

Deforestation

Deforestation, **clearance**, or **clearing** is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use.^[2] Examples of deforestation include conversion of forestland to farms, ranches, or urban use. The most concentrated deforestation occurs in tropical rainforests.^[3] About 30 percent of Earth's land surface is covered by forests.^[4]

Deforestation occurs for multiple reasons: trees are cut down to be used for building or sold as fuel (sometimes in the form of charcoal or timber), while cleared land is used as pasture for livestock and plantation. The removal of trees without sufficient reforestation has resulted in habitat damage, biodiversity loss, and aridity. It has adverse impacts on biosequestration of atmospheric carbon dioxide. Deforestation has also been used in war to deprive the enemy of vital resources and cover for its forces. Modern examples of this were the

use of Agent Orange by the British military in Malaya during the Malayan Emergency and the United States military in Vietnam during the Vietnam War. As of 2005, net deforestation rates have ceased to increase in countries with a per capita GDP of at least US\$4,600.^{[5][6]} Deforested regions typically incur significant adverse soil erosion and frequently degrade into wasteland.

Disregard of ascribed value, lax forest management, and deficient environmental laws are some of the factors that allow deforestation to occur on a large scale. In many countries, deforestation—both naturally occurring and human-induced—is an ongoing issue.^[7] Deforestation causes extinction, changes to climatic conditions, desertification, and displacement of populations as observed by current conditions and in the past through the fossil record.^[8] More than half of all plant and land animal species in the world live in tropical forests.^[9]

Between 2000 and 2012, 2.3 million square kilometres (890,000 sq mi) of forests around the world were cut down.^[10] As a result of deforestation, only 6.2 million square kilometres (2.4 million square miles) remain of the original 16 million square kilometres (6 million square miles) of forest that formerly covered the Earth.^[10] An area the size of a soccer football pitch is cleared from the Amazon rainforest every minute, with 136 million acres (55 million hectares) of rainforest cleared for animal agriculture overall.^[11]



Satellite image of deforestation in progress in eastern Bolivia. Worldwide, 10% of wilderness areas were lost between 1990 and 2015.^[1]

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Causes

According to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, the overwhelming direct cause of deforestation is agriculture. Subsistence farming is responsible for 48% of deforestation; commercial agriculture is responsible for 32%; logging is responsible for 14%, and fuel wood removals make up 5%.^[12]

Experts do not agree on whether industrial logging is an important contributor to global deforestation.^{[13][14]} Some argue that poor people are more likely to clear forest because they have no alternatives, others that the poor lack the ability to pay for the materials and labour needed to clear forest.^[13] One study found that population increases due to high fertility rates were a primary driver of tropical deforestation in only 8% of cases.^[15]

Other causes of contemporary deforestation may include corruption of government institutions,^{[16][17]} the inequitable distribution of wealth and power,^[18] population growth,^[19] and overpopulation,^{[20][21]} and urbanization.^[22] Globalization is often viewed as another root cause of deforestation,^{[23][24]} though there are cases in which the impacts of globalization (new flows of labor, capital, commodities, and ideas) have promoted localized forest recovery.^[25]

In 2000 the United Nations Food and Agriculture Organization (FAO) found that "the role of population dynamics in a local setting may vary from decisive to negligible," and that deforestation can result from "a combination of population pressure and stagnating economic, social and technological conditions".^[49]

The degradation of forest ecosystems has also been traced to economic incentives that make forest conversion appear more profitable than forest conservation.^[26] Many important forest functions have no markets, and hence, no economic value that is readily apparent to the forests' owners or the communities that rely on forests for their well-being.^[26] From the perspective of the developing world, the benefits of forest as carbon sinks or biodiversity reserves go primarily to richer developed nations and there is insufficient compensation for these services. Developing countries feel that some countries in the developed world, such as the United States of America, cut down their forests centuries ago and benefited economically from this deforestation, and that it is hypocritical to deny developing countries the same opportunities, i.e. that the poor shouldn't have to bear the cost of preservation when the rich created the problem.^[27]



The last batch of sawnwood from the peat forest in Indragiri Hulu, Sumatra, Indonesia. Deforestation for oil palm plantation.

Some commentators have noted a shift in the drivers of deforestation over the past 30 years.^[28] Whereas deforestation was primarily driven by subsistence activities and government-sponsored development projects like transmigration in countries like Indonesia and colonization in Latin America, India, Java, and so on, during the late 19th century and the earlier half of the 20th century, by the 1990s the majority of deforestation was caused by industrial factors, including extractive industries, large-scale cattle ranching, and extensive agriculture.^[29]

Environmental effects

Atmospheric

Deforestation is ongoing and is shaping climate and geography.^{[30][31][32][33]}

Deforestation is a contributor to global warming^{[34][35]} and is often cited as one of the major causes of the enhanced greenhouse effect. Tropical deforestation is responsible for approximately 20% of world greenhouse gas emissions.^[36] According to the Intergovernmental Panel on Climate Change deforestation, mainly in tropical areas, could account for up to one-third of total anthropogenic carbon dioxide emissions.^[37] But recent calculations suggest that carbon dioxide emissions from deforestation and forest degradation (excluding peatland emissions) contribute about 12% of total anthropogenic carbon dioxide emissions with a range from 6 to 17%.^[38] Deforestation causes carbon dioxide to linger in the atmosphere. As carbon dioxide accrues, it produces a layer in the atmosphere that traps radiation from the

sun. The radiation converts to heat which causes global warming, which is better known as the greenhouse effect.^[39] Plants remove carbon in the form of carbon dioxide from the atmosphere during the process of photosynthesis, but release some carbon dioxide back into the atmosphere during normal respiration. Only when actively growing can a tree or forest remove carbon, by storing it in plant tissues. Both the decay and burning of wood releases much of this stored carbon back to the atmosphere. In order for forests effectively to take up carbon, there must be a net accumulation of wood. One way is for the wood to be harvested and turned into long-lived products, with new young trees replacing them.^[40] Deforestation may also cause carbon stores held in soil to be released. Forests can be either sinks or sources depending upon environmental circumstances. Mature forests alternate between being net sinks and net sources of carbon dioxide (see carbon dioxide sink and carbon cycle).

In deforested areas, the land heats up faster and reaches a higher temperature, leading to localized upward motions that enhance the formation of clouds and ultimately produce more rainfall.^[41] However, according to the Geophysical Fluid Dynamics Laboratory, the models used to investigate remote responses to tropical deforestation showed a broad but mild temperature increase all through the tropical atmosphere. The model predicted <0.2 °C warming for upper air at 700 mb and 500 mb. However, the model shows no significant changes in other areas besides the Tropics. Though the model showed no significant changes to the climate in areas other than the Tropics, this may not be the case since the model has possible errors and the results are never absolutely definite.^[42] Deforestation affects wind flows, water vapour flows and absorption of solar energy thus clearly influencing local and global climate.^[43]

Reducing emissions from deforestation and forest degradation (REDD) in developing countries has emerged as a new potential to complement ongoing climate policies. The idea consists in providing financial compensations for the reduction of greenhouse gas (GHG) emissions from deforestation and forest degradation.^[44]

Rainforests are widely believed by laymen to contribute a significant amount of the world's oxygen,^[45] although it is now accepted by scientists that rainforests contribute little net oxygen to the atmosphere and deforestation has only a minor effect on atmospheric oxygen levels.^{[46][47]} However, the incineration and burning of forest plants to clear land releases large amounts of CO₂, which contributes to global warming.^[35] Scientists also state that tropical deforestation releases 1.5 billion tons of carbon each year into the atmosphere.^[48]



Illegal "slash-and-burn" practice in Madagascar, 2010

Hydrological

The water cycle is also affected by deforestation. Trees extract groundwater through their roots and release it into the atmosphere. When part of a forest is removed, the trees no longer transpire this water, resulting in a much drier climate. Deforestation reduces the content of water in the soil and groundwater as well as atmospheric moisture. The dry soil leads to lower water intake for the trees to extract.^[49] Deforestation reduces soil cohesion, so that erosion, flooding and landslides ensue.^{[50][51]}

Shrinking forest cover lessens the landscape's capacity to intercept, retain and transpire precipitation. Instead of trapping precipitation, which then percolates to groundwater systems, deforested areas become sources of surface water runoff, which moves much faster than subsurface flows. Forests return most of the water that falls as precipitation to the atmosphere by transpiration. In contrast, when an area is deforested, almost all precipitation is lost as run-off.^[52] That quicker transport of surface water can translate into flash flooding and more localized floods than would occur with the forest cover. Deforestation also contributes to decreased evapotranspiration, which lessens atmospheric moisture which in some cases affects precipitation levels downwind from the deforested area, as water is not recycled to downwind forests, but is lost in runoff and returns directly to the oceans. According to one study, in deforested north and northwest China, the average annual precipitation decreased by one third between the 1950s and the 1980s.^[53]

Trees, and plants in general, affect the water cycle significantly:^[54]

- their canopies intercept a proportion of precipitation, which is then evaporated back to the atmosphere (canopy interception);
- their litter, stems and trunks slow down surface runoff;
- their roots create macropores – large conduits – in the soil that increase infiltration of water;
- they contribute to terrestrial evaporation and reduce soil moisture via transpiration;
- their litter and other organic residue change soil properties that affect the capacity of soil to store water
- their leaves control the humidity of the atmosphere by transpiring. 99% of the water absorbed by the roots moves up to the leaves and is transpired.^[55]

As a result, the presence or absence of trees can change the quantity of water on the surface, in the soil or groundwater, or in the atmosphere. This in turn changes erosion rates and the availability of water for either ecosystem functions or human services. Deforestation on lowland plains moves cloud formation and rainfall to higher elevations.^[43]

The forest may have little impact on flooding in the case of large rainfall events, which overwhelm the storage capacity of forest soil if the soils are at or close to saturation.

Tropical rainforests produce about 30% of our planet's fresh water.^[45]

Deforestation disrupts normal weather patterns creating hotter and drier weather thus increasing drought, desertification, crop failures, melting of the polar ice caps, coastal flooding and displacement of major vegetation regimes.^[43]

Soil

Due to surface plant litter, forests that are undisturbed have a minimal rate of erosion. The rate of erosion occurs from deforestation, because it decreases the amount of litter cover, which provides protection from surface runoff.^[56] The rate of erosion is around 2 metric tons per square kilometre.^[57] This can be an advantage in excessively leached tropical rain forest soils. Forestry operations themselves also increase erosion through the development of (forest) roads and the use of mechanized equipment.

Deforestation in China's Loess Plateau many years ago has led to soil erosion; this erosion has led to valleys opening up. The increase of soil in the runoff causes the Yellow River to flood and makes it yellow colored.^[57]



Fires on Borneo and Sumatra 2006. People use slash-and-burn deforestation to clear land for agriculture.

Greater erosion is not always a consequence of deforestation, as observed in the southwestern regions of the US. In these areas, the loss of grass due to the presence of trees and other shrubbery leads to more erosion than when trees are removed.^[57]

Soils are reinforced by the presence of trees, which secure the soil by binding their roots to soil bedrock. Due to deforestation, the removal of trees causes sloped lands to be more susceptible to landslides.^[54]

Biodiversity

Deforestation on a human scale results in decline in biodiversity,^[58] and on a natural global scale is known to cause the extinction of many species.^[8] The removal or destruction of areas of forest cover has resulted in a degraded environment with reduced biodiversity.^[21] Forests support biodiversity, providing habitat for wildlife,^[59] moreover, forests foster medicinal conservation.^[60] With forest biotopes being irreplaceable source of new drugs (such as taxol), deforestation can destroy genetic variations (such as crop resistance) irretrievably.^[61]

Since the tropical rainforests are the most diverse ecosystems on Earth,^{[62][63]} and about 80% of the world's known biodiversity could be found in tropical rainforests,^{[64][65]} removal or destruction of significant areas of forest cover has resulted in a degraded^[66] environment with reduced biodiversity.^{[8][67]} A study in Rondônia, Brazil, has shown that deforestation also removes the microbial community which is involved in the recycling of nutrients, the production of clean water and the removal of pollutants.^[68]

It has been estimated that we are losing 137 plant, animal and insect species every single day due to rainforest deforestation, which equates to 50,000 species a year.^[69] Others state that tropical rainforest deforestation is contributing to the ongoing Holocene mass extinction.^{[70][71]} The known extinction rates from deforestation rates are very low, approximately 1 species per year from mammals and birds which extrapolates to approximately 23,000 species per year for all species. Predictions have been made that more than 40% of the animal and plant species in Southeast Asia could be wiped out in the 21st century.^[72] Such predictions were called into question by 1995 data that show that within regions of Southeast Asia much of the original forest has been converted to monospecific plantations, but that potentially endangered species are few and tree flora remains widespread and stable.^[73]

Scientific understanding of the process of extinction is insufficient to accurately make predictions about the impact of deforestation on biodiversity.^[74] Most predictions of forestry related biodiversity loss are based on species-area models, with an underlying assumption that as the forest declines species diversity will decline similarly.^[75] However, many such models have been proven to be wrong and loss of habitat does not necessarily lead to large scale loss of species.^[75] Species-area models are known to overpredict the number of species known to be threatened in areas where actual deforestation is ongoing, and greatly overpredict the number of threatened species that are widespread.^[73]

A recent study of the Brazilian Amazon predicts that despite a lack of extinctions thus far, up to 90 percent of predicted extinctions will finally occur in the next 40 years.^[76]



Deforestation for the use of clay in the Brazilian city of Rio de Janeiro. The hill depicted is Morro da Covança, in Jacarepaguá



Illegal logging in Madagascar In 2009, the vast majority of the illegally obtained rosewood was exported to China.

Economic impact

Damage to forests and other aspects of nature could halve living standards for the world's poor and reduce global GDP by about 7% by 2050, a report concluded at the Convention on Biological Diversity (CBD) meeting in Bonn in 2008.^[77] Historically, utilization of forest products, including timber and fuel wood, has played a key role in human societies, comparable to the roles of water and cultivable land. Today, developed countries continue to utilize timber for building houses, and wood pulp for paper. In developing countries almost three billion people rely on wood for heating and cooking.^[78]



A satellite image showing deforestation for a palm oil plantation in Malaysia

The forest products industry is a large part of the economy in both developed and developing countries. Short-term economic gains made by conversion of forest to agriculture, or over-exploitation of wood products, typically leads to loss of long-term income and long-term biological productivity. West Africa, Madagascar, Southeast Asia and many other regions have experienced lower revenue because of declining timber harvests. Illegal logging causes billions of dollars of losses to national economies annually.^[79]

The new procedures to get amounts of wood are causing more harm to the economy and overpower the amount of money spent by people employed in logging.^[80] According to a study, "in most areas studied, the various ventures that prompted deforestation rarely generated more than US\$5 for every ton of carbon they released and frequently returned far less than US\$1". The price on the European market for an offset tied to a one-ton reduction in carbon is 23euro (about US\$35).^[81]

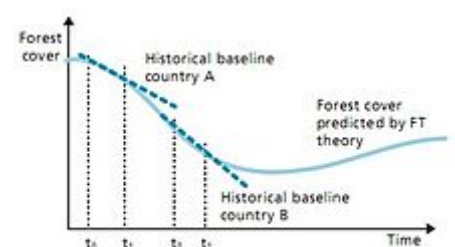
Rapidly growing economies also have an effect on deforestation. Most pressure will come from the world's developing countries, which have the fastest-growing populations and most rapid economic (industrial) growth.^[82] In 1995, economic growth in developing countries reached nearly 6%, compared with the 2% growth rate for developed countries.^[82] As our human population grows, new homes, communities, and expansions of cities will occur. Connecting all of the new expansions will be roads, a very important part in our daily life. Rural roads promote economic development but also facilitate deforestation.^[82] About 90% of the deforestation has occurred within 100 km of roads in most parts of the Amazon.^[83]

The European Union is one of the largest importer of products made from illegal deforestation.^[84]

Forest transition theory

The forest area change may follow a pattern suggested by the forest transition (FT) theory,^[86] whereby at early stages in its development a country is characterized by high forest cover and low deforestation rates (HFLD countries).^[29]

Then deforestation rates accelerate (HFHD, high forest cover – high deforestation rate), and forest cover is reduced (LFHD, low forest cover – high deforestation rate), before the deforestation rate slows (LFLD, low forest cover – low deforestation rate), after which forest cover stabilizes and eventually starts recovering. FT is not a “law of nature,” and the pattern is influenced by national context (for example, human population density, stage of development, structure of the economy), global economic forces, and government policies. A country may reach very low levels of forest cover before it stabilizes, or it might through good policies be able to “bridge” the forest transition.^[87]



Source: Angelsen 2008.

The forest transition and historical baselines.^[85]

FT depicts a broad trend, and an extrapolation of historical rates therefore tends to underestimate future BAU deforestation for countries at the early stages in the transition (HFLD), while it tends to overestimate BAU deforestation for countries at the later stages (LFHD and LFLD).

Countries with high forest cover can be expected to be at early stages of the FT. GDP per capita captures the stage in a country's economic development, which is linked to the pattern of natural resource use, including forests. The choice of forest cover and GDP per capita also fits well with the two key scenarios in the FT

(i) a forest scarcity path, where forest scarcity triggers forces (for example, higher prices of forest products) that lead to forest cover stabilization; and

(ii) an economic development path, where new and better off-farm employment opportunities associated with economic growth (= increasing GDP per capita) reduce profitability of frontier agriculture and slows deforestation.^[29]

Historical causes

Prehistory

The Carboniferous Rainforest Collapse^[8] was an event that occurred 300 million years ago. Climate change devastated tropical rainforests causing the extinction of many plant and animal species. The change was abrupt, specifically, at this time climate became cooler and drier, conditions that are not favourable to the growth of rainforests and much of the biodiversity within them. Rainforests were fragmented forming shrinking 'islands' further and further apart. Populations such as the sub class Lissamphibia were devastated, whereas Reptilia survived the collapse. The surviving organisms were better adapted to the drier environment left behind and served as legacies in succession after the collapse.^[7]

Rainforests once covered 14% of the earth's land surface; now they cover a mere 6% and experts estimate that the last remaining rainforests could be consumed in less than 40 years.^[88] Small scale deforestation was practiced by some societies for tens of thousands of years before the beginnings of civilization.^[89] The first evidence of deforestation appears in the Mesolithic period.^[90] It was probably used to convert closed forests into more open ecosystems favourable to game animals.^[89] With the advent of agriculture, larger areas began to be deforested, and fire became the prime tool to clear land for crops. In Europe there is little solid evidence before 7000 BC. Mesolithic foragers used fire to create openings for red deer and wild boar. In Great Britain, shade-tolerant species such as oak and ash are replaced in the pollen record by hazels, brambles, grasses and nettles. Removal of the forests led to decreased transpiration, resulting in the formation of upland peat bogs. Widespread decrease in elm pollen across Europe between 8400–8300 BC and 7200–7000 BC, starting in southern Europe and gradually moving north to Great Britain, may represent land clearing by fire at the onset of Neolithic agriculture.



An array of Neolithic artifacts, including bracelets, axe heads, chisels, and polishing tools.

The Neolithic period saw extensive deforestation for farming land.^{[91][92]} Stone axes were being made from about 3000 BC not just from flint, but from a wide variety of hard rocks from across Britain and North America as well. They include the notable Edgdale axe industry in the English Lake District, quarries developed at Penmaenmawr in North Wales and numerous other locations. Rough-outs were made locally near the quarries, and some were polished locally to give a fine finish. This step not only increased the mechanical strength of the axe, but also made penetration of wood easier. Flint was still used from sources such as Grimes Graves but from many other mines across Europe.

Evidence of deforestation has been found in Minoan Crete; for example the environs of the Palace of Knossos were severely deforested in the Bronze Age.^[93]

Pre-industrial history

Throughout prehistory, humans were hunter gatherers who hunted within forests. In most areas, such as the Amazon, the tropics, Central America, and the Caribbean,^[95] only after shortages of wood and other forest products occur are policies implemented to ensure forest resources are used in a sustainable manner

In ancient Greece, Tjeered van Andel and co-writers^[96] summarized three regional studies of historic erosion and alluviation and found that, wherever adequate evidence exists, a major phase of erosion follows, by about 500-1,000 years the introduction of farming in the various regions of Greece, ranging from the later Neolithic to the Early Bronze Age. The thousand years following the mid-first millennium BC saw serious, intermittent pulses of soil erosion in numerous places. The historic silting of ports along the southern coasts of Asia Minor (e.g. Clarus, and the examples of Ephesus, Priene and Miletus, where harbors had to be abandoned because of the silt deposited by the Meander) and in coastal Syria during the last centuries BC.

Easter Island has suffered from heavy soil erosion in recent centuries, aggravated by agriculture and deforestation.^[97] Jared Diamond gives an extensive look into the collapse of the ancient Easter Islanders in his book Collapse. The disappearance of the island's trees seems to coincide with a decline of its civilization around the 17th and 18th century. He attributed the collapse to deforestation and over-exploitation of all resources.^{[98][99]}

The famous silting up of the harbor for Bruges, which moved port commerce to Antwerp, also followed a period of increased settlement growth (and apparently of deforestation) in the upper river basins. In early medieval Riez in upper Provence, alluvial silt from two small rivers raised the riverbeds and widened the floodplain, which slowly buried the Roman settlement in alluvium and gradually moved new construction to higher ground; concurrently the headwater valley above Riez were being opened to pasturage.^[100]

A typical progress trap was that cities were often built in a forested area, which would provide wood for some industry (for example, construction, shipbuilding, pottery). When deforestation occurs without proper replanting, however; local wood supplies become difficult to obtain near enough to remain competitive, leading to the city's abandonment, as happened repeatedly in Ancient Asia Minor. Because of fuel needs, mining and metallurgy often led to deforestation and city abandonment.^[101]

With most of the population remaining active in (or indirectly dependent on) the agricultural sector, the main pressure in most areas remained land clearing for crop and cattle farming. Enough wild green was usually left standing (and partially used, for example, to collect firewood, timber and fruits, or to graze pigs) for wildlife to remain viable. The elite's (nobility and higher clergy) protection of their own hunting privileges and game often protected significant woodland.^[87]

Major parts in the spread (and thus more durable growth) of the population were played by monastical 'pioneering' (especially by the Benedictine and Commercial orders) and some feudal lords' recruiting farmers to settle (and become tax payers) by offering relatively good legal and fiscal conditions. Even when speculators sought to encourage towns, settlers needed an agricultural belt around or sometimes within defensive walls. When populations were quickly decreased by causes such as the Black Death or devastating warfare (for example, Genghis Khan's Mongol hordes in eastern and central Europe, Thirty Years' War in Germany), this could lead to settlements being abandoned. The land was reclaimed by nature, but secondary forests usually lacked the original biodiversity.

From 1100 to 1500 AD, significant deforestation took place in Western Europe as a result of the expanding human population. The large-scale building of wooden sailing ships by European (coastal) naval owners since the 15th century for exploration, colonisation, slave trade—and other trade on the high seas consumed many forest resources. Piracy also contributed to the over harvesting of forests, as in Spain. This led to a weakening of the domestic economy after Columbus' discovery of America, as the economy became dependent on colonial activities (plundering, mining, cattle, plantations, trade, etc.)^[102]

In *Changes In the Land* (1983), William Cronon analyzed and documented 17th-century English colonists' reports of increased seasonal flooding in New England during the period when new settlers initially cleared the forests for agriculture. They believed flooding was linked to widespread forest clearing upstream.



Easter Island, deforested. According to Jared Diamond "Among past societies faced with the prospect of ruinous deforestation, Easter Island and Mangareva chiefs succumbed to their immediate concerns, but Tokugawa shoguns, Inca emperors, New Guinea highlanders, and 16th century German landowners adopted a long view and reforested."^[94]

The massive use of charcoal on an industrial scale in Early Modern Europe was a new type of consumption of western forests; even in Stuart England, the relatively primitive production of charcoal has already reached an impressive level. Stuart England was so widely deforested that it depended on the Baltic trade for ship timbers, and looked to the untapped forests of New England to supply the need. Each of Nelson's Royal Navy war ships at Trafalgar (1805) required 6,000 mature oaks for its construction. In France, Colbert planted oak forests to supply the French navy in the future. When the oak plantations matured in the mid-19th century, the masts were no longer required because shipping had changed.



Deforestation of Brazil's Atlantic Forest c.1820–1825

Norman F. Cantor's summary of the effects of late medieval deforestation applies equally well to Early Modern Europe.^[103]

Europeans had lived in the midst of vast forests throughout the earlier medieval centuries. After 1250 they became so skilled at deforestation that by 1500 they were running short of wood for heating and cooking. They were faced with a nutritional decline because of the elimination of the generous supply of wild game that had inhabited the now-disappearing forests, which throughout medieval times had provided the staple of their carnivorous high-protein diet. By 1500 Europe was on the edge of a fuel and nutritional disaster [from] which it was saved in the sixteenth century only by the burning of soft coal and the cultivation of potatoes and maize.

Industrial era

In the 19th century, introduction of steamboats in the United States was the cause of deforestation of banks of major rivers, such as the Mississippi River, with increased and more severe flooding one of the environmental results. The steamboat crews cut wood every day from the riverbanks to fuel the steam engines. Between St. Louis and the confluence with the Ohio River to the south, the Mississippi became more wide and shallow, and changed its channel laterally. Attempts to improve navigation by the use of snag pullers often resulted in crews' clearing large trees 100 to 200 feet (61 m) back from the banks. Several French colonial towns of the Illinois Country, such as Kaskaskia, Cahokia and St. Philippe, Illinois were flooded and abandoned in the late 19th century, with a loss to the cultural record of their archeology.^[104]

The wholesale clearance of woodland to create agricultural land can be seen in many parts of the world, such as the Central forest-grasslands transition and other areas of the Great Plains of the United States. Specific parallels are seen in the 20th-century deforestation occurring in many developing nations.

Rates of deforestation

Global deforestation^[105] sharply accelerated around 1852.^{[106][107]} It has been estimated that about half of the Earth's mature tropical forests—between 7.5 million and 8 million km² (2.9 million to 3 million sq mi) of the original 15 million to 16 million km² (5.8 million to 6.2 million sq mi) that until 1947 covered the planet^[108]—have now been destroyed.^{[9][109]} Some scientists have predicted that unless significant measures (such as seeking out and protecting old growth forests that have not been disturbed)^[108] are taken on a worldwide basis, by 2030 there will only be 10% remaining,^{[106][109]} with another 10% in a degraded condition.^[106] 80% will have been lost, and with them hundreds of thousands of irreplaceable species.^[106] Some cartographers have attempted to illustrate the sheer scale of deforestation by country using a cartogram.^[110]



Slash-and-burn farming in the state of Rondônia, western Brazil

Estimates vary widely as to the extent of tropical deforestation.^{[111][112]} Over a 50-year period, percentage of land cover by tropical rainforests has decreased by 50%. Where total land coverage by tropical rainforests decreased from 14% to 6%. A large contribution to this loss can be identified between 1960 and 1990, when 20% of all tropical rainforests were destroyed. At this rate, extinction of such forests is projected to occur by the mid 21st century.^[7]

A 2002 analysis of satellite imagery suggested that the rate of deforestation in the humid tropics (approximately 5.8 million hectares per year) was roughly 23% lower than the most commonly quoted rates.^[113] Conversely, a newer analysis of satellite images reveals that deforestation of the Amazon rainforest is twice as fast as scientists previously estimated.^{[114][115]}

Some have argued that deforestation trends may follow a Kuznets curve,^[116] which if true would nonetheless fail to eliminate the risk of irreversible loss of non-economic forest values (for example, the extinction of species).^{[117][118]}

A 2005 report by the United Nations Food and Agriculture Organization (FAO) estimated that although the Earth's total forest area continued to decrease at about 13 million hectares per year, the global rate of deforestation has recently been slowing.^{[119][120]} The 2016 report by the FAO^[121] reports from 2010 to 2015 there was a worldwide decrease in forest area of 3.3 million ha per year. During this five-year period, the biggest forest area loss occurred in the tropics, particularly in South America and Africa. Per capita forest area decline was also greatest in the tropics and subtropics but is occurring in every climatic domain (except in the temperate) as populations increase.

Others claim that rainforests are being destroyed at an ever-quickenning pace.^[122] The London-based Rainforest Foundation notes that "the UN figure is based on a definition of forest as being an area with as little as 10% actual tree cover, which would therefore include areas that are actually savannah-like ecosystems and badly damaged forests."^[123] Other critics of the FAO data point out that they do not distinguish between forest types,^[124] and that they are based largely on reporting from forestry departments of individual countries,^[125] which do not take into account unofficial activities like illegal logging.^[126]

Despite these uncertainties, there is agreement that destruction of rainforests remains a significant environmental problem. Up to 90% of West Africa's coastal rainforests have disappeared since 1900.^[127] In South Asia, about 88% of the rainforests have been lost.^[128] Much of what remains of the world's rainforests is in the Amazon basin, where the Amazon Rainforest covers approximately 4 million square kilometres.^[129] The regions with the highest tropical deforestation rate between 2000 and 2005 were Central America —which lost 1.3% of its forests each year—and tropical Asia.^[123] In Central America, two-thirds of lowland tropical forests have been turned into pasture since 1950 and 40% of all the rainforests have been lost in the last 40 years.^[130] Brazil has lost 90–95% of its Mata Atlântica forest.^[131] Paraguay was losing its natural semi humid forests in the country's western regions at a rate of 15,000 hectares at a randomly studied 2-month period in 2010,^[132] Paraguay's parliament refused in 2009 to pass a law that would have stopped cutting of natural forests altogether.^[133]

Madagascar has lost 90% of its eastern rainforests.^{[134][135]} As of 2007, less than 50% of Haiti's forests remained.^[136] Mexico, India, the Philippines, Indonesia, Thailand, Burma, Malaysia, Bangladesh, China, Sri Lanka, Laos, Nigeria, the Democratic Republic of the Congo, Liberia, Guinea, Ghana and the Ivory Coast, have lost large areas of their rainforest.^{[137][138]} Several countries, notably Brazil, have declared their deforestation a national emergency.^{[139][140]} The World Wildlife Fund's ecoregion project catalogues habitat types throughout the world, including habitat loss such as deforestation, showing for example that even in the rich forests of parts of Canada such as the Mid-Continental Canadian forests of the prairie provinces half of the forest cover has been lost or altered.



Satellite image of Haiti's border with the Dominican Republic(right) shows the amount of deforestation on the Haitian side



Deforestation around Pakke Tiger Reserve, India

Regions

Rates of deforestation vary around the world.

In 2011 Conservation International listed the top 10 most endangered forests, characterized by having all lost 90% or more of their original habitat, and each harboring at least 1500 endemic plant species (species found nowhere else in the world).^[141]

Top 10 Most Endangered Forests 2011				
Endangered forest	Region	Remaining habitat	Predominate vegetation type	Notes
<u>Indo-Burma</u>	Asia-Pacific	5%	<u>Tropical and subtropical moist broadleaf forests</u>	Rivers, floodplain wetlands, mangrove forests. <u>Burma</u> , <u>Thailand</u> , <u>Laos</u> , <u>Vietnam</u> , <u>Cambodia</u> , <u>India</u> . ^[142]
<u>New Caledonia</u>	Asia-Pacific	5%	Tropical and subtropical moist broadleaf forests	See note for region covered. ^[143]
<u>Sundaland</u>	Asia-Pacific	7%	Tropical and subtropical moist broadleaf forests	Western half of the Indo-Malayan archipelago including southern <u>Borneo</u> and <u>Sumatra</u> . ^[144]
<u>Philippines</u>	Asia-Pacific	7%	Tropical and subtropical moist broadleaf forests	Forests over the entire country including 7,100 islands. ^[145]
<u>Atlantic Forest</u>	South America	8%	Tropical and subtropical moist broadleaf forests	Forests along Brazil's Atlantic coast, extends to parts of <u>Paraguay</u> , <u>Argentina</u> and <u>Uruguay</u> . ^[146]
Mountains of Southwest China	Asia-Pacific	8%	<u>Temperate coniferous forest</u>	See note for region covered. ^[147]
<u>California Floristic Province</u>	North America	10%	<u>Tropical and subtropical dry broadleaf forests</u>	See note for region covered. ^[148]
<u>Coastal Forests of Eastern Africa</u>	Africa	10%	Tropical and subtropical moist broadleaf forests	<u>Mozambique</u> , <u>Tanzania</u> , <u>Kenya</u> , <u>Somalia</u> . ^[149]
<u>Madagascar & Indian Ocean Islands</u>	Africa	10%	Tropical and subtropical moist broadleaf forests	<u>Madagascar</u> , <u>Mauritius</u> , <u>Reunion</u> , <u>Seychelles</u> , <u>Comoros</u> . ^[150]
<u>Eastern Afromontane</u>	Africa	11%	Tropical and subtropical moist broadleaf forests <u>Montane grasslands and shrublands</u>	Forests scattered along the eastern edge of Africa, from <u>Saudi Arabia</u> in the north to <u>Zimbabwe</u> in the south. ^[151]

Table source:^[141]

Control

Reducing emissions

Main international organizations including the United Nations and the World Bank, have begun to develop programs aimed at curbing deforestation. The blanket term Reducing Emissions from Deforestation and Forest Degradation (REDD) describes these sorts of programs, which use direct monetary or other incentives to encourage developing countries to limit and/or roll back deforestation. Funding has been an issue, but at the UN Framework Convention on Climate Change (UNFCCC) Conference of the

Parties-15 (COP-15) in Copenhagen in December 2009, an accord was reached with a collective commitment by developed countries for new and additional resources, including forestry and investments through international institutions, that will approach USD 30 billion for the period 2010–2012.^[152] Significant work is underway on tools for use in monitoring developing country adherence to their agreed REDD targets. These tools, which rely on remote forest monitoring using satellite imagery and other data sources, include the Center for Global Development's FORMA (Forest Monitoring for Action) initiative^[153] and the Group on Earth Observations' Forest Carbon Tracking Portal.^[154] Methodological guidance for forest monitoring was also emphasized at COP-15.^[155] The environmental organization Avoided Deforestation Partners leads the campaign for development of REDD through funding from the U.S. government.^[156] In 2014, the Food and Agriculture Organization of the United Nations and partners launched Open Foris – a set of open-source software tools that assist countries in gathering, producing and disseminating information on the state of forest resources.^[157] The tools support the inventory lifecycle, from needs assessment, design, planning, field data collection and management, estimation analysis, and dissemination. Remote sensing image processing tools are included, as well as tools for international reporting for Reducing emissions from deforestation and forest degradation (REDD) and MRV (Measurement, Reporting and Verification)^[158] and FAO's Global Forest Resource Assessments

In evaluating implications of overall emissions reductions, countries of greatest concern are those categorized as High Forest Cover with High Rates of Deforestation (HFHD) and Low Forest Cover with High Rates of Deforestation (LFHD). Afghanistan, Benin, Botswana, Burma, Burundi, Cameroon, Chad, Ecuador, El Salvador, Ethiopia, Ghana, Guatemala, Guinea, Haiti, Honduras, Indonesia, Liberia, Malawi, Mali, Mauritania, Mongolia, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Philippines, Senegal, Sierra Leone, Sri Lanka, Sudan, Togo, Uganda, United Republic of Tanzania, Zimbabwe are listed as having Low Forest Cover with High Rates of Deforestation (LFHD). Brazil, Cambodia, Democratic Peoples Republic of Korea, Equatorial Guinea, Malaysia, Solomon Islands, Timor-Leste, Venezuela, Zambia are listed as High Forest Cover with High Rates of Deforestation (HFHD).^[159]

Payments for conserving forests

In Bolivia, deforestation in upper river basins has caused environmental problems, including soil erosion and declining water quality. An innovative project to try and remedy this situation involves landholders in upstream areas being paid by downstream water users to conserve forests. The landholders receive US\$20 to conserve the trees, avoid polluting livestock practices, and enhance the biodiversity and forest carbon on their land. They also receive US\$30, which purchases a beehive, to compensate for conservation for two hectares of water-sustaining forest for five years. Honey revenue per hectare of forest is US\$5 per year, so within five years, the landholder has sold US\$50 of honey.^[160] The project is being conducted by Fundación Natura Bolivia and Rare Conservation, with support from the Climate & Development Knowledge Network

Land rights

Transferring rights over land from public domain to its indigenous inhabitants is argued to be a cost effective strategy to conserve forests.^[161] This includes the protection of such rights entitled in existing laws, such as India's Forest Rights Act.^[161] The transferring of such rights in China, perhaps the largest land reform in modern times, has been argued to have increased forest cover.^[162] In Brazil, forested areas given tenure to indigenous groups have even lower rates of clearing than national parks.^[162]



Transferring land rights to indigenous inhabitants is argued to efficiently conserve forests.

Farming

New methods are being developed to farm more intensively, such as high-yield hybrid crops, greenhouse, autonomous building gardens, and hydroponics. These methods are often dependent on chemical inputs to maintain necessary yields. In cyclic agriculture, cattle are grazed on farm land that is resting and rejuvenating. Cyclic agriculture actually increases the fertility of the soil. Intensive farming can also decrease soil nutrients by consuming at an accelerated rate the trace minerals needed

for crop growth.^[7] The most promising approach, however, is the concept of food forests in permaculture, which consists of agroforestral systems carefully designed to mimic natural forests, with an emphasis on plant and animal species of interest for food, timber and other uses. These systems have low dependence on fossil fuels and agro-chemicals, are highly self-maintaining, highly productive, and with strong positive impact on soil and water quality and biodiversity.

Monitoring deforestation

There are multiple methods that are appropriate and reliable for reducing and monitoring deforestation. One method is the “visual interpretation of aerial photos or satellite imagery that is labor-intensive but does not require high-level training in computer image processing or extensive computational resources”.^[83] Another method includes hot-spot analysis (that is, locations of rapid change) using expert opinion or coarse resolution satellite data to identify locations for detailed digital analysis with high resolution satellite images.^[83] Deforestation is typically assessed by quantifying the amount of area deforested, measured at the present time. From an environmental point of view, quantifying the damage and its possible consequences is a more important task, while conservation efforts are more focused on forested land protection and development of land-use alternatives to avoid continued deforestation.^[83] Deforestation rate and total area deforested, have been widely used for monitoring deforestation in many regions, including the Brazilian Amazon deforestation monitoring by INPE.^[48] A global satellite view is available.^{[163][164]}

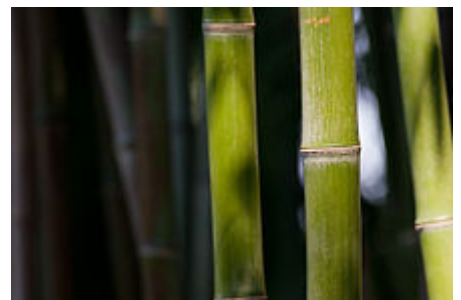
Forest management

Efforts to stop or slow deforestation have been attempted for many centuries because it has long been known that deforestation can cause environmental damage sufficient in some cases to cause societies to collapse. In Tonga, paramount rulers developed policies designed to prevent conflicts between short-term gains from converting forest to farmland and long-term problems forest loss would cause,^[165] while during the 17th and 18th centuries in Tokugawa, Japan,^[166] the shoguns developed a highly sophisticated system of long-term planning to stop and even reverse deforestation of the preceding centuries through substituting timber by other products and more efficient use of land that had been farmed for many centuries. In 16th-century Germany, landowners also developed silviculture to deal with the problem of deforestation. However, these policies tend to be limited to environments with *good rainfall*, *no dry season* and *very young soils* (through volcanism or glaciation). This is because on older and less fertile soils trees grow too slowly for silviculture to be economic, whilst in areas with a strong dry season there is always a risk of forest fires destroying a tree crop before it matures.

In the areas where “slash-and-burn” is practiced, switching to “slash-and-char” would prevent the rapid deforestation and subsequent degradation of soils. The biochar thus created, given back to the soil, is not only a durable carbon sequestration method, but it also is an extremely beneficial amendment to the soil. Mixed with biomass it brings the creation of terra preta, one of the richest soils on the planet and the only one known to regenerate itself.

Sustainable practices

Certification, as provided by global certification systems such as Programme for the Endorsement of Forest Certification and Forest Stewardship Council, contributes to tackling deforestation by creating market demand for timber from sustainably managed forests. According to the United Nations Food and Agriculture Organization (FAO), “A major condition for the adoption of sustainable forest management is a demand for products that are produced sustainably and consumer willingness to pay for the higher costs entailed. Certification represents a shift from regulatory approaches to market incentives to promote sustainable forest management. By promoting the positive attributes of forest products from sustainably managed forests, certification focuses on the demand side of environmental conservation.”^[168] Rainforest Rescue argues that the standards of



Bamboo is advocated as a more sustainable alternative for cutting down wood for fuel!^[167]

organizations like FSC are too closely connected to timber industry interests and therefore do not guarantee environmentally and socially responsible forest management. In reality, monitoring systems are inadequate and various cases of fraud have been documented worldwide!^[169]

Some nations have taken steps to help increase the number of trees on Earth. In 1981, China created National Tree Planting Day. Forest and forest coverage had now reached 16.55% of China's land mass, as against only 12% two decades ago.^[170]

Using fuel from bamboo rather than wood results in cleaner burning, and since bamboo matures much faster than wood, deforestation is reduced as supply can be replenished faster.^[167]

Reforestation

In many parts of the world, especially in East Asian countries, reforestation and afforestation are increasing the area of forested lands.^[171] The amount of woodland has increased in 22 of the world's 50 most forested nations. Asia as a whole gained 1 million hectares of forest between 2000 and 2005. Tropical forest in El Salvador expanded more than 20% between 1992 and 2001. Based on these trends, one study projects that global forest will increase by 10%—an area the size of India—by 2030.^[172]

In the People's Republic of China, where large scale destruction of forests has occurred, the government has in the past required that every able-bodied citizen between the ages of 1 and 60 plant three to five trees per year or do the equivalent amount of work in other forest services. The government claims that at least 1 billion trees have been planted in China every year since 1982. This is no longer required today, but 12 March of every year in China is the Planting Holiday. Also, it has introduced the Green Wall of China project, which aims to halt the expansion of the Gobi desert through the planting of trees. However, due to the large percentage of trees dying off after planting (up to 75%), the project is not very successful. There has been a 47-million-hectare increase in forest area in China since the 1970s.^[172] The total number of trees amounted to be about 35 billion and 4.55% of China's land mass increased in forest coverage. The forest coverage was 12% two decades ago and now is 16.55%.^[170]

An ambitious proposal for China is the Aerially Delivered Re-forestation and Erosion Control System and the proposed Sahara Forest Project coupled with the Seawater Greenhouse

In Western countries, increasing consumer demand for wood products that have been produced and harvested in a sustainable manner is causing forest landowners and forest industries to become increasingly accountable for their forest management and timber harvesting practices.

The Arbor Day Foundation's Rain Forest Rescue program is a charity that helps to prevent deforestation. The charity uses donated money to buy up and preserve rainforest land before the lumber companies can buy it. The Arbor Day Foundation then protects the land from deforestation. This also locks in the way of life of the primitive tribes living on the forest land. Organizations such as Community Forestry International, Cool Earth, The Nature Conservancy, World Wide Fund for Nature, Conservation International, African Conservation Foundation and Greenpeace also focus on preserving forest habitats. Greenpeace in particular has also mapped out the forests that are still intact^[173] and published this information on the internet.^[174] World Resources Institute in turn has made a simpler thematic map^[175] showing the amount of forests present just before the age of man (8000 years ago) and the current (reduced) levels of forest!^[176] These maps mark the amount of afforestation required to repair the damage caused by people.

Forest plantations

In order to acquire the world's demand for wood, it is suggested that high yielding forest plantations are suitable according to forest writers Botkins and Sedjo. Plantations that yield 10 cubic meters per hectare a year would supply enough wood for trading of 5% of the world's existing forestland. By contrast, natural forests produce about 1–2 cubic meters per hectare; therefore, 5–10 times more forestland would be required to meet demand. Forester Chad Oliver has suggested a forest mosaic with high-yield forest lands interspersed with conservation land.^[177]

Globally, planted forests increased from 4.1% to 7.0% of the total forest area between 1990 and 2015.^[478] Plantation forests made up 280 million ha in 2015, an increase of about 40 million ha in the last ten years.^[179] Globally, planted forests consist of about 18% exotic or introduced species while the rest are species native to the country where they are planted. In South America, Oceania, and East and Southern Africa, planted forests are dominated by introduced species: 88%, 75% and 65%, respectively. In North America, West and Central Asia, and Europe the proportions of introduced species in plantations are much lower at 1%, 3% and 8% of the total area planted, respectively.^[178]

In the country of Senegal, on the western coast of Africa, a movement headed by youths has helped to plant over 6 million mangrove trees. The trees will protect local villages from storm damages and will provide a habitat for local wildlife. The project started in 2008, and already the Senegalese government has been asked to establish rules and regulations that would protect the new mangrove forests.^[180]

Military context

While the preponderance of deforestation is due to demands for agricultural and urban use for the human population, there are some examples of military causes. One example of deliberate deforestation is that which took place in the U.S. zone of occupation in Germany after World War II. Before the onset of the Cold War, defeated Germany was still considered a potential future threat rather than potential future ally. To address this threat, attempts were made to lower German industrial potential, of which forests were deemed an element. Sources in the U.S. government admitted that the purpose of this was that the "ultimate destruction of the war potential of German forests." As a consequence of the practice of clear-felling, deforestation resulted which could "be replaced only by long forestry development over perhaps a century"^[181]



American Sherman tanks knocked out by Japanese artillery on Okinawa.

Deforestation can also be one consequence of war. For example, in the 1945 Battle of Okinawa, bombardment and other combat operations reduced the lush tropical landscape into "a vast field of mud, lead, decay and maggots".^[182] Deforestation can also be an intentional tactic of military forces. Defoliants (like Agent Orange or others) was used by the British in the Malayan Emergency, and by the United States in the Korean War and Vietnam War.^{[183][184][185]}

Public health context

Deforestation eliminates a great number of species of plants and animals which also often results in an increase in disease.^[186] Loss of native species allows new species to come to dominance. Often the destruction of predatory species can result in an increase in rodent populations which can carry plague. Additionally, erosion can produce pools of stagnant water that are perfect breeding grounds for mosquitos, well known vectors of malaria, yellow fever, nipah virus, and more.^[187] Deforestation can also create a path for non-native species to flourish such as certain types of snails, which have been correlated with an increase in schistosomiasis cases.^{[186][188]}

Deforestation is occurring all over the world and has been coupled with an increase in the occurrence of disease outbreaks. In Malaysia, thousands of acres of forest have been cleared for pig farms. This has resulted in an increase in the zoonosis the Nipah virus.^[189] In Kenya, deforestation has led to an increase in malaria cases which is now the leading cause of morbidity and mortality the country.^{[190][191]} A 2017 study in the American Economic Review found that deforestation substantially increased the incidence of malaria in Nigeria.^[192]

Another pathway through which deforestation affects disease is the relocation and dispersion of disease-carrying hosts. This disease emergence pathway can be called "range expansion," whereby the host's range (and thereby the range of pathogens) expands to new geographic areas.^[193] Through deforestation, hosts and reservoir species are forced into neighboring habitats. Accompanying the reservoir species are pathogens that have the ability to find new hosts in previously unexposed regions. As these pathogens and species come into closer contact with humans, they are infected both directly and indirectly

A catastrophic example of range expansion is the 1998 outbreak of Nipah virus in Malaysia.^[194] For a number of years, deforestation, drought, and subsequent fires led to a dramatic geographic shift and density of fruit bats, a reservoir for Nipah virus.^[195] Deforestation reduced the available fruiting trees in the bats' habitat, and they encroached on surrounding orchards which also happened to be the location of a large number of pigsties. The bats, through proximity spread the Nipah to pigs. While the virus infected the pigs, mortality was much lower than among humans, making the pigs a virulent host leading to the transmission of the virus to humans. This resulted in 265 reported cases of encephalitis, of which 105 resulted in death. This example provides an important lesson for the impact deforestation can have on human health.

Another example of range expansion due to deforestation and other anthropogenic habitat impacts includes the Capybara rodent in Paraguay.^[196] This rodent is the host of a number of zoonotic diseases and, while there has not yet been a human-borne outbreak due to the movement of this rodent into new regions, it offers an example of how habitat destruction through deforestation and subsequent movements of species is occurring regularly

A now well-developed theory is that the spread of HIV it is at least partially due deforestation. Rising populations created a food demand and with deforestation opening up new areas of the forest the hunters harvested a great deal of primate bushmeat, which is believed to be the origin of HIV^[186]

See also

- | | | |
|---|---|----------------------------------|
| ▪ <u>Assarting</u> | ▪ <u>Ecoforestry</u> | ▪ <u>Lumberjack</u> |
| ▪ <u>Biochar</u> | ▪ <u>Economic impact analysis</u> | ▪ <u>Moisture recycling</u> |
| ▪ <u>Clearcutting</u> | ▪ <u>Environmental issues with paper</u> | ▪ <u>Mountaintop removal</u> |
| ▪ <u>Deforestation and climate change</u> | ▪ <u>Environmental philosophy</u> | ▪ <u>Natural landscape</u> |
| ▪ <u>Deforestation by region</u> | ▪ <u>Extinction</u> | ▪ <u>Neolithic</u> |
| ▪ All pages with a title containing <i>deforestation in</i> | ▪ <u>CDM & JI A/R projects</u> | ▪ <u>Rainforest</u> |
| ▪ All pages with a title containing <i>deforestation of</i> | ▪ <u>Forestry</u> | ▪ <u>Richard St. Barbe Baker</u> |
| ▪ All pages with a title containing <i>land clearing in</i> | ▪ <u>Overpopulation</u> | ▪ <u>Satoyama</u> |
| ▪ <u>Deforestation during the Roman period</u> | ▪ <u>Illegal logging</u> | ▪ <u>Slash-and-burn</u> |
| ▪ <u>Desertification</u> | ▪ <u>Intact forest landscape</u> | ▪ <u>Slash-and-char</u> |
| | ▪ <u>International Year of Forests</u> | ▪ <u>Terra preta</u> |
| | ▪ <u>Land use, land-use change and forestry</u> | ▪ <u>Wilderness</u> |
| | | ▪ <u>World Forestry Congress</u> |

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External links

- [Global map of deforestation based on Landsat data](#)
- [JICA-JAXA Forest Early Warning System in the Tropics: JJ-FAST \(FOREST GOVERNANCE INITIATIVE\)- JICA-JAXA](#)
- [Old-growth forest zones within the remaining world forests](#)
- [EIA forest reports](#) Investigations into illegal logging.
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- [Cocaine destroys 4 m2 of rainforest per gram](#) The Guardian
- ["Avoided Deforestation" Plan Gains Support- Worldwatch Institute](#)
- [OneWorld Tropical Forests Guide](#)
- [Some Background Info to Deforestation and REDD+](#)
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Films online

- Watch the [National Film Board of Canada](#) documentaries [Battle for the Trees](#) & [Forest in Crisis](#)
- [Video on Illegal Deforestation In Paraguay](#)

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