
EUROPEAN EXPANSION AND LAND COVER TRANSFORMATION

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The expansion of Europe overseas 500 years ago was the prelude to what was probably the greatest change in the natural land cover of the world since the Ice Age. Events were put in train that had far-reaching consequences on the distribution of peoples, plants, animals, and diseases, all of which had knock-on effects on soils, hydrology and other biogeographical phenomena.

The story, however, is not only one of changing distributions but also one of changing technologies and changing magnitudes of scale. Humans could now intervene and alter nature on an unprecedented scale, increase the production of all commodities to unparalleled levels, and move commodities in unheard-of quantities, all to cater for accelerating human needs. There is a tendency to see territorial expansion and control, technology, and the conditions of material life, as separate, independent topics. But nothing could be further from the truth. Each was intertwined with the other to produce an ever-upwardly ascending spiral of increased production and consumption, economic change and biome modification, leading to the permanent transformation of the land use of most parts of the globe.

The 500 years from about 1500 to the present is a vast and varied canvas to look at, and it is best divided into three equal periods, 1500–1649, 1650–1799, and 1800–1950. Such a periodization emphasizes the emergence of the European core of intensive (usually urban-oriented) land use, and the creation of successive waves or frontiers of exploitation in the periphery where the land and its stored energy were extracted for the benefit of the core. Such a core/ periphery conceptualization makes it clear that the exploits of the seaborne, capitalist, Western European economies of first northern Italy and then Spain and Portugal during the sixteenth century, followed by Britain, the Low Countries, and to a lesser extent France, in succeeding centuries, united the world ecumene and brought people and places into contact with each other, so laying the foundations of biome modification (Braudel 1984). But it was the new technology of the

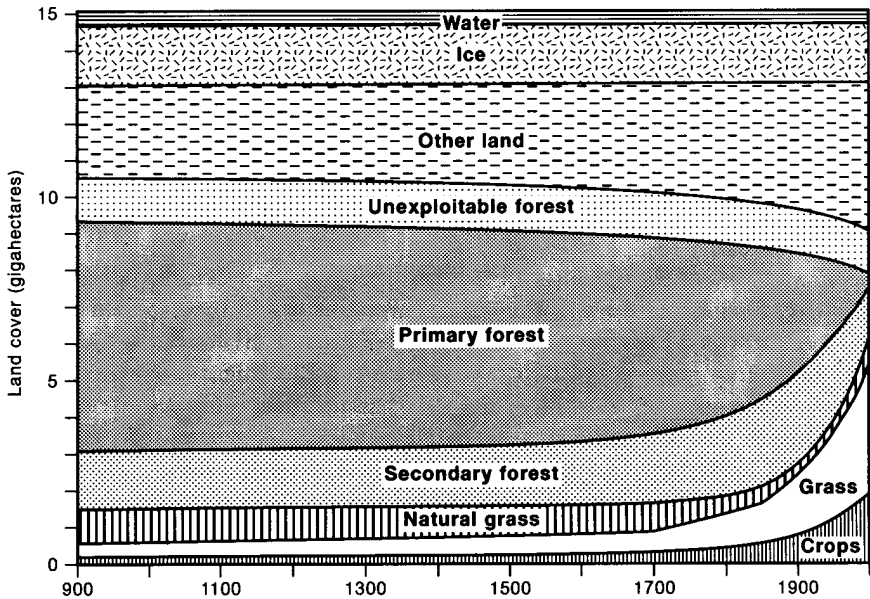


Figure 9.1 Transformation of land, 900–1977. Small differences cannot be depicted at this scale. The most important transformation took place during the last two hundred years. After Buringh and Dudal, 1987.

industrial mid-nineteenth century that facilitated and ‘deepened these contacts into a constant flow of goods, people and ideas’ (Headrick 1981:176). From then on, isolated subsistence societies with limited trade relationships became part of a single world market in basic commodities that drew on natural resources, such as top soil, wood, water, minerals and wild game from throughout the world. Mechanical energy (particularly steam), medicine, and the agricultural modification of land shattered traditional relationships, and laid the foundations for a transformation of the land cover of the world (Figure 9.1).

1500–1650: BREAKING THE BOUNDS

Why Europe?

Before 1500 civilization had been essentially land-centred and contacts by sea were relatively unimportant. Therefore the continents were isolated one from another, except for a few overland trading routes which linked Europe with India and Africa. But the exploits of Columbus and others after 1492 established sea contacts between continents, and started a process of cultural and economic

expansion and domination by Europe (Figure 9.2). Before these voyages Europe was a peripheral appendage of the civilized world, which consisted of the landbased empires of Ming China, Ottoman Middle East and North Africa, Safavid Persia and Mogul northern India. After about 1500 Europe gradually moved to being at the centre of world innovation, trade and change. With this shift in focus the relative peace and harmonious relationship between the inhabitants and their environment in the peripheral parts of the world was shattered as Europe extracted the unused and stored-up potential of land and its vegetation for its own use.

The success of Europe after 1492 was staggering. To a detached observer of the early fifteenth century, Europe and Europeans would have seemed to have had no qualities inherently superior to those of Eastern civilizations. They were not necessarily more progressive, venturesome, achievement-oriented or more modern than societies elsewhere, and they had no advanced maritime technology. Much that was innovative in medieval society (e.g. compass, astrolabe, chainmail, crossbow, gunpowder, methods of rigging, paper making and printing, to say nothing of mathematics and trigonometry) had first been received by Islam from

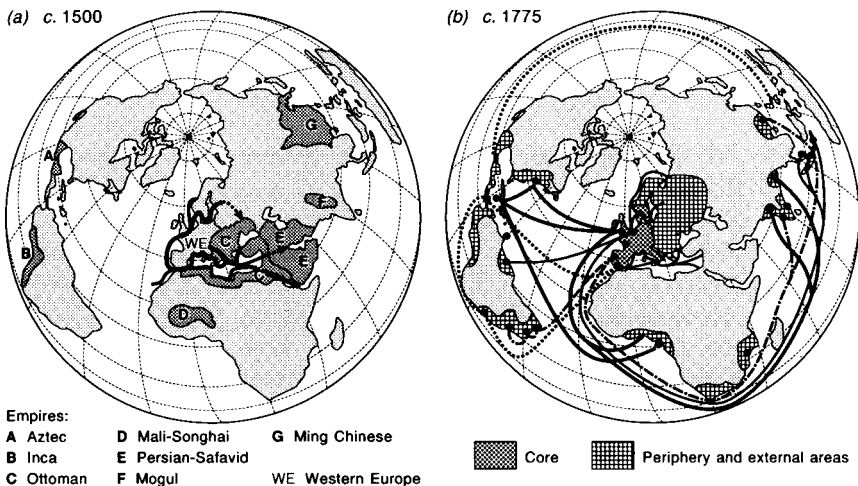


Figure 9.2 European world economies, (a) c. 1500. Western Europe was only one of a number of land-based empires, and extra-continental trade was restricted to its coastal areas and overland routes. After Braudel (1984) and Barraclough (1978). (b) c. 1775. By the mid-eighteenth century the core of Western Europe was firmly established, and the spectacular extension of ocean trading meant that large areas of the world constituted its periphery or external areas which were economically (and often, politically) tributary to it. After Braudel (1984) and Barraclough (1978).

China and had been brought back from the Levant during the Crusades (Jones 1987).

Also, long distance oceanic voyages were being undertaken by mercantilemaritime communities everywhere, from Africa to South-East Asia, from India to East Africa. But critically, Spanish and Portuguese sailors were already exploring the currents and winds down the coast of Africa and out to the Atlantic islands of the Canaries, Azores and Madeira. They were aided in their enormous leap across the Atlantic by advantages of accessibility and constant and reliable wind patterns, all of which compare very favourably with the unreliable winds elsewhere in the world. The Trade Winds *do* blow from the Canaries to the Caribbean and the return voyage *could* be made northward via the westerlies. Simply, environmental conditions aided long sea voyages from Europe (or hindered them from elsewhere). By the late fifteenth century it was Europe that leaped ahead, breaking out of the bounds of its land-based civilization and turning the continents inside out (Whittlesey 1944) by, in effect, reorienting them to face the sea. More important than the voyages, however, was the penchant of Europeans to rationalize encounters with new lands and 'to develop the resources they brought within their reach'; that really changed the existing world (Jones 1987:80). Portents of what was to come were already in place in the fourteenth century with the vigorous and aggressive politico-commercial networks of Genoa and Venice which had reached at least a thousand miles across the Aegean to outposts in the Levant and the Black Sea, and they 'connected with all the great trade routes of western Asia' (Meinig 1969:211).

Ecological imperialism: disease

Because of the assured contact that the currents gave, the supply of Old World biological forces of humans, plants, animals, and, above all, diseases, was constant and unrelenting, all of which reinforced the settlement process. Europeans carried with them many pathogens to which the native population had no immunity. The long isolation of the New World continents excluded exposure to a whole range of Old World epidemic diseases, many of which had evolved with domesticated animals (Crosby 1986; McNeill, 1976). With these Old World pathogens the Indians met their 'most hideous enemy' (Crosby 1986:198). Each new European contact brought a new wave of diseases, first influenza, smallpox, measles, mumps and pneumonic plague, followed later by diphtheria, trachoma, whooping cough, chicken pox, malaria, typhoid fever, cholera, yellow fever, and scarlet fever (Chapter 8).

The evidence is fragmentary but it is abundant, and it parallels the well-documented experience of susceptibility of isolated peoples in more recent times, from the Inuit of Northern Canada, to the Aborigines of Australia and to many tribes in the depths of tropical rain forests. In the Americas each new pandemic not only displaced or eliminated hundreds of cultural groups, but the cumulative

effect was a demographic collapse. Dene van (1992a, 1992b) estimates conservatively that the population for the hemisphere was 53.9 million in 1492, but only 5.6 million in 1650, an 89 per cent drop, and that in North America it fell from 3.8 million in 1492 to 1 million in 1800, a 74 per cent drop. Others would put the original population total for the hemisphere much higher at 100–13 million, which would merely make the decline even more dramatic (e.g. Dobyns 1966; Lovell 1992).

Whatever the exact numbers the fact remains that depopulation did happen on a catastrophic level. Metal weapons—to say nothing of gunpowder and horses (the Amerinds had none of these)—though decisive in campaigns, were nothing compared to the biological advantages possessed by Columbus and those who followed him. ‘It was their germs, not the imperialists themselves, for all their brutality and callousness, that were chiefly responsible for sweeping aside the indigenes and opening the Neo-Europes to demographic takeover’ (Crosby 1986:196). One could say, fancifully, that they triumphed through breath alone. It was an ecological imperialism far more effective and far more terrible than an imperialism of arms.

Ecological imperialism: plants and animals

The loss of up to 90 per cent of the population led to the widespread abandonment of agricultural land, and it is possible that in places the forest actually expanded in extent and density. Much land use was dominated by shifting agriculture and it usually supported only moderate population densities, but at certain times and places it had been capable of producing vast food surpluses. In this way the cities of the Mayan civilization (C. AD 250 to 1000) had been supported, replete with their sophisticated water and waste management systems, and a monumental architecture that ranked with the greatest in the world at the time (Doolittle 1992; Turner and Whitmore 1992).

Thus, the availability of the cleared fields and their crops of abundant and nutritious plants—such as squash, tomatoes, potatoes, and maize—was a major factor in the ability of the newcomers to gain a successful toe-hold on the continent. They thought it was a God-given reward for their endeavour. Little wonder a settler in tidewater Virginia could say many years later:

The objection that the country is overgrown by woods, and consequently not in many years to be penetrable for the plough, carried a great feebleness with it for there is an immense quantity of Indian fields cleared ready to hand by the natives, which, till we are grown over-populous, may be every way abundantly sufficient.

(Quoted in Maxwell 1910:81)

While nutritious food crops were utilized other flora and fauna disappeared and were replaced by opportunistic and aggressive Old World varieties. From the St Lawrence to the Rio de la Plata, ferns, thistles, nettles, artichokes and plantain (weeds we would call them), as well as the more common grasses and

clovers such as Blue Grass and white clover, found eco-niches on the bared and eroded ground of abandoned Amerind fields or new European clearings. Plants moved with feral stock in advance of people. The story of the famed Kentucky Blue Grass country is instructive in this respect. *Poa pratensis* is not a native American grass yet when the English pioneers topped the Appalachians at the end of the eighteenth century they found vast areas of Blue Grass and English white clover awaiting them and their herds. The grasses must have entered with the French in the seventeenth, or early eighteenth, century and have been spread northwards by wild stock. In other places in the Caribbean, soils were changed as the humus layer was leached or destroyed, with detrimental long-term effects.

The ecological advantage of the Europeans over the indigenes, however, was not so much a matter of crop plants as of domesticated animals. Their multiplication was prolific as they ran wild in a world without natural predators and competitors. In particular, pigs flourished in forested environments; they are omnivorous and healthy sows can have litters of ten or more piglets. The eight pigs brought by Columbus to Hispaniola in 1492 multiplied prodigiously in the wild. Within ten years leave was given to hunt them as they were damaging crops and over-running the Island. They spread to mainland Mexico during the late 1490s and were soon said by the Spanish to be '*infinitos*'.

Cattle were said to have multiplied tenfold in three or four years. Horses adapted more slowly, as did sheep. Slower they may have been, but the rate of increase was unimpeded. These feral goats, sheep, horses, pigs, mules, and cattle were the forerunners and forebears of the millions that were to populate the land from the Prairies in the north to the Pampas in the south. Felix Azara, an unusually keen observer of natural phenomena, noted in 1700 that the numbers of cattle in the Pampas had reached 48 million, an exaggeration, perhaps, but even if he got it only half or even quarter right it was still a staggering number (Crosby 1986).

All stock had a devastating effect on the land because they put a premium on pastures and hence on the creation of wholly cleared land which had not been a part of the native economy. They also trampled and over-grazed land, causing erosion and, incidentally, aiding the spread of Old World crops and weeds.

Rats, bees, mice and rabbits; the story was the same. Old World stock seemed to do well, if not better, in their New World situations than in their homeland, and the Europeans benefited with better nutrition.

'The Great Frontier'

The social energy and surging economies of the countries of the core of Western Europe were breaking out of national confines and beginning to devour resources from the wider world. In so doing they tightened their grip on local and regional economies. In the words of Walter Prescott Webb (1952) the whole process was

part of the 'Great Frontier' of European outward expansion that gave it unprecedented windfalls of land, minerals, fish, timber, furs, and crops.

Jones (1987) suggests that there were four main ecological zones of biological exploitation on the periphery of the core (to which must be added the inorganic minerals and precious metals of Latin America). All were becoming evident, though not all were fully developed, from the mid-sixteenth century onwards. Some, as of old, were on Europe's edge, most were overseas. They were:

- 1 The fisheries on the Grand Banks and Atlantic generally, particularly for cod and whales, which provided protein and essential oil for lamps.
- 2 The boreal forests of Russia and Scandinavia provided furs, and the essential timber, tar and turpentine for merchant ships. Around the Baltic fringes, especially the southern fringes, surpluses of grains were exported to Western Europe, which trade might have been as important in sustaining the Low Countries and Britain during the late sixteenth and early seventeenth centuries as bullion had been for Spain and Portugal at an earlier period (Wallerstein 1974).
- 3 In time the newly acquired tropical and sub-tropical regions provided a range of new industrial and food crops, such as tea, sugar, tobacco, cotton, indigo and rice, which varied diet, influenced consumption patterns and stimulated trade.
- 4 By the nineteenth century the forests and grasslands of the newly settled neo-European lands of North America, South America, Australia, and southern Africa and the steppes of southern Russia provided timber, grain and livestock.

As this unmatched flow of abundant and cheap resources gathered momentum 'the expansive process of land transformation in the modern world began' (Richards 1990a: 167). Space does not permit the examination of all these resource frontiers, so only those in the extra-European world are looked at.

The Caribbean and Brazilian peripheries

Whatever the primary motive of the colonizers, all wanted to achieve an economy with an assured domestic food base and some sort of export staple. Thus, sugarcane was introduced from the Canary Islands to Hispaniola (Dominican Republic) by 1498. Fourteen years later, bananas, again from the Canaries, were introduced. In between those two dates many other Old World (specifically Spanish) crops and vegetables were imported, including wheat, barley, rice, onions, radishes, melons, grapevines, cabbage, lettuce, cauliflower, carrots, garlic, pomegranates and aubergines. Yams came from Africa with the slaves, as did castor and pigeon peas. They all flourished wonderfully.

Although not very extensive the islands of the Caribbean experienced intense change in a remarkably short period of time. They were a microcosm and

example of how the new, alien, commercial objectives of the Europeans, serving a world-wide market, let loose a whole host of ecological and biogeographical changes.

By 1642 there were about 80,000 European settlers in the Caribbean (mainly in Barbados and St Kitts) which compared to only about 49,000 in New England and Maryland at this time. Many of the settlers were sponsored by trading companies that were attempting to settle the land and stimulate trade. The record of the impact on the forests is particularly clear in Barbados where after 1625 the aim was to plant sugar as a commercial crop. Initially, small patches of forest were selected and removed by either clear-cutting or ring-barking followed by the burning of the dried-out debris and trees towards the end of the dry season. Soon, more systematic clearing resulted in vast swathes being cleared. By 1647 about one-fifth of the rain forest and the secondary scrub along the coasts had been cleared and extensive sugar plantations established. Later, the large infusion of capital and the importation of black slaves from Africa ensured profitability of the plantations, and they expanded rapidly, consuming the bulk of the remainder of the forests. By 1665 the once forest-covered landscape of Barbados was almost totally open except for forest on the highest peaks, and dominated by large sugar estates.

By 1672 the same devastation and transformation had happened in the neighbouring islands of St Kitts, Nevis, and Montserrat. By 1690 the same was true of Martinique and Guadeloupe, and Jamaica was not far behind. Throughout the Caribbean the severity of clearing was highlighted by the scarcity and high price of timber for construction and fuel wood, particularly for refining the sugar, so that by 1671 it was reported from Barbados that 'all the trees are destroyed' and that coal had to be imported from England (Watts 1987).

In contrast to the relatively small area of forests in the Caribbean islands those of Brazil were amongst the most extensive in the world. In addition to the wellknown Amazonian rain forest there was once a vast (approximately 78,000,000 ha) and very similar sub-tropical rain forest that stretched along the Atlantic coast from Recife (Pernambuco) in the north to Rio de Janeiro in the south, and it covered most of the eastern portions of the states of Bahia, Minas Gerais and São Paulo.

In pre-Columbian and early European times shifting, slash-and-burn cultivation was practised, and crops of manioc, maize, squash, beans, peppers and peanuts grown. When European contact intensified after 1600 the Amerind population was gradually replaced by a mixed mestizo population, but the concomitant introduction of iron axes and machetes, and the herding of pigs intensified the shifting regime. Whereas the Amerinds might have cut and burned about one hectare per family per annum, the Europeanized mestizo was capable of destroying three hectares or more with his tools of greater efficiency. The forest did not regenerate under such widespread cutting and burning, and the open ground left as a result of periodic shifting was colonized by exotic grasses, ferns and weeds (Dean 1983).

This more extensive and thorough clearing was the first step in the establishment of export-oriented plantation crops. Sugar, for example, had been introduced from Madeira in about 1560 and cultivation concentrated in a narrow strip from a little north of Pernambuco to just south of Bahia, with a minor concentration around Rio de Janeiro. Primary forest was always favoured for sugar growing, and the clearing and harvesting was done by slaves. Demands on the forest were not confined to clearing the land for cultivation alone as extreme heat was required to crystallize the juice. Thus, vast areas were cut for wood fuel. By the mid-eighteenth century the remaining forest on the coast was under immense pressure.

Wealth in nature

One could go on piling up example after example of biological change but it would be pointless. What is important, perhaps, is to recognize that the emergent commercial/social system of Europe, often typified as incipient capitalism, saw wealth in nature. It was the major purposeful driving force in the ecological transformation. Nature could be commodified and ecological changes were translated into economic advantages. The land cover of the world would never be the same again.

1650–1800: CONTINUITY AND CONSOLIDATION

Cores and peripheries

Ever since the breakdown of feudalism in the late fourteenth century, Europe had been moving towards a more entrepreneurial and capitalist system. But the transition was not clear-cut. Historians have debated long and fiercely about the onset of modernity. Was it 1510, 1600, 1650, 1750 or some other date? What we do know, however, is that a qualitatively different social system, and systems of production and distribution, emerged during the late sixteenth century when compared to anything which had existed in medieval times. Also, the role of state structures strengthened considerably (Tilley 1990). Thus, we see the emergence of truly capitalist states from about 1650, first in the Low Countries and then Britain, and the rise of Amsterdam and London as international trading and financial centres (Wallerstein 1980). Continuity with consolidation was the theme of the age.

Geographically, the boundaries of the world created by the voyages of discovery did not change significantly until after 1750. The world-system remained much the same, but the dominant role of Europe was consolidated. Specifically, the countries in the core (Britain, the Low Countries, northern France) strengthened their position while others declined. Spain and Portugal waned as did Sweden and, to a lesser extent, northern Italy, but Brandenburg-Prussia rose in importance. Uneven development was as much a feature of

seventeenth-century Europe as of the modern world. Outside Europe the New England and Middle Atlantic colonies, and the Caribbean, were drawn into the core via the triangular trade in slaves, molasses, and manufactured goods. Beyond lay the new peripheries of exploitation noted already, and beyond them again lay the external areas of Asia, Africa and parts of Latin America that were tributary to the core.

Driving forces

Implicit in the above discussion is the idea that there were a number of forces that drove change—a shift in the economic system and means of production, a strengthening of state structures and control. But in addition there were a number of other factors that interacted with each other in an upwardly ascending spiral of consumption and production.

First, Europeans had the means to ship and organize this trade. It is estimated that in 1650 there were about 20,000 ships in the world carrying trade of which the Dutch—‘the carriers of the world’—owned over two-thirds. By the end of this period the British had usurped Dutch hegemony. The timber and naval stores supplies from the Baltic ‘frontier’ (later superseded by North America) were essential for this vast construction.

Second, just as the development of fast-moving and reliable sailing ships in large numbers was essential to the establishment of this new global trade so was the development of a financial infrastructure. Increasingly, barter as a means of exchange gave way to a money economy (boosted by the shipments of gold and silver bullion from Latin America after 1550) and the development of credit. Credit was important in this new system of global interchange. Goods took months, if not years to collect, dispatch and sell, and this was done only through the development of bills of exchange, notes of credit, and other promissory instruments and the refinement of banking. The founding of the Bank of Amsterdam (Wisselbank) in 1609, the Bank of Rotterdam in 1635, the Royal Exchange in 1576, and the Bank of England in 1694 were all institutional landmarks in the organization of money and credit (Kindleberger 1984).

Symptomatic of the new organization needed was the rise of the trading or joint-stock company, in which people ventured capital in hazardous overseas enterprises in return for monopolies guaranteed by royal charter. Such were the British East India Company (1600), the Dutch East India Company (1602), the Dutch West India Company (1621), and there were many minor ones. The companies were the powerful and well-organized spearheads of exploitation and the precursors of colonial land empires. They spread the risks and concentrated settlement, and combined the various tasks of conquest, settlement, investment and defence all in one.

Third, global population numbers certainly rose during this period, probably from about 425 million in 1500 to 679 million in 1700, which must have stimulated consumption. But rising numbers were of less significance than the rise

in the purchasing power of the rapidly expanding European population. During the later sixteenth century there was a shift from the medieval preoccupation with a land-based trade in small quantities of high-value luxury goods, such as spices, perfumes, porcelain, dyestuffs, and silk clothes and rugs from Asia and Africa, to a seaborne mass trade of far bulkier commodities from the Americas, for an increasingly affluent and growing home population.

Wallerstein typifies this shift as a move from 'preciosities' from the largely socially unaffected 'external area' of contact in Africa and most of Asia, in contrast to the trade in lower-ranking goods from the 'periphery' of the Americas, and the East Indies, which trade had led to massive social change, division of labour, *and* land, use in those areas (Wallerstein 1974:301–2).

Many of these 'lower-ranking' goods were tropical products such as tea, coffee, chocolate, sugar, potatoes and cotton that related to needs of food and clothing, though some were more optional like tobacco. For example, the stimulants and tonics of tea, coffee and chocolate were introduced into Britain during the 1650s and the Low Countries a few decades earlier. Braudel (1973) attempted to trace the origin and diffusion of these commodities of material life. What is clear is that, initially, in Europe these goods were regarded as exotic products or luxuries that only the wealthy could afford. But from the mid-seventeenth century onwards, rising affluence for many, better transport, and a cheapening of production meant that they became the staples or necessities of a large part of the population. When that transition got under way the impact on the biomes of the world really began. The impact became greater and more purposeful with the settlement in the temperate lands of North America, Argentina and southern Brazil in later years.

Land cover change

The history of vegetation change is very largely the history of the expansion of arable land and the large-scale conversion of natural into managed ecosystems. Data on this expansion are confused and blurred, and the best we have is Table 9.1, which is a modelled estimate of overall changes, 1700 and 1850, with population numbers for the same years. It would be fascinating to know what had happened to land use between 1600 and 1750. Table 9.1 does suggest a significant change during the eighteenth century, especially in the core, and Figure 9.1 puts the shift into a temporal perspective. Between 1700 and 1850 world forests had declined by 250 million ha (–4 per cent), pastures by 23 million ha (–0.3 per cent), and world cropland had risen by 272 million ha (+102.6 per cent). In some cases, pastures increased as forests were cleared. The rise in cropland is important as it is the most easily traceable change. Predictably, the greatest proportionate increases were in Europe, USSR, and North America, but also occurred in China and Latin America.

EUROPEAN EXPANSION

Table 9.1 Possible increase in population and cropland, 1700–1850, and change in cropland, forests and woodland, grassland and pasture, 1700–1850 (land use and land use change in millions ha)

	<i>Population (millions)</i>		<i>Cropland (million ha)</i>		<i>Cropland change</i>	<i>Forests and woodland change</i>	<i>Grassland and pasture change</i>
	1700	1850	1700	1850	1700–1850	1700–1850	1700–1850
<i>Core</i>							
Europe	92	208	67	132	+65	–25	–40
USSR	30	79	33	94	+61	–71	+10
N. America	2	25	3	50	+47	–45	–1
Total	124	312	103	276	+173	–141	–31
<i>Periphery and external areas</i>							
Africa	107	111	64	84	20	–26	+5
Asia	} 435	371	57	78	21	–19	–2
China		430	29	75	46	–39	–7
Latin America	10	34	7	18	11	–25	+13
Oceania	3	2	5	6	1	–	–1
Total	555	948	162	261	99	–109	+8
World total	679	1,260	265	537	272	–250	–23

Sources: Richards (1990); Demeny (1990).

The neo-European world

In the neo-European world the virtues of agriculture, freehold tenure, dispersed settlement, ‘improvement’ and personal and political freedom were extolled, which all led to a rapid and successful expansion of settlement. The United States was the classic example of land transformation through forest clearing. Before 1850 approximately 46 million ha were felled (Williams 1989a), the overwhelming bulk of it to create farmland. Such clearing was a combination of ‘sweat, skill and strength’ (Ellis 1946:73), and the pioneer farmer was seen as the heroic subduer of a sullen and unyielding wilderness that needed to be tamed. It was a universal and integral part of rural life. ‘Such are the means’, marvelled the French traveller, the Marquis de Chastellux in 1789,

by which North-America, which one hundred years ago was nothing but a vast forest, is peopled with three million of inhabitants... Four years ago, one might have travelled ten miles in the woods I traversed, without seeing a single habitation.

(Chastellux 1789, Vol. I: 47)

But it was not only the United States where European pioneers were hacking out a life for themselves and their families in the forest. There were other parts of the world, such as Canada, New Zealand, South Africa and Australia where the same

was beginning to happen. The initial probes into the forest lands were destined to accelerate and expand rapidly during the ensuing nineteenth century.

Europe

However, in focusing on the overseas expansion of Europe one should not forget that the continent was also colonized internally during these centuries (Darby 1956), particularly eastwards into the mixed forest zone of central European Russia. The increase in the amount of land cultivated was phenomenal and rose from an estimated total of *c.* 100 million ha in 1700 to a known total of 231.9 million ha by 1860 (Table 9.2).

Much of this was a response to expanding population numbers which more than doubled during the same period. But it is likely that as much was due to the vast expansion of world trade that had occurred in the first three-quarters of the seventeenth century well before the Industrial Revolution got under way. Europe's trading connections with America and Asia were making an important contribution to its prosperity as they offered large markets for her manufactures in exchange for the exotic foods and raw materials that Europe itself could not produce. In addition, capital was invested in land improvement, particularly in the Low Countries and England, so that there was land-use intensification as well as the extension of land use. The 'frontier' was being actively colonized by

Table 9.2 Area converted to regular cropping, 1880, 1920, 1978 (million ha)

	1860	<i>Area cropped</i> 1920	1978	1860–1919	<i>Net change</i> 1920–1978	1860–1978
<i>Core</i>						
Europe	120.0	140.6	141.7	20.6	1.1	21.7
USSR	81.0	169.0	231.9	88.0	62.9	150.0
Canada/USA	76.0	237.2	235.7	161.2	–1.5	159.7
Total	277.0	546.8	609.3	269.8	62.5	331.4
<i>Periphery</i>						
Africa	63.0	79.9	164.4	16.9	89.5	106.4
Asia	211.0	302.5	445.4	91.5	142.9	234.4
Latin America	17.0	57.1	140.5	40.1	83.4	123.5
Oceania	4.0	19.1	59.1	15.1	40.0	55.1
Total	295.0	458.6	809.4	162.4	356.8	519.4
World total	572.0	1,005.4	1,418.7	433.4	418.3	850.8

Source: Richards (1986).

agriculturalists, and over 6.7 million ha of mixed forest in central European Russia was eliminated between the end of the seventeenth century and the beginning of the twentieth (French 1983).

China

These land frontiers in Europe and the neo-European lands were paralleled by the vast inland frontier of China, which was a world unto itself. The Ching Dynasty (1644–1911) was a highly centralized, bureaucratic and expansionist regime. None the less, at the local level a fairly liberal and flexible market system encouraged a merchant class, credit, and thriving market towns. The feudal system of landholding and tenure gave way to a greater commercialization, and the country undoubtedly profited from the exports of the new-found European delight—tea—which was said to be more valuable in trade than gold.

Richards (1990a: 171) calculates that the cultivated area rose ‘from 33 (+/–7) million ha in 1600 under the Ming to 63 (+/–7) million ha in 1766, or nearly double... Over the next century, cultivated area grew more slowly, to 81 (+/–3) million ha in 1873.’

Much of this new cultivation was in the northern forests and grasslands, but it must have happened in all parts of the Chinese realm, as is shown in Perdue’s (1987) detailed study of mainly seventeenth-century forest clearance and land reclamation in the south-central province of Hunan.

The tropical and sub-tropical world

Elsewhere, and particularly in the sub-tropical and tropical forests, European systems of exploitation led to the harvesting of indigenous tree crops (particularly hardwoods for domestic and naval construction), but also to the replacement of the original forest by the mono-culture of crops grown for maximum returns in relation to the labour and capital inputs. The ‘plantation’ system was now perfected, worked either by indentured labour but mostly by slaves, one of the new ‘commodities’ traded around the world. Classic examples of this were the highly profitable crops of sugar in the West Indies (Watts 1987); coffee (‘green gold’), and sugar in the sub-tropical coastal forests of Brazil (Monbeig 1952; Dean 1983); cotton and tobacco in the southern United States, and spices in the East Indies.

A variation of this agricultural clearing occurred in southern Asia where peasant proprietors were drawn into the global commercial market. Throughout the Indian sub-continent there was a complex and varied expansion of all types of crops, often for cash, that led to massive forest clearing (e.g. Richards and McAlpin 1983).

In emphasizing the direct and indirect European impacts on these traditional societies one should not forget that the latter were also hierarchical, exploiting their forests vigorously in a manner no more egalitarian or caring than Europe.

There is plenty of evidence from individual studies of, for example, south-west India (Nadkarni *et al.* 1989) and Hunan province in China (Perdue 1987) from the sixteenth century onwards to show that the commercialization of the forest was not a European invention. In pre-British south-west India permanent agricultural settlement existed side by side with shifting cultivation, and village councils regulated how much forest exploitation could be undertaken by agriculturalists. The forest was not regarded as a community resource; larger land owners dominated forest use in their local areas. Scarce commodities such as sandalwood, ebony, cinnamon, and pepper were under state and/or royal monopolies. In Hunan, a highly centralized administration encouraged land clearance in order to enhance local state revenues so as to increase the tax base and support a bigger bureaucracy and militia.

Simply, natural ecosystems everywhere were being exploited and were diminishing in size as a response to the expansion of cultivation which was related to increasing population numbers and the increasing complexity of societies. The changes were just slower than those unleashed by the Europeans with their new aims and technologies, and, most importantly, their consuming market and intercontinental trade links.

1800-c. 1950: GLOBAL CONTROL

Land control

The nineteenth century witnessed an unprecedented escalation of change in the world's vegetation as European industrial technology interacted with European imperial (territorial) ambitions. At the opening of the period, Europe occupied or controlled approximately 35 per cent of the world's land surface; by 1878 that proportion had risen to 67 per cent; and on the eve of the First World War it was 84 per cent—more than four-fifths of the globe. Nowhere was too small, too remote, or too barren not to be incorporated in the new nationalistic empires (Meinig 1969). Concomitant with territorial control went the vigorous, expansive spread of European industrial technology, with its 'omnivorous demands for materials, its need for expanding markets and its development of even more efficient tools for overcoming distance and conquering peoples' (Meinig 1969:231). Successive inventions and discoveries made the conquest of the new territories cheaper in cost, cheaper in lives, and more effective than ever before.

The global territorial control was broadly of two kinds. First there was the continued settlement and exploitation of the neo-European temperate lands of the United States, Canada, New Zealand, Australia, southern Africa and southern Latin America. For all intents and purposes these were 'plantations' in the older sense, simplified social and political offshoots of the European mother countries that were quickly incorporated into the periphery. Some, like the United States, were independent by this time, to be sure, but most of the others were not. But independent or not, they resembled each other in that they were

vigorous neo-European 'settler empires' that took on a life of their own. They experimented with, and exploited their resources, particularly the land, its soil and vegetation.

But the significant diffusion of the nineteenth century compared to previous centuries was the concentration on the tropical world, particularly Africa and Asia. These were the 'external areas' of intermittent contact, into which forays had been made to create coastal way stations and trading points in the past. These contacts had been shallow in depth, temporary in duration and rarely the basis of settlement and control. They contrasted to the 'periphery' of the Americas and Caribbean (Wallerstein 1974) which had been a theatre of colonization and settlement, as well as exploitation. Now Europe attempted to create colonies in Asia and Africa that were politically submissive and economically profitable to them in crops, minerals and other raw materials.

'The tools of empire'

It would be impossible to mention all the 'tools of empire' that evolved during the nineteenth century; there was a dazzling array of interacting inventions and discoveries. Some used natural resources, some integrated economic systems, and some allowed a greater manipulation and control of lands. However, some were especially significant in the creation of the 'new' imperialism in the new, tropical areas of colonization in Africa and Asia (Headrick 1981, 1986).

Disease, which had so favoured Europe in its expansion in the New World and the Antipodes, was now an obstacle to penetration. The mortality of European settlers, missionaries, and traders was in the order of 250–750/1,000, particularly in Africa. In addition, the sheer number of people in these territories made political control difficult. But solutions were at hand. Mortality dropped dramatically to 50–100/1,000 between 1820 and 1840 with the discovery and widespread prophylactic use of quinine to counteract malaria. Rates of European mortality were still ten times higher than for similar groups in Europe, but Africa was no longer 'the white man's grave' (Headrick 1981).

Now that access was possible the penetration of the interior was facilitated in succeeding decades by the development of steamboats (often gunboats) on the navigable rivers and sheltered coastal waters of Africa and South-East Asia, China, the Persian Gulf, and India, often transported to these locations in pieces and then reassembled *in situ*. Gunboats came into their own with devastating effect in the First Opium War in China where they demonstrated their effectiveness in prompting 'political persuasion' (Headrick 1981:54). Another key technology establishing early superiority was the development of the breachloading gun during the 1860s, and eventually of the machine gun in the 1880s; the 'arms gap' between colonizer and colonized was awesome.

But the 'political persuaders' of gunboats and machine guns counted for nothing if the conquered territory was not connected effectively to the metropole. And that was what distinguished the 'new' imperialism (whether in

the settler or nationalistic empires) from the old imperialism of the fifteenth to seventeenth centuries. Goods, information and reports were the life-blood of the new global thrust, and Europe acquired the means 'to communicate almost directly with their remotest colonies, and to engage in an extensive trade in bulky goods that would never have borne the freight costs of any previous empire' (Headrick 1981:130).

The world was transformed to a greater extent than ever before as space and time were compressed to allow an integrated global market of communications and goods. Previously backward, isolated subsistence economies were now drawn into the commercial world market. Political control usually meant taxes, which could only be paid for by selling crops for cash and the importation of foreign expertise. The network of communications meant that goods could be transported cheaply, and information flows meant instant price fluctuation, adjustment, and fine-tuning. All meant financial infrastructures, banking, credit, and a reliable monetary system.

Railways and steamships increased cargo loads, increased reliability, made human travel comfortable, but above all, reduced time and hence costs. One example must suffice. Before the 1830s a message and its reply from London to, say, Calcutta, may have taken up to two years. By the 1850s, with steamships and trains, it could take about three months. With the opening of the Suez Canal, a letter took about thirty days. With the advent of the telegraph a few years later a message could be sent and a reply received in a day. By 1924 the submarine cable network allowed a message to circle the globe in eighty seconds (Headrick 1983). Economic networks were established and new techniques were developed in order to exploit these territories.

Global land-cover change

While it is relatively easy to demonstrate how these technical innovations bound all parts of the world together and were instrumental in facilitating land-use change, it is much more difficult to be precise about the amount and nature of change on the land itself. But there are two lines of enquiry. First, there is the expansion of the world's arable land and the large-scale conversion of natural ecosystems to managed systems. Second, there is the abundant evidence of the processes whereby expansion occurred: for example, clearing, irrigating, etc.

A growing and spreading world population has caused more land to be brought into cultivation as it searches for food. World population started its upward and accelerating trajectory during this period, rising from 957 million in 1800, to 1,650 million in 1900. But after that medicine and better hygiene and nutrition triggered the exponential growth of modern times to 2,515 million in 1950, to double again to 5,000 million in 1985. Concomitant with this growth was the spread of people; about 60 million left Europe between 1850 and 1950, primarily for the Americas, but also for Australia, New Zealand and southern Africa.

EUROPEAN EXPANSION

Table 9.3 Area of different ecosystems converted to cropping, 1860–1978 (million ha)

	<i>Forests</i>	<i>Woodlands</i>	<i>Savannahs</i>	<i>Grass lands</i>	<i>Wetlands</i>	<i>Deserts</i>	<i>Total</i>
<i>Core</i>							
Europe	7.8	0.3	1.8	8.4	3.4	—	21.7
USSR	44.0	13.6	1.7	88.4	—	3.2	150.9
Canada/USA	51.1	13.0	10.7	84.9	—	—	159.7
Total	102.9	26.9	14.2	181.7	3.4	3.2	332.3
<i>Periphery</i>							
Africa	18.0	28.9	23.9	32.5	—	3.1	106.4
Asia	59.2	62.8	50.0	37.4	17.7	7.3	234.4
Latin America	38.8	25.3	16.1	40.1	0.1	3.1	123.5
Oceania	23.9	12.3	13.3	5.1	—	0.5	55.1
Total	139.9	129.3	103.3	115.1	17.8	14.0	519.4
World total	242.8	156.2	117.5	296.8	21.2	17.2	851.7

Source: Revelle (1984).

Note: In Richards (1986), the conversions were revised as per Table 9.1 and the overall adjustment of 7 million ha was assigned to forest ecosystems in the above table by this author, as many of the adjustments concerned forest regrowth.

Undoubtedly, the need for subsistence has fuelled, and continues to fuel, the drive for expansion, but probably far more important during the earlier years of this period was the commercialization of agriculture and market orientation of cropping by peasant proprietors, sharecroppers and estate and plantation workers, for an integrated global economy. All the communication and fiscal tools of expansion mentioned so far played a complementary part in this expansion.

The total amount of land in regular cropping in 1860 was approaching 600 million ha (Richards 1986). During the succeeding sixty years to 1919, an additional 433.4 million ha net were added to this amount, and a further 418.3 million ha net from 1920 to 1978 (Table 9.2), so that the world's arable land increased by 851.7 million ha, to become 2.5 times the extent it had been in 1860.¹ It is also possible to calculate the approximate areas of the different natural ecosystems that were affected by the transformation of land to agriculture (Table 9.3). Approximately 242.8 million ha of forest and 156.2 million ha of woodland, or 46.9 per cent of the total global area, were converted to agricultural land. Also another 117.5 million ha of savannah were also cleared. In addition to woodlands of varying density, 296.8 million ha of grasslands were also converted.

The expansion of arable land was equally vigorous in both the New and the Old World areas alike. Everywhere the trend has been upward. Only in the more industrialized parts of North America, Europe and Eastern Asia has there been any

reversion, largely through the retreat from agriculturally marginal areas. Also, the intensification of output from the most productive areas with chemical innovations such as fertilizer, biological innovations such as higher-yielding crop varieties, and mechanical innovations such as more comprehensive farm machinery, has lessened the amount of land needed (Grigg 1987).

The processes of change

It goes without saying that processes of land transformation modify, replace, or eliminate existing vegetation covers. Such processes can be divided into three broad, and at times overlapping, categories. They are:

- 1 *Transference*, which includes fertilizing, applying water from an external source, using machinery and hence fossil fuels.
- 2 *Replacement*, which includes such actions as irrigating, draining, clearing/firing/cutting, terracing, and ploughing and planting.
- 3 *Harvesting*, which includes timber cutting, fuelwood gathering, grazing, hunting and fishing, gathering, mining, and slash-and-burn cultivation.

It would be impossible to deal with all of these in the space available so just three of the most important in the replacement category (clearing, draining and irrigating) are singled out for treatment.

Clearing

It is possible that the cutting down of trees has been the most important factor in altering the face of the earth (Williams 1989b, 1990a). The forest has been subjected to a sustained and steady attack by humankind throughout the centuries. The fact that the forest provides wood for construction, shelter and warmth as well as the creation of 'new' land for growing crops, explains the vast devastation that has happened.

Overall figures are difficult to calculate but it is probable that during the course of human history between 750 and 806 million ha have been eliminated, over 50 per cent of that total during the years since 1850. Some of the betterdocumented and larger regional impacts are those in the United States where over 77 million ha were cleared for agriculture between 1850 and 1910 (Williams 1989a); in Brazil, where about 14 million ha was cleared for coffee growing by 1931 (Williams 1990a); and South and South-East Asia where forests declined from 88.8 million ha in 1880 to 67.5 million ha in 1950 to 54.2 million ha in 1980 as a result of expanding cultivation, while interrupted forests declined overall by 9.4 million ha during the same two end dates (Richards *et al.* 1987). Smaller regional stories of deforestation are too numerous to mention.

Clearing will not diminish in extent and intensity in the future. Tropical forests, in particular, are one of the world's last great frontiers in which new agricultural

land can be created. But it will no longer be Europe that spearheads that transformation, but the rapidly expanding population of the developing world.

Draining

Whereas the process of forest clearing is piecemeal, individual and largely unrecorded, the process of draining land of its excess water is well planned, communal, and reasonably well documented. Moreover, draining systems have to be maintained in order to function efficiently, and that has to be an agreed co-operative project. Without vigilance, the carefully controlled agricultural landscape could soon become wetland again.

Draining has existed for probably well over two millennia as a means of transforming land and raising agricultural productivity. The knowledge and experience that periodically flooded lands often produced above-average yields when dry was a spur to draining. For over a thousand years the coasts of the North Sea, particularly in the Low Countries and in similar lowlands in England, such as the Fens, the Somerset Levels and Romney Marsh, all experienced small-scale communal reclamation often organized under the aegis of powerful ecclesiastical houses or secular landholders (Williams 1990b). Similar, and largely unrecorded, reclamation occurred in low-lying wetlands in the early civilizations of South and South-East Asia (Richards 1990b).

But the big increase in wetland draining came from the mid-nineteenth century onwards when western technology in the form of steam-powered excavators and draglines (first demonstrated successfully in the construction of the Suez Canal in 1869) lowered costs and increased returns. In addition, powerful mechanical pumps replaced windmills and animal power, cheaply manufactured earthenware pipes facilitated underdraining, and generally increased hydrological knowledge made larger and more ambitious schemes possible.

Table 9.4 Documented changes in wetland due to draining

	<i>Approximate date of activity</i>	<i>Approximate area ('000 ha)</i>
<i>Temperate wetlands</i>		
Fens	Post c. AD 800	700
Holland	Post c. AD 800	2,000
SE of S Australia	Post 1865	1,700
USA	Post 1780	39,000
<i>Tropical wetlands</i>		
Undarbans	Post 1800	800
Irrawaddy Delta	Post 1800	700
Zhuziang Delta	?	1,200

Source: Williams (1990b), pp. 181–233, and Richards (1990b), pp. 217–33.

How much land has been drained is difficult to calculate. A modest estimate is 160 million ha, nearly three-quarters of which has occurred in the temperate world. Like clearing, instances of draining are numerous and scattered and it is difficult to get an overall picture. Table 9.4 shows a number of major regional examples.

Irrigation

Like draining the process of irrigation is old, but it too has to be well-organized and co-operative because it involves the control of a highly dynamic element, water. Modern Western technology, in the form of mechanical means of excavating and the development of engineering skills to build high dams and convert falling water to electricity, have ensured the continued expansion of the process. In addition, as Richards (1986:63) points out, it is 'a much more visible, and appealing' process than any other because 'making the deserts bloom responds to some of our deepest aesthetic and cultural instincts. The drama of towering dams, huge turbines and massive canal systems has made large irrigation systems one index of modernity.'

Since the latter part of the nineteenth century the pace of irrigation works in the world's drier regions has accelerated almost exponentially. Early twentieth-century multiple-use projects on the Colorado and Columbia in the American West are well known, and during the subsequent years these schemes were augmented and accompanied by others on the Missouri and by the withdrawal of underground waters. By 1978 there was 17.7 million ha of irrigated land in the western USA.

Less well known, but larger in size, were the massive irrigation systems initiated by the British on the waters of the Ganges, Godavari, and Krishna in Northern India from the 1850s onwards, and then on the Indus and its five territories in the dry Punjab and Sind in Pakistan during the early years of this century. By 1917 the Triple Canal project watered over 2.2 million ha of the Punjab. By 1939 approximately 11.6 million ha of land were irrigated in colonial British India by over 116,000 km of canals (Richards 1986), and by the late 1970s that figure had risen to 26.1 million ha in India and Pakistan, supplemented by 19.8 million ha of tube-well irrigation. In total, therefore, a massive 45.9 million ha came under irrigation in the sub-continent.

Similar stories could be told of Egypt, Sudan, Australia, Mexico, Iraq, South Africa, and the former Soviet Union, so that by 1979 it has been calculated that 207 million ha, or 14.3 per cent, of the world's arable land is irrigated land (Richards 1986). The point has been reached where few rivers flowing through arid or semiarid regions are left untapped.

However, not all is gain and there is much loss of the irrigated land which has been won so expensively. Over-watering causes waterlogging and salinization, erosion causes sedimentation of reservoirs—all of which may be eliminating each year as much productive arable land as is being created. Sluggish irrigation water

encourages the spread of killer diseases such as malaria and schistosomiasis. But whatever the downside, the glamour of irrigation ensures its continuation as an earth-transforming process.

CONCLUSION

The breaking down of the biological isolation of the continents that had existed for millennia, and the replacement of one vegetation cover by another, was the supreme example of what Columbus's voyages really meant. Although not in conscious control initially, the biological alterations Europeans wrought were soon augmented by many purposeful changes as large areas of the earth's surface were either cultivated or grazed more intensively.

The human control of the earth is increasing. The comprehensive global political control begun by Europe in the early nineteenth century has now been replaced by comprehensiveness of individual state land use and ecological control. This is not only a result of settlement expansion but also of tenure control and intervention to manage activities on every hectare of land in some form or another.

NOTE

- 1 In 1990 Richards recalculated these figures for slightly different dates. He suggested that the amount of land in regular cropping in 1850 was 537 million ha, which rose to 913 million ha in 1920, 1.17 billion ha in 1950 and 1.501 billion ha in 1980, a total increment of 964 million ha in 130 years.

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