Bio Factsheet

Number 27

Biological Effects of Deforestation

Forests help to regulate atmospheric composition and the hydrological cycle. They also help to form and then maintain soil structure and provide a habitat for millions of species. This Factsheet will summarise the most important features of these roles and the consequences of deforestation.

Atmospheric composition

By absorbing carbon dioxide during photosynthesis, forests help to maintain its atmospheric concentration. This is important because carbon dioxide is a greenhouse gas - it absorbs outgoing longwave radiation which warms the lower atmosphere (troposphere) keeping it at an average temperature of about 17°C warmer than it would otherwise be. The greenhouse effect is therefore essential to life on Earth.

However, increasing combustion of fossil fuels has caused global carbon dioxide concentrations to increase and this has accelerated the greenhouse effect. In practice, the climate of some areas will become warmer whilst that of other areas will become cooler. Thus, the biological effects of the greenhouse effect will differ in different countries. By absorbing carbon dioxide, trees and forests slow down the enhanced greenhouse effect. Scientists have estimated that the stems, roots and leaves of moist tropical forests account for 30% to 40% of the Earth's terrestrial living carbon pool. Felling and burning such forests will clearly lead to an increase in atmospheric carbon dioxide concentrations. More carbon dioxide in the atmosphere means higher average temperatures. The resulting thermal expansion and ice melt will lead to the rise of sea levels and this will dramatically affect or even destroy coastal habitats.

There is some evidence that forest destruction, particularly in the tropics and in hot, arid areas, initiates a vicious cycle; large scale deforestation reduces transpiration, rainfall and average relative humidity, all of which further increases the risk of fire which is then capable of destroying even more forest. Possible examples of this have been seen recently in South East Asia, Brazil and parts of Australia.

Hydrological Cycle

Forest canopies **intercept** rainfall, absorbing the energy of the raindrops, reducing their velocity and therefore the force with which they hit the soil. Following deforestation, the kinetic energy of raindrops causes splash erosion. When falling to the ground, the soil particles may then be carried away in surface run-off or may block the soil pores, resulting in a sealing crust of very fine silt and clay particles. Surface run-off is then accelerated and this may lead to gullying and downstream flooding.

Forests effectively **store** water. The rainfall intercepted by leaves, twigs and branches drips slowly from leaf to leaf or down the stem of the trees. Much of the rain evaporates before it reaches the ground. So forest canopies not only **slow down** movement of rain to the soil but they also **decrease** the **total volume** which reaches the soil. Thus, deforestation increases the volume and velocity of rainfall reaching soil and accelerates soil erosion or leaching - the downward movement of soluble nutrients through the soil profile. Both soil erosion and leaching will decrease the overall productivity of the soil. The decomposition of leaves, twigs, fruits and branches returns essential nutrients such as nitrates and phosphates to the soil. Decomposing foliage provides humus which helps soil particles bind together and increases the water holding capacity of the soil. In turn, both of these help to prevent soil erosion. Tree roots physically bind the soil and the microclimatic effect of forests reduces temperature extremes and wind levels below the canopy. The role of forests in conserving soil is crucial in the tropics. Tropical rainforest soils are often infertile; the lush vegetation and high primary productivity are a consequence of high temperatures, high rainfall and extremely fast recycling. Unlike temperate forests, nutrients are locked in the biomass i.e. the trees above the ground, rather than in the soil (Fig 1).

Fig 1. The distribution of inorganic nutrients above and below ground in three Tropical Rainforest areas

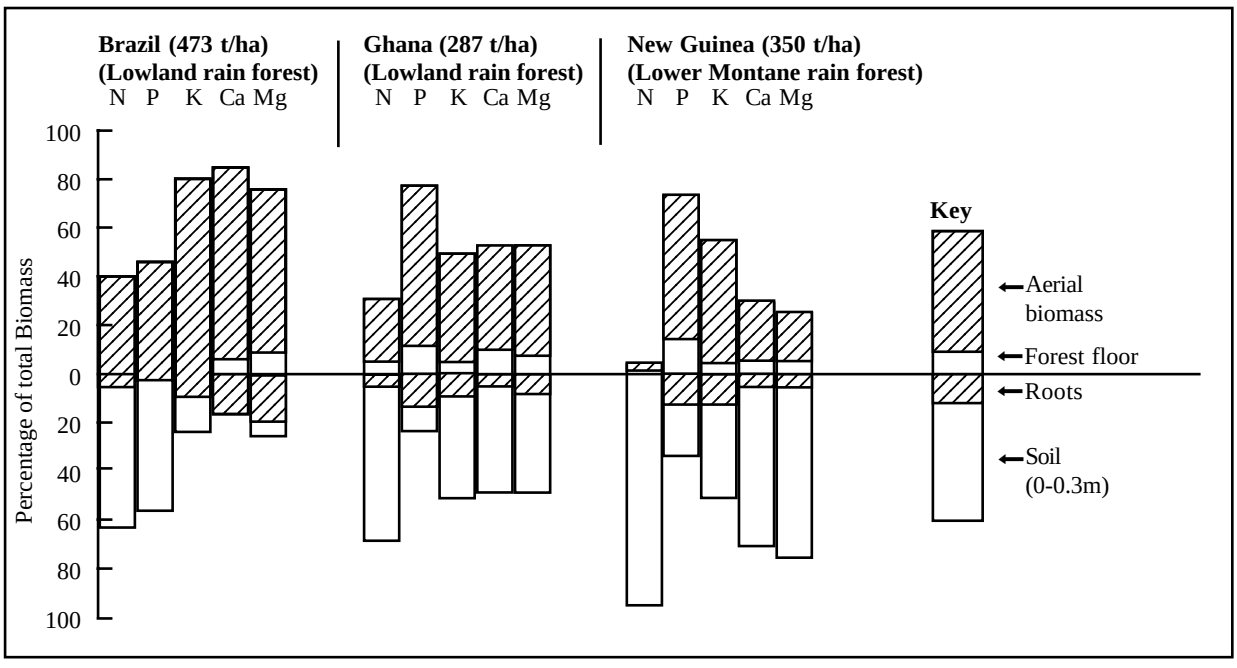
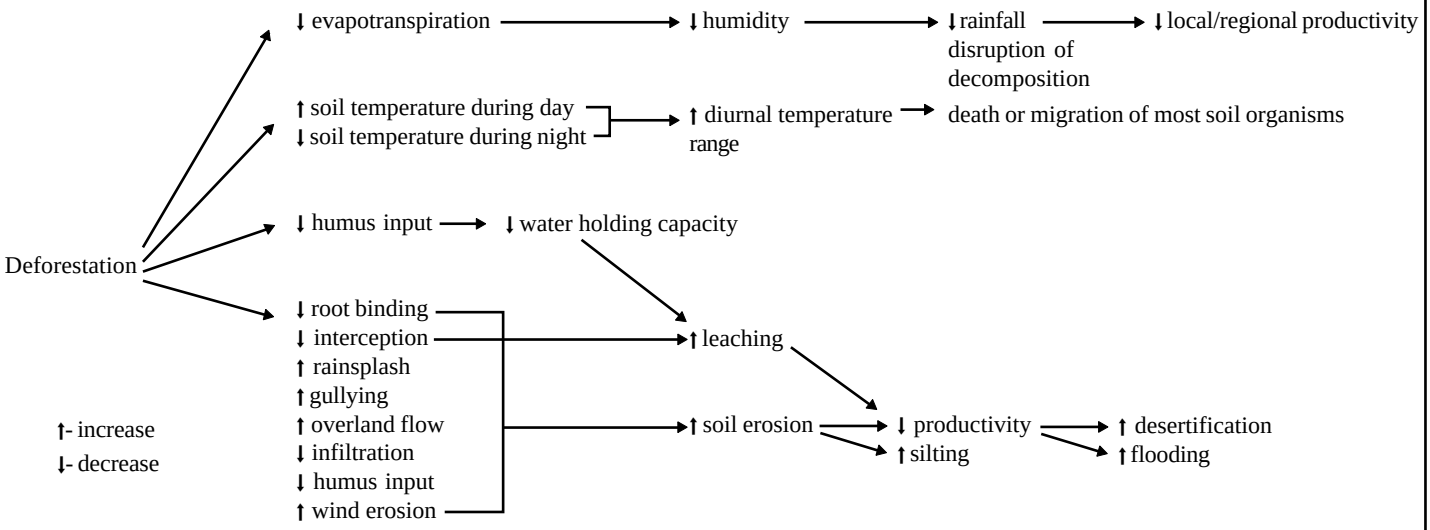


Fig 2. Biological effects of deforestation



Chopping down and removing an area of tropical rainforest therefore has a much greater effect on soil quality (structure and nutrient levels) than felling an equivalent area of temperate forest. Rainforest clearance effectively removes the nutrients from that area forever - the resulting infertile soil may quickly erode.

In the tropics, tree roots may extend 40m below the surface of the soil, absorbing water from deep aquifers and returning it to the atmosphere via transpiration. Tropical forests made up of deciduous species which possess wide vessels within their xylems may transpire thousand of gallons of water daily. The release of so much moisture to the atmosphere may result in forests creating their own clouds - hence the term tropical rainforests. Deforestation may therefore reduce local or even regional humidity levels, eventually increasing the aridity of the area.

Succession

Depending upon how the trees are removed, the deforested area may still be covered in ground vegetation or it may be entirely bare. However, in either case, the removal of the trees may have a dramatic effect on the growth and species composition of any vegetation which is left behind or which develops. The change to the microclimate (localised temperature, moisture levels, wind speeds etc.) along with the great reduction in root competition, will affect the ground vegetation and will benefit some species more than others. In other words, deforestation may dramatically alter the pattern of succession. The size and shape of a deforested area is crucial in this but in all cases, new trees will emerge from seeds, roots, stumps or even fallen trees. Within a woodland, light intensity is the usual limiting factor for the herbs, shrubs and young trees below the canopy. Deforestation may therefore simply benefit the light dependent species at the expense of shared tolerant species.

Biodiversity

Tropical rainforests contain 40-50% of the planet's species but destruction of any natural forest, whether tropical or temperate, will reduce biodiversity. Deforestation leads to species extinction and the loss of food chains and webs which we know little about. As a general rule, complex ecosystems are the most stable and since all ecosystems are in some ways interconnected, forest destruction threatens global stability. Deforestation destroys genetic material which may be of great scientific and economic value. Humans have only studied a tiny percentage of the plants and animals which live in the tropical rainforests and only a fraction of these have been genetically studied. It seems likely that the genetic diversity contained in such ecosystems will prove to be of immense value and this is one of the major justifications of forest conservation.

Practice Question

The table shows soil characteristics as measured in 1994 and 1997 of an area of deciduous woodland in Wales. 90% of the woodland was cleared in the winter of 1995.

Temperature	1994	1997
Mean soil temperature (°C) - Day	9.1	11.5
Mean soil tmperature (°C) - Night	5.2	3.0
Soil moisture content (%)	32	21
Soil nitrogen (mg/kg)	13.6	2.3
Soil potassium (mg/kg)	11.0	1.9
Soil calcium (mg/kg)	15.3	4.8
pH	7.4	6.9

(a) Suggest what effect these changes will have had on the rate of decomposition. Explain your answer. (2 marks)

(b) Suggest an explanation for the changes in soil nutrient levels. (1 mark)

Answer

Semicolons indicate marking points.

(a) Either: Increases the rate of decomposition because there is a higher soil temperature during the day;
rate of respiration of decomposers increase;
Or: Decreases it because lower soil temperature at night/diurnal range hostile;
pH decreases therefore there are less earthworms/lower moisture level, inhibits microbial activity;

(b) Decreased interception, increased leaching/decreased release of nutrients from decomposition;

Acknowledgements;
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