1 Interactions between nature and society in the late-medieval world

The Great Transition spanned the late thirteenth to the late fifteenth centuries. It ended one sustained phase of European expansion, cultural efflorescence and trans-Eurasian commercial integration and defined the baseline from which the next eventually sprang. Unique combinations of environmental and human factors triggered the Great Transition and then shaped and determined its course. These included, on the one hand, global climate change and the re-emergence of deadly plagues of livestock and humans and, on the other, mounting warfare, commercial recession, economic contraction, bullion scarcity and a massive implosion of Old World populations. The full ecological and geographical dimensions of these developments are only now coming to light thanks to detailed scientific research into past climates, biological decoding of the *Yersinia pestis* genome, the application of aDNA analysis to Black Death burials, the emergence of global history as a significant field of scholarly enquiry, and the extension of historical national income analysis back to the fourteenth and fifteenth centuries. There have been many attempts to describe and explain the changes in historical trajectory that took place between the 1270s and 1470s but this is the first to take advantage of these new insights and to integrate the role of physical and biological processes and developments fully into the narrative.[1] To do so has required broadening the scale of enquiry to encompass, as appropriate, Latin Christendom, the whole of Eurasia and, in the case of climate, the northern hemisphere and, on occasion, the world.

The Great Transition followed an extended period when in both western Europe and eastern Asia favourable climatic conditions, relative freedom from major epidemics, technical progress and a raft of institutional innovations underscored sustained increases in population and economic output. The resurgence of Latin Christendom in the West was paralleled

[1] For reviews of the relevant historiography see Hybel (1989); Hatcher and Bailey (2001). For an almost exclusively anthropocentric interpretation of the transition see Aston and Philpin (1985), and for an environmentally informed view, Hoffmann (2014), 342–51.

in the East by the rise of Song China, the Champa, Dai Viet, Angkor and Pagan states of Southeast Asia, and the Chola Empire of south India.[2] All experienced a flowering of domestic and overseas trade and benefited from the enhanced opportunities for market specialization which this bestowed. One of the greatest achievements of the age was the progressive growth and widening of these independent orbits of exchange until, as documented by Janet Abu-Lughod, they coalesced into an integrated world system of trade that connected the commerce of the Orient with that of the Occident.[3] This was when European elites acquired their cravings for the spices, silks and ceramics of the East which they mostly paid for with bullion produced by Europe's booming silver mines. These developments are the subject of Section 2 (Efflorescence: the enabling environment and the rise of Latin Christendom) and are of fundamental importance to understanding the changes which then ensued as the environmental and societal foundations upon which the era's prosperity had been founded shifted and fractured. Whether the expansion and prosperity of this era of efflorescence was sustainable in the long term can be debated but that it powerfully shaped and influenced the contraction that followed is indisputable.[4]

The first indications of impending change become apparent in the 1260s and 1270s. From then until the 1340s forms the first stage of the Great Transition (Section 3: A precarious balance: mounting economic vulnerability in an era of increasing climatic instability and re-emergent pathogens), when the climatic, biological, military and commercial developments were initiated from which a major socio-ecological regime shift would in due course spring. That critical transition took place between the 1340s and 1370s during the second and most dramatic stage of the Great Transition (Section 4: Tipping point: war, climate change and plague shift the balance). During this short watershed period profound and irreversible changes occurred in both environmental and human conditions. Over the course of the next hundred years, during the third and final stage of the Great Transition (Section 5: Recession: the inhibiting environment and Latin Christendom's late-medieval demographic and economic contraction), the socio-ecological processes then set in train worked themselves out until the point was eventually reached during the last quarter of the fifteenth century when, under significantly altered environmental and commercial circumstances and within the context of

[2] Lieberman (2009), 687–9; Lieberman and Buckley (2012), 1053–68; Tana (2014), 324–32; Abu-Lughod (1989), 263.
[3] Abu-Lughod (1989); below, Figure 2.1.
[4] For arguments in favour of the inevitability of some form of crisis see Aston and Philpin (1985).

an enlarged and redefined world, economic and demographic renewal and regrowth began. As outlined in Section 1.02, this eventually led to the Great Divergence between the revitalized and aggressively competitive maritime economies of the West and the more anciently commercialized and technologically advanced but stagnating economies of the East.[5]

Before considering the character of the interactions between nature and society that characterized the Great Transition (Section 1.03) and the practical issues of how best to analyse and describe it given the nature of the available evidence (Section 1.04), it is useful to rehearse in outline the essential features of each of the Great Transition's three stages. As this account of events is unfolded it will be plain that there was nothing pre-ordained about what transpired. At any given juncture several different outcomes were possible depending upon the precise configuration of human and environmental forces. Contingency therefore mattered and so, too, did fortuitous conjunctures of natural and human processes. Because there was so much that was unique about the Great Transition, the Epilogue (Theory, contingency, conjuncture and the Great Transition) will argue that it was in almost all essential respects an intrinsically historical phenomenon.

1.01 The Great Transition: an outline chronology

1.01.1 1260s/70s–1330s: the Great Transition begins

Until onset of the Wolf Solar Minimum in the final decades of the thirteenth century, relatively high levels of solar irradiance had sustained above-average global and northern hemisphere temperatures (Figure 1.1A) and correspondingly settled atmospheric circulation patterns across both hemispheres.[6] This was the last extended phase of the Medieval Climate Anomaly (MCA). Its salient features, which were especially well developed around 1250, are summarized in Figures 1.1B and 1.1C. The dry conditions verging on mega-drought in the North and South American West, in combination with heavy monsoon rainfall across South Asia, are diagnostic of a strongly positive El Niño Southern Oscillation (ENSO) over the Pacific Ocean.[7] The corresponding configuration of monsoon circulation over the Indian Ocean favoured India

[5] Pomeranz (2000) coined the term the 'Great Divergence' to describe the point when the leading Asian economies were overtaken by those of Europe.
[6] Delaygue and Bard (2010a); Vieira and others (2011); below, Section 2.02.
[7] Cook and others (2004c); Rein and others (2004); below, Section 2.02.1.

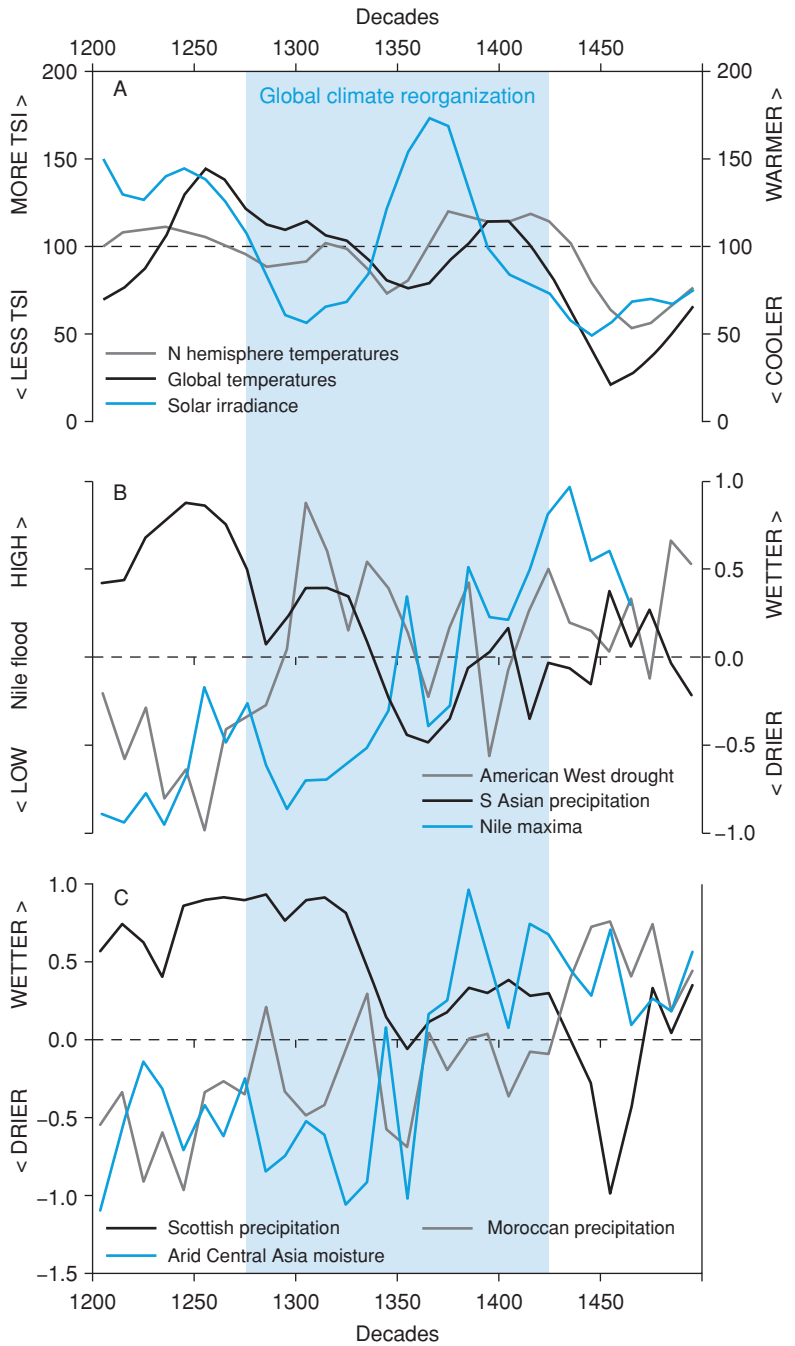

Figure 1.1 (A) Indexed solar irradiance, global temperatures and northern hemisphere temperatures, 1200–1500. (B) Indexed precipitation

and Pakistan over East Africa, with the result that monsoon-fed flood discharge of the River Nile at Cairo remained well below its potential maximum. Long-distance teleconnections between the Indian and Pacific Oceans and the North Atlantic maintained the North Atlantic Oscillation (NAO) in equally positive mode.[8] A strong westerly air-stream kept winters over northwest Europe mild and wet, as exemplified by the regular heavy rainfall experienced by western Scotland, at the expense of precipitation levels over much of Mediterranean Europe and North Africa (Figure 1.1C).[9] Low winter rainfall in these southerly regions meant that the westerly air-stream over Arid Central Asia was equally deficient in moisture, with the result that Eurasia's continental interior remained locked in a state of perpetual drought, never more severe than in the 1190s and early 1200s.[10] Marginal variations in precipitation had potentially big ecological consequences across this vast parched region, with wider human and biological repercussions which would play a big role in the Great Transition.[11]

It was from the 1270s, as solar irradiance diminished and global and northern hemisphere temperatures cooled (Figure 1.1A), that these long-established circulation patterns began to change. El Niño events, when warm water and air replaced cold in the eastern Pacific, now began to occur with increased frequency. Accordingly, precipitation levels rose over the North and South American West, culminating in a major wet

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Figure 1.1 (*cont.*) in the North and South American West and in South Asia and the maximum height of the Nile flood, 1200–1500. (C) Indexed precipitation in Scotland and Morocco and moisture levels in Arid Central Asia, 1200–1500.
Sources: (A) Delaygue and Bard (2010b); Vieira and others (2011); Loehle and McCulloch (2008); Mann and others (2008): 100 = mean of the period 1250–1450. (B) Cook and others (2004c); Rein and others (2004); Rad and others (1999); Berkelhammer and others (2010b); Zhang and others (2008); Wang and others (2006); Popper (1951), 221–3. (C) Proctor and others (2002b); Esper and others (2009); Chen and others (2012)

[8] A teleconnection pattern is 'a recurring and persistent, large-scale pattern of pressure and circulation anomalies that spans vast geographical areas': United States National Weather Service, Climate Prediction Center, http://www.cpc.ncep.noaa.gov/data/teledoc/teleintro.shtml. Below, Section 2.02.2.
[9] Proctor and others (2002a). [10] Chen and others (2010); below, Section 2.02.3.
[11] Below, Sections 3.03.1b and 4.02.2.

event *c.*1300.[12] Thereafter, although droughts periodically recurred they would never again be as extreme as in the 1250s.[13] Concurrently, the South Asian monsoon started to weaken (Figure 1.1B) and India's first systemic monsoon failures followed in the 1280s.[14] With a lag, the NAO, in turn, began to weaken. From the 1320s rainfall over Scotland declined and northern Europe began to experience some notably 'arctic' winters, when polar high pressure spilled south and Atlantic cyclones were deflected to a more southerly track.[15] The latter brought bouts of wetter weather to southern Europe and North Africa and penetration of Arid Central Asia by a moister westerly airflow, so that here, too, humidity levels began fitfully to rise (Figure 1.1C).[16] Established circulation patterns were destabilizing almost everywhere and, as they did so, extreme weather events and major back-to-back harvest failures caused economic havoc across Eurasia.[17]

Great as were the dangers posed by extreme weather to agrarian-based economies, disease had the potential to inflict the greater damage. In 1279, for instance, English flocks succumbed to a debilitating outbreak of sheep scab which halved national wool output at a time when the country was Europe's premier producer of fine wool.[18] Scab's causal agent is the mite *Psoroptes ovis*, which lives on the skin of sheep and whose faeces cause an acute or chronic form of allergic dermatitis in the animals. In the 1279 outbreak many of the sheep thus stricken died or were slaughtered, the fleece weights of those that could be shorn plummeted and so inferior was the quality of the wool clip that the unit sale price slumped.[19] For the economy at large the ramifications of the massive shortfall in national wool output were considerable: agricultural incomes were squeezed, want of raw wool depressed English textile output, export earnings contracted, GDP per head took a direct hit, and overseas cloth producers reliant upon fine English wool were starved of vital raw materials, sparking riots among industrial workers in Flanders.[20]

England's commercial specialization in wool production, the sheer size of the national flock and the geographical extent of associated movements of stock, fleeces and wool had left the country's 15 million sheep wide

[12] Below, Section 3.02; Magilligan and Goldstein (2001); Mohtadi and others (2007), 1062–3.
[13] Rein and others (2004); Cook and others (2004c).
[14] Cook and others (2004b).
[15] Proctor and others (2002a); Trouet and others (2009a); below, Section 3.02.
[16] Below, Section 2.02.3.
[17] Below, Section 3.02; Figures 3.3 and 3.8B.
[18] Sheep numbers fell by approximately 30 per cent and fleece weights were down by 20–25 per cent: below, Figure 3.4. Lloyd (1977), 63; Stephenson (1988), 372–3, 381, 385.
[19] Below, Figure 3.4.
[20] Broadberry and others (2015), 206–7, 227; below, Section 3.01.2.

open to an infection which, in its early stages, was as difficult to detect as it was easy to spread. Commerce, in effect, amplified a vector-spread epizootic infection of ovines into a national agronomic disaster. In the decades that followed commercial exchange, in combination with high densities of bovines and humans, would similarly aid dissemination of both cattle plague and human plague, with repercussions in the latter case that would be felt across Europe for centuries.

Cattle plague (alias rinderpest) had last posed a major threat to European livestock producers in the mid-tenth century.[21] For over 300 years farmers apparently had little to fear from this most virulent and contagious of viral infections. In the 1290s and early 1300s, however, after unification of the Eurasian interior under the Mongols and the increased latitudinal movement that followed, chroniclers across eastern and central Europe again began to report heavy mortalities of cattle, although from what cause is unclear.[22] Then, between 1316 and 1321 and under conditions of extreme weather and acute ecological stress, rinderpest erupted in Bohemia and thence swiftly spread westwards, devastating herds and destroying vital draught oxen across northern Europe as far as the Atlantic coast of pastoral-farming Ireland.[23] A disease which had long remained effectively dormant as an enzootic infection among the native cattle of Eurasia's continental interior had been amplified by the combination of ecological stress and commercial exchange into a fast-spreading and deadly panzootic against which biologically naïve stock further to the west had little resistance.[24]

Meanwhile, microbiologists and geneticists have inferred that sometime after *c.*1268 *Yersinia pestis*, the causative agent of bubonic plague, entered a more active phase within its reservoir regions in Arid Central Asia.[25] Plague's sudden advance from an enzootic to an epizootic state appears to have been marked by the proliferation of new branches or polytomies in what has been described as a biological 'big bang'.[26] Biologists believe that these developments took place in the semi-arid Tibetan–Qinghai Plateau of western China, where plague had long persisted as an enzootic infection of the region's ground-burrowing gerbils and marmots.[27] Partly responsible may have been a trophic cascade set in

[21] In AD 809–10 outbreaks of cattle plague, possibly rinderpest, are noted in well over a dozen surviving chronicles from Austria to northern England and Ireland: Newfield (2012). For the AD 939–42 cattle plague see Newfield (2012).
[22] Below, Figures 3.25, 3.29 and 3.30 and Section 3.03.1b; McNeill (1977), 134; Abu-Lughod (1989), 154–84.
[23] Newfield (2009); below, Figure 3.25.
[24] Spinage (2003), 51; below, Section 3.03.1b.
[25] Bos and others (2011), 509; Cui and others (2013), 579–80; below, Section 4.04.
[26] Cui and others (2013). [27] Below, Section 3.03.2c.

motion by the stimulus given by incursions of a moister westerly airstream to vegetation growth, sylvatic rodent numbers, their burdens of flea parasites and the overall pathogen load. Once amplified in volume and escalated in activity, caravan traffic along the trade routes that traversed this reservoir region may then have transmitted the pathogen and its insect vectors to communities of sylvatic rodents ever further west along the Silk Road, until by 1338 it had reached Issyk-Kul in Kirgizia, at the eastern extremity of the steppe grasslands that extended westwards almost without interruption as far as the Great Hungarian Plain.[28] Here, if not before, it appears to have crossed over and as a zoonotic inflicted significant human fatalities. Plague's full destructive potential would not, however, be revealed until it had crossed the Caspian Basin, reached the lands of the Kipchak Khanate of the Golden Horde and, thence, the busy Genoese-controlled ports of Kaffa, Pera and Trebizond on the Black Sea, with their extensive maritime connections throughout the Mediterranean world and beyond.[29]

As plague was insidiously spreading by one means or another along the caravan routes that traversed the interior of Eurasia, other more vital commercial links between East and West were closing. Mongol and Mamluk conquests in the Middle East, commencing with the sack of Baghdad in 1258 and ending with the fall of Acre in 1291, started the process by obstructing and deterring traffic along the once busy trans-Syrian routes that linked the Persian Gulf with the eastern Mediterranean.[30] Defeat of the crusader states dispossessed the Italian maritime republics of Genoa and Venice of their former commercial privileges; retaliatory papal embargoes upon continuing trade with Muslims further constricted this once thriving forum of Italian commerce and source of sought-after Oriental luxuries. At the same time the Kārimīs cartel of merchants tightened its control of the Indian spice trade reaching the Mediterranean via the Red Sea and extracted the maximum tolls these commodities would bear.[31] Under the circumstances, it is hardly surprising that Venice and more especially Genoa refocused their attention on the alternative commercial opportunities offered by the Black Sea, terminus of the trans-Asian caravan route to Sarai Batu and Tana via Qinghai from Beijing that had prospered following creation of the Mongol Empire, as also of the trade from the Persian Gulf re-routed via Tabriz in Persia to Trebizond.[32] This, however, did nothing to prevent Europe's already negative trade balance with Asia from deteriorating further or to staunch the reciprocal

[28] Below, Figure 4.9. [29] Below, Section 4.03.3 and Figure 4.9.
[30] Abu-Lughod (1989); below, Section 2.05.1. [31] Munro (1991), 122.
[32] Below, Section 3.01 and Figure 3.1.

outflow of silver and gold. The one-sidedness of this trade was affordable while output from Europe's silver mines was buoyant but not once, from the 1330s, it was falling.[33]

Meanwhile, Italy's trans-Alpine trade with northern Europe suffered a serious setback due to political interference by the French Crown in operation of the hitherto neutral Champagne fairs, at that time the northern hub of European commerce. Following overt discrimination by Philip IV (r. 1285–1314) against both the Italian and Flemish merchants, the volume of trade handled by the fairs started to wither.[34] The Genoese responded by developing their recently established direct maritime link with Bruges via the Straits of Gibraltar, using convoys of heavily armed galleys to counter the threat posed by corsairs and Barbary pirates. This, however, had the effect of raising freight rates by at least a fifth.[35] Brigandage, banditry and predatory lords were similarly posing a mounting threat to merchants plying the old overland routes, rendering trade both riskier and costlier. Rising transaction costs proved especially detrimental to the bulk trade in low-value commodities with narrow profit margins, obliging manufacturers and merchants to switch to high-value products better able to bear these costs.[36] This explains the substitution by Flemish producers of fine woollens for cheap light *says*.[37] With problems mounting in both its North Sea and Mediterranean orbits of exchange, it is hardly surprising that from the 1290s Europe found itself in the grip of a worsening commercial recession from which there was little immediate prospect of relief.[38]

As expansion of the manufacturing and service sectors stalled, the agricultural sector was left to bear the brunt of any further increases in population. The upshot was mounting rural congestion as manifest in the extreme morcellation of holdings, rent seeking via the subdivision and subletting of land, and the piecemeal reclamation and colonization of much environmentally marginal land.[39] The more that this progressed the more that poor rural households multiplied and the greater the exodus of landless migrants to the towns, where they added to the spiralling problem of urban poverty.[40] Recurrent harvest shortfalls exacerbated these trends by sparking the surges of distress land sales that drove the relentless reduction in holding sizes.[41] By the opening of the fourteenth century two out of five English households could afford little more than a bare-bones standard of subsistence.[42] With so little to live on, such

[33] Below, Section 3.01. [34] Edwards and Ogilvie (2012); below, Figure 3.1.
[35] Munro (1991), 124–30. [36] Munro (1991), 111–14, 133–8.
[37] Below, Section 3.01.2; Munro (1991). [38] Below, Section 3.01.
[39] Below, Section 3.01.3d. [40] Below, Sections 3.01.3b and 3.01.3d.
[41] Below, Figures 3.16 and 3.18. [42] Below, Table 3.2 and Figure 3.10.

economically marginalized households were cruelly exposed to the recessions of trade and failures of harvest that began to recur with increasing frequency and severity as the international recession bit deeper, extremes of weather and panzootics of livestock became more frequent and wars were waged for ever higher stakes. The buoyancy of the preceding era of efflorescence had given way to a precarious balance.

1.01.2 1340s–1370s: from one socio-ecological regime to another

During the 1340s the series of environmental and human crises that had been looming finally materialized: global climate reorganization accelerated and entered a highly unstable phase, warfare escalated and drove international commerce and economic output deeper into recession, and plague reached the shores of the Black Sea and within seven years had spread throughout the European trading system. This trio of crises cohered into a perfect storm, each component of which compounded and amplified the actions of the others. It was the magnitude and comprehensiveness of this composite event, and the fallout from it, that precipitated the abrupt shift from one socio-ecological regime to another. The years from the 1340s to the 1370s thus constitute the pivotal episode within the Great Transition.

The destabilization of climatic conditions was evident almost everywhere as the circulation patterns formerly sustained by high levels of solar irradiance were undermined by the cumulative effect of six decades of significantly diminished irradiance. Global cooling reduced northern hemisphere temperatures to their lowest level in over eight centuries (Figure 1.1A), with significant consequences for ocean–atmosphere interactions, pressure gradients, circulation patterns, wind force and direction and, of course, growing conditions. The negative impact upon temperate tree growth is evident in a marked narrowing of ring widths between 1342 and 1354, which was at its most pronounced in 1348.[43] For this ring pattern to show up so clearly in so many independent dendrochronologies and in both hemispheres implies powerful climate forcing at a global scale. Long-established circulation patterns were thrown into disarray, delivering weather that swung from one extreme to another (Figures 1.1B and 1.1C), as the altered climate regime that would characterize the Little Ice Age (LIA) began to make itself felt.[44]

[43] Below, Figure 4.2B.

[44] Grove (2004); Wang and others (2005); Sinha and others (2011). Although sceptics continue to doubt whether a LIA with discernibly colder temperatures ever existed, this misses the essential point that what differentiated this climatic era from the preceding Medieval Climate Anomaly was less average annual temperatures than patterns of