *Speaking of Yangzhou*, pp. 152-71 for a description not just of the hydraulic infrastructure, but also the complex bureaucratic machinery necessary to manage the Yellow River conservancy and the Grand Canal, and the place of salt drying in the economy of the region.

[40] Leonard, *Controlling from Afar*, p. 48.

[41] Leonard, *Controlling from Afar*, p. 49.

[42] James L. A. Webb, *Humanity's Burden: A Global History of Malaria* (New York: Cambridge University Press, 2009), pp 120-21.

[43] Pietz, *Engineering the State*, p. 17.

[44] Pietz, *Engineering the State*, pp. 17-18. The story of attempts to "control" the Huai River continued after the establishment of the People's Republic of China, and will be taken up in chapter 7. Briefly, in the spring of 1950, Mao Zedong called for a mass movement to "harness" the Huai River, with ambiguous results. Mao ordered the "mountains to bend their tops, and the rivers to give way." Millions of peasants dug a new outlet to the Yangzi, dug reservoirs to hold floodwaters, and built dikes to constrain the river, but severe flooding in 1954 called into question the efficacy of those efforts. See James Nickum, *Hydraulic Engineering and Water Resources in the People's Republic of China* (Stanford, 1977) , Robert Carin, *River Control in Communist China* (Hong Kong, 1962); Jasper

Becker, "The Death of China's Rivers," *AsiaTimesOnline*, August 26, 2003. In the post-Mao reform era, chemical plants sited on former rice paddies dumped tons of toxic waste into ill-prepared holding ponds which burst in a 2001 flood, poisoning the waters downstream, prompting mass protests, and lending the title to Elizabeth Economy's book, *The River Runs Black: The Environmental Challenge to China's Future* (Ithaca: Cornell University Press, 2004).

[45] Diana Lary, "The Waters Covered the Earth: China's War-Induced Natural Disasters," in Mark Selden and Alvin Y. So eds., *War and State Terrorism: The United States, Japan, and the Asia-Pacific in the Long Twentieth Century* (Lanham, MD: Rowman & Littlefield, 2004), pp. 143-47.

[46] Quoted in Micah Muscolino, "Violence against the People and the Land: Refugees and the Environment in China's Henan Province, 1938-45," *Environment and History*, forthcoming.

[47] Ibid., pp. 8-9.

[48] After the war and with the help of the UNRRA (United Nations Relief and Rehabilitation Administration), the breach was closed and by late 1946 the Yellow River resumed its northerly course. Lary, "The Waters Covered the Earth," p. 156.

[49] Kenneth Pomeranz, *The Making of a Hinterland: State, Society, and Economy in Inland North China, 1853-1937* (Berkeley and Los Angeles: University of California Press, 1993).

[50] Pomeranz, *The Making of a Hinterland,* p. 122.

[51] Pomeranz, *The Making of a Hinterland* p. 127.

[52] Pomeranz, *The Making of a Hinterland,* p. 137.

[53] Lowdermilk, "Forestry in Denuded China," p. 137.

[54] Pomeranz, *The Making of a Hinterland,* p. 151.

[55] Lillian Li, *Fighting Famine in North China: State, Market, and Environmental Decline, 1690s-1990s* (Stanford: Stanford University Press, 2007), p. 41.

[56] Li, *Fighting Famine in North China* pp. 46-47.

[57] Li, *Fighting Famine in North China* p. 67.

[58] Quoted in Li, *Fighting Famine in North China* p. 68.

[59] For a recent update, see Edward Wong, "Plan for China's Water Crisis Spurs Concern," *The New York Times*, June 1, 2011.

[60] Li, *Fighting Famine in North China*, p. 19.

[61] Zuo Dakang and Zhang Peiyuan, "The Huang-Huai-Hai Plain," in B. L. Turner et al. eds, *The Earth as Transformed by Human Action: Global and Regional changes in the Biosphere over the Past 300 Years* (New York: Cambridge University Press, 1990), p. 476.

[62] Li, *Fighting Famine in North China*, ch. 10. Li also demonstrates the extraordinary extent to which the Chinese state provided effective famine relief, how those efforts failed in the late nineteenth and early twentieth centuries, and how international organizations provided famine relief.

[63] Mike Davis, *Late Victorian Holocausts: El Niño Famines and the Making of the Third World* (London and New York: Verso Press, 2001). For a discussion of the connections between ENSO events and harvests in China, see Robert B. Marks and Georgina Endfield, "Environmental Change in the Tropics in the Past 1000 Years," in Sarah Metcalf and David Nash eds., *Quaternary Environmental Change in the Tropics* (Oxford: Blackwell Publishing, forthcoming).

[64] On the Nian, the Red Spears, and the Chinese Communists, see Perry, *Rebels and Revolutionaries*. On the Boxers, see Joseph W. Esherick, *The Origins of the Boxer Uprising* (Berkeley and Los Angeles: University of California Press, 1987).

[65] On the connections among environmental degradation, rural poverty, and Communist base areas, see Yan Ruizhen and Wang Yuan, *Poverty and Development: A Study of China's Poor Areas* (Beijing: New World Press, 1992).

[66] Jiayang Zhang, "Environment, Market, and Peasant Choice: The Ecological Relationships in the Jianghan Plain in the Qing and the Republic," *Modern China* vol. 32 no. 1 (Jan 2006), pp. 31-63. Zhang makes the additional important point that peasant cropping choices increasingly were influenced in the first instance by the changing environment and hence their subsistence needs, and secondarily by market opportunities.

[67] See also Lyman P. Van Slyke, *Yangtze: Nature, History, and the River* (reading, MA: Addison-Wesley Publishing Co., Inc.,1988), esp. pp. 20-27.

[68] Keith Schoppa, *Xiang Lake—Nine Centuries of Chinese Life* (New Haven: Yale University Press, 1989). Quotes are from pages 6, 65, and 190.

[69] Quoted in Marks, *Tigers*, p. 311.

[70] Albert N. Steward, "The Burning of Vegetation on Mountain Land, and Slope Cultivation in Ling Yuin Hsien, Kwangsi Province, China," *Lingnan Science Journal;* v. 13 no. 1 (Jan 1934), p. 1.

[71] Chris Coggins, *The Tiger and the Pangolin: Nature, Culture, and Conservation in China* (Honolulu: University of Hawai'i Press, 2003), pp. 147-48.

[72] According to geologist Walter Parham, "The process of degradation follows a predictable path. When vegetation is removed in these regions, the exposed soil bakes in the sun; it reaches temperatures so high that seeds and sprouts are killed or stunted. Since new vegetation cannot be established easily, soil organic matter is reduced, and the soil

becomes desiccated. Soil organic matter decreases quickly as soil temperature and biotic decomposition rates increase. Further, removal of vegetation and litter by farmers for fuel inhibits buildup of new organic matter. Soil organic matter plays a large role in retaining nutrients in a form available to plants. Even small decreases in soil organic matter have a pronounced negative effect on the soil's fertility. Granite underlies most of South China and when the original topsoil is removed by erosion, the surface becomes a mixture of aluminum-rich clays and quartz sand that contain very few minerals useful to plant life. The loss of vegetative cover and soil organic matter leaves the soil subject to damage from intense tropical rainfall. With little organic matter in the soil, clay particles are moved by raindrops and plug soil pores, thus inhibiting water infiltration and increasing runoff and erosion. Residual boulders of fresh granite (core stones) as large as automobiles sometime slide and tumble down hillsides when the surrounding soft weathered material is eroded during heavy rains. The finer-grained eroded sediments damage aquatic productivity and bury what were once freshwater and near-shore marine aquatic breeding grounds. The remaining coarser, sandy material of the weathered granite yields soils of low fertility. Stripped of vegetation that would otherwise have absorbed or slowed the flow of water, the water pours rapidly into streams and rivers, cutting deep ravines in the soft, deeply weathered granite." Walter Parham, "Degraded Lands: South China's Untapped Resource," *FAS Public Interest Report: The Journal of the Federation of American Scientists*, vol. 54 no. 2 (Mar/Apr 2001) http://www.fas.org/faspir/2001/v54n2/resource.htm.

[73] Marks, *Tigers*, pp. 319-21.

[74] There is a long and interesting history of the relationship among warring in China, malaria, and malaria cures, going back to the fourth century CE and continuing through the Vietnam War and China's development of a new anti-malarial drug derived from two variants of artemisia (*Artemisia annua*; known more commonly in the West as sweet wormwood, or mugwort, and *Artemisia apiacea*). Elisabeth Hsu, "The History of *qing hao* in the Chinese *materia medica*," *Transactions of the Royal Society of Tropical Medicine and Hygiene* 100 (2006), pp. 505-508.

[75] James L. A. Webb, *Humanity's Burden: A Global History of Malaria* (New York: Cambridge University Press, 2009), p. 156.

[76] Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (New York: Cambridge University Press, 2001), pp. 112-114.

[77] The quotes in this paragraph are from handwritten notes on the back side of the photographs in Fig. 6.3a-d. The photographs are at the Library of Congress Prints and Photographs Division in a collection entitled "Malaria Control in India and China, 1929-40," call number LOT 1786 (M) [P&P].

[78] On the history of malaria, see Webb, *Humanity's Burden*. See also Russell, *War and Nature*, pp. 112-17.

[79] Shaw, *China's Forest Trees* (1914); Vaclav Smil, *The Bad Earth* (Armonk, NY: M.E. Sharpe, 1984); and Richard Louis Edmonds, *Patterns of China's Lost Harmony: A Survey of the Country's Environmental Degradation and Protection* (London: Routledge, 1994).

[80] Shaw, *China's Forest Trees*, p. 141.

[81] Ruth Mostern, "The Dujiangyan Waterworks," Association for Asian Studies annual meeting, March 26-29, 2009, Chicago, Il. For a brief description, see Mark Edward Lewis, *The Early Chinese Empires: Qin and Han* (Cambridge MA: Harvard University Press, 2007), pp. 35-36.

[82] The history of Tibet and its relationship with China is complex and contentious. Suffice it to say here that the Qing state consolidated its rule over Tibet in the eighteenth century, and incorporated parts of Tibet into its administrative structure, with some being annexed by neighboring provinces, and some becoming organized as the Qing province of Qinghai.

[83] Wolfgang Holzner and Monika Kriechbaum, "Man's Impact on the Vegetation and Landscape in the Inner Himalaya and Tibet," in Mark Elvin and Liu Ts'ui-jung eds., *Sediments of Time: Environment and Society in Chinese History* (New York: Cambridge University Press, 1998), p. 100.

[84] Ibid., p. 71.

[85] Ibid., p. 73.

[86] Ibid., pp. 89-91.

[87] Jack Hayes, "Rocks, Trees and Grassland on the Borderlands: Tibetan and Chinese Perceptions and Manipulations of the Environment along Ecotone Froniers, 1911-1982," paper presented at March, 2011 AAS Annual Meeting, Honolulu HI.

[88] Jack Hayes, "Fire Disasters on the Borderland: Qing Dynasty Chinese, Tibetan and Hui Fire Landscapes in Western China, 1821-1911," paper presented at the AAS Annual Meeting, March 2010, Philadelphia PA.

[89] Micah Muscolino, "The Yellow Croaker War: Fishery Disputes between China and Japan, 1925-1935," *Environmental History* 13 (April 2008), pp. 305-24; Micah Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China* (Cambridge, MA: Harvard University Press, 2009).

[90] See also S. A. M. Adshead, "An Energy Crisis in Early Modern China*." Ch'ing-shi wen-t'i* [*Late Imperial China*] vol. 3 no. 2 (Dec. 1974): 20-28.

[91] Nicholas K. Menzies, *Forest and Land Management in Imperial China* (New York: St. Martin's Press, 1994), pp. 1-2.

[92] Ibid., p. 87. Two examples of forest management that appear to have been successful were forests and wood products that were closely integrated into the economy and met some clearly defined market demand. In Jiangxi and northern

Fujian, forests were maintained by wealthy local merchants largely because they supplied fuel to the imperial kilns at Jingdezhen, and thereby had a higher economic value as trees than as farmland, and were managed as such. Similarly, some tree species, in particular *cunninghamia*, or the Chinese fir, proved to be economical because they were fast growing and provided fuel to nearby cities.

[93] See Marks, *Tigers*, p. 320 for an example.

[94] One indicator typically cited as evidence of ecological degradation in China is an increased frequency of flooding. With hills and mountains deforested and no longer able to hold rains, and lowland catchment basins hemmed in by dikes to protect farmland or filled in completely, one would expect there to have been an increasing incidence of floods. The problem is, I have not been able to find good evidence to support that hypothesis. An early analysis shows mostly that flooding increased with China's size and its population, not particularly surprising since water overflowing riverbanks needs people to record it as a "flood." See Yao Shan-yu, "The Geographical Distribution of Floods and Droughts in Chinese History, 206 B.C.-A.D. 1911," *The Far Eastern Quarterly*, vol. 2 no. 4 (Aug. 1943), pp. 357-78. Analysis of data from the massive compilation by Chinese climatologists who quantified every reference to floods or droughts in China's voluminous written record (*Zhongguo jin wubai nian han lao fenbutu ji* (Beijing: Kexue chuban she, 1981)) shows a decrease in incidences of "normal" precipitation from 1800-1979, and an increase in the number of places in China that experienced extreme dryness or extreme wetness. Jie Song, "Changes in Dryness/Wetness in China during the Last 529 Years," *International Journal of Climatology* 20 (2000), p. 1007. Other climatologists who have analyzed that data have found 80-year cyclical patterns (Wang Zhao-wu and Zhao Zong-ci, "Droughts and Floods in China, 1470-1979," in T. M. L. Wigley et al. eds., *Climate and History: Studies in Past Climates and Their Impact on Man* (Cambridge University Press, 1981)). None of these studies distinguish between climatic or other causes for the observed patterns. Pierre-Etienne Will, of course, presented an important argument for hydrological cycles that paralleled the rise and decline of dynastic power ("State Intervention in the Administration of a Hydraulic Structure: The Example of Hubei Province in Late Imperial Times," in Stuart Schram ed., *The Scope of State Power in China* (New York: St. Martin's Press, 1985). But good statistical evidence that flooding increased in late imperial China eludes us.

[95] Lowdermilk, "Forestry in Denuded China," p. 129.

[96] Jung-Chao Liu, *China's Fertilizer Economy* (Chicago: Aldine Publishing Co., 1970), 104–5.

[97] For more on the place of nitrogen in Chinese agriculture, see Vaclav Smil*, China's Past, China's Future: Energy, Food, Environment* (New York: RoutledgeCurzon, 2004), 109–20.

[98] Edwin Moise, "Downward Social Mobility in Pre-Revolutionary China," *Modern China* 3, no. 1 (1977): 8.

[99] Those dynamics were not involutionary, but involved the history of the Han Chinese state, family farming, markets, and demography. The classic formulation of involution is Clifford Geertz, *Agricultural Involution: The Processes of Ecological Change in Indonesia* (Berkeley: University of California Press, 1963). For a summary of its critics, see Benjamin White, "Agricultural Involution and its Critics: Twenty Years After," *Bulletin of Concerned Asian Scholars* vol. 15 no. 2 (1983), pp. 19-31.

[100] The 1750 figure is derived from Ling Daxie, "Wo guo senlin ziyuan de bianqian," *Zhongguo nongshi* 1983 No. 2: 26-36. For 1950, official statistics figure China about 13 percent forested, but others think the forest cover was about half that. See Vaclav Smil, *The Bad Earth*, pp. 10-12. Richardson, *Forests and Forestry in China*, p. 89; and Smil, *China's Environmental Crisis*, p. 60.

[101] See Marks, *Tigers*; Chris Coggins, *The Tiger and the Pangolin: Nature, Culture, and Conservation in China* (Honolulu: University of Hawai'i Press, 2003).

[102] Mark Elvin, *Retreat of the Elephants* (New Haven: Yale University Press, 2004), ch. 2 and p. 11.

[103] In John Richards's view, "Without surplus population, no frontier can exist. Without funding and outside outlets for produce, settlers cannot live. Without the ability of human beings to form communities and to organize themselves for self-sufficiency, frontiers would not be possible. But above all, it is the state that has created and sustained settler frontiers by appropriating 'empty' tracts as pubic lands. These lands are surveyed, allocated, and titled to pioneers and their backers or to state agencies." John Richards, "Land Transformation," in B. L. Turner II et al eds., *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years* (New York: Cambridge University Press, 1993), p. 176.

[104] Lee and Wang, *One Quarter of Humanity*, p. 118.

[105] E. A. Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England* (New York: Cambridge University Press, 1988), 50-51.

[106] Wrigley, *Continuity*, pp. 34, 52.

[107] As J. S. Mill observed in *The Principles of Political Economy* (1909, various editions, ch. 6): "It must always have been seen, more or less distinctly, by political economists, that the increase of wealth is not boundless: that at the end of what they term the progressive state lies the stationary state, that all progress in wealth is but a postponement of this, and that each step in advance is an approach to it.…

This impossibility of ultimately avoiding the stationary state — this irresistible necessity that the stream of human industry should finally spread itself out into an apparently stagnant sea must have been, to the political economists of the last two generations, an unpleasing and discouraging prospect; for the tone and tendency of their

speculations goes completely to identify all that is economically desirable with the progressive state, and with that alone."

[108] And not just China, but Holland as well. Jack Goldstone, "The Problem of the Early Modern World," *Journal of the Economic and Social History of the Orient* vol. 41 no. 3 (1998), pp. 264-65.