Population and atmosphere

PEOPLE have been altering the atmosphere on a small scale ever since they learnt to make fire. But today's fires and industrial processes create so much smoke, gas and particulate matter that they can degrade ecosystems hundreds of kilometers away and threaten to transform climate worldwide.

Wherever humans have lived in dense settlements, pollution from smoke and gases has been a problem. The first attempt to ban coal burning to reduce smoke in London was in 1273[1]. But during the industrial age the amount of fossil-fuel burning – in the form of coal, oil and gas – has risen steeply. All these fuels generate smoke and gaseous compounds when burnt, producing a series of chemical reactions with oxygen in the air to create sulfur dioxide (SO_2), oxides of nitrogen (NO_X) and carbon dioxide (CO_2). Between 1800 and the mid-1990s, the world population increased sixfold, while global CO_2 emissions rose 800-fold over the same period, notably from burning fossil fuels[2]. Growing wealth and new fuel-burning technologies, particularly for generating electricity and powering the internal combustion engine, drove this.

Industrialization has also added to the range of pollutants in the air. A variety of synthetic compounds, invented mostly in the 20th century, are now widely dispersed in the atmosphere. These include certain pesticides and compounds containing chlorine and bromine used as inert gases in refrigerators and sprays and as solvents. The volume of all these emissions to the air, and the persistence of some of them, has caused their build-up and transformation in the atmosphere to levels that cause ecological damage on a wide, and sometimes global, scale.

SO_2 and NO_X both acidify water droplets in the air. The resulting acid deposition (through rain, fog or snow) may fall locally or travel long distances in clouds. Below a pH of 4, it can acidify soils and leach metals from them, poisoning trees. And it can make lakes and streams too acidic for some fish, such as the brown trout. In the 19th century, European acidification of ecosystems was confined to regions close to industrial centers such as the German Hartz mountains and the English Pennines, where tree growth became patchy. But in the mid-20th century increased fossil-fuel burning caused the first internationally recognized case of transboundary air pollution – with German, British and Polish pollution causing acid deposition and fish deaths, particularly in Scandinavia[3].

In other atmospheric chemical transformations, NO_X reacts with hydrocarbons in sunlight to create a new range of photochemical pollutants, notably low-level ozone, the component of smog most dangerous to human health and crops[4]. Atmospheric emissions of nitrogen compounds also add to those from intensive agriculture, sewage discharges and the cultivation of leguminous crops to disrupt the global nitrogen cycle, causing overfertilization of both marine and terrestrial ecosystems[5].

In the latter half of the 20th century, it became clear that other pollutants were accumulating globally. Pesticides such as DDT and toxaphene, and industrial synthetic compounds such as polychlorinated biphenyls (PCBs), collectively known as persistent organic pollutants (POPs),

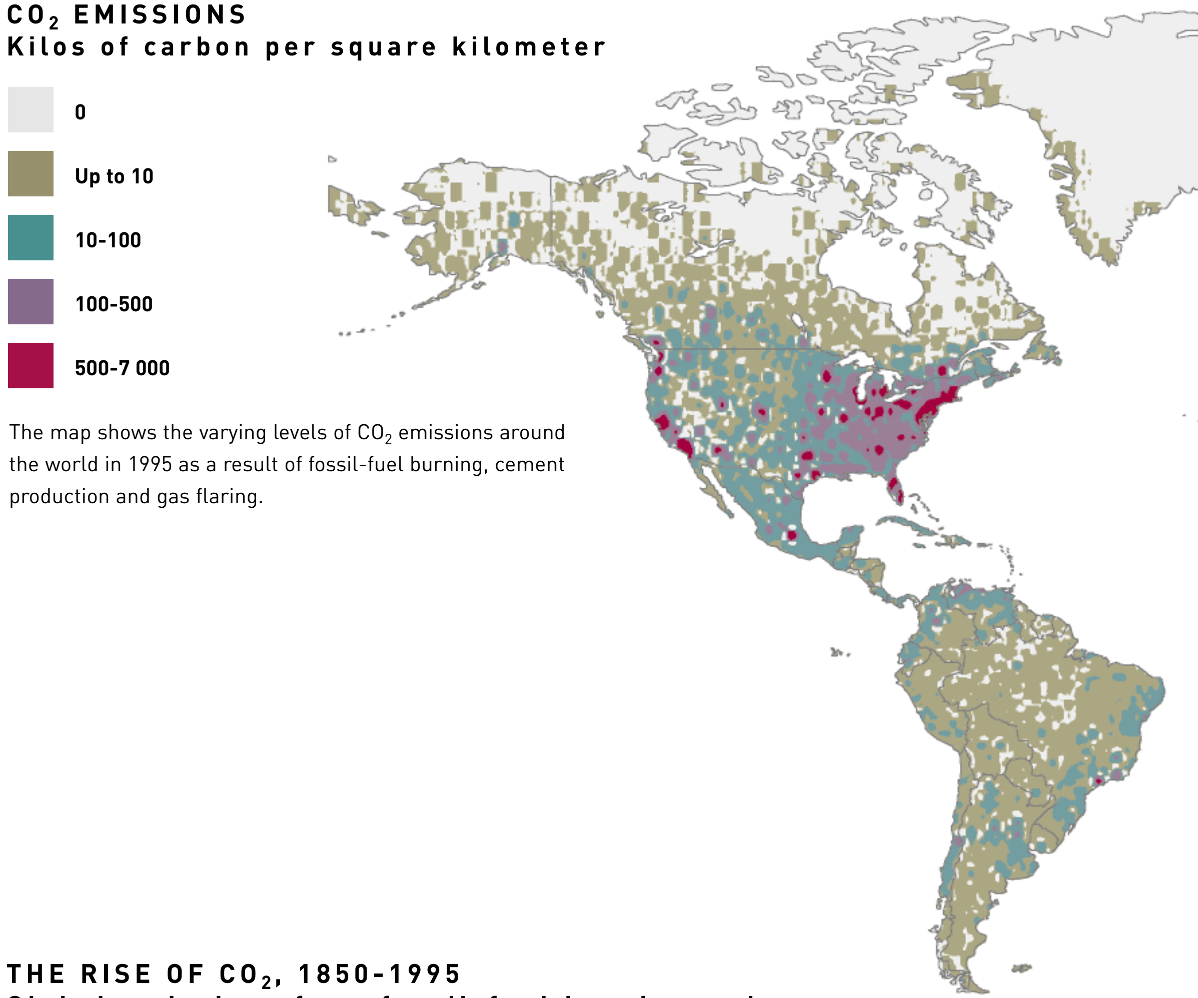
THE TEN BIGGEST PER-CAPITA CO_2 EMITTERS, 1995

	Emissions* Metric tons	GDP per capita US$ 1995
United Arab Emirates	30.9	17 696
Kuwait	28.8	15 760
USA	20.5	26 026
Singapore	19.1	25 156
Norway	16.7	33 692
Australia	16.2	19 522
Canada	14.8	19 350
Saudi Arabia	13.9	6 875
Trinidad and Tobago	13.3	4 139
Kazakhstan	13.2	1 273

* From fossil-fuel burning and cement manufacture

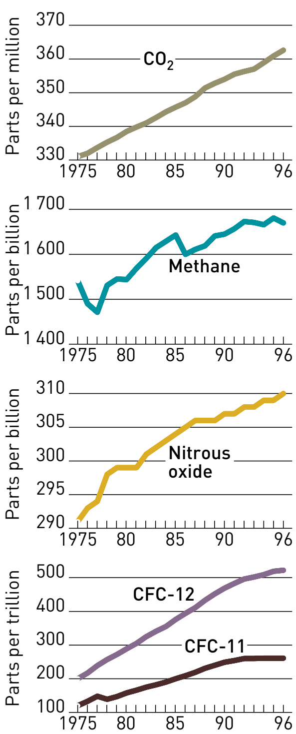
Source: WRI.

CO_2 EMISSIONS
Kilos of carbon per square kilometer



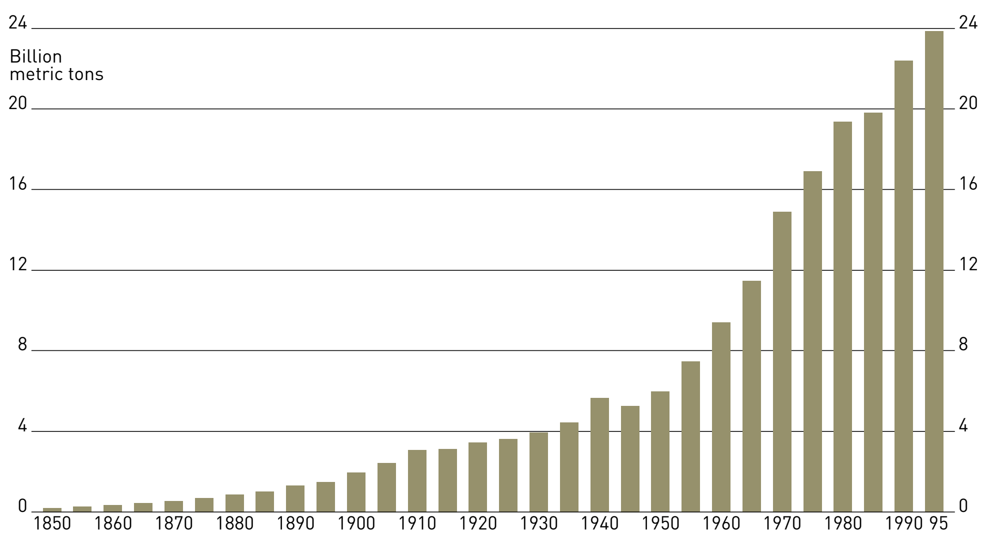
The map shows the varying levels of CO_2 emissions around the world in 1995 as a result of fossil-fuel burning, cement production and gas flaring.

ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE AND OZONE-DEPLETING GASES



Source: WRI.

THE RISE OF CO_2, 1850-1995
Global emissions from fossil-fuel burning and cement manufacture



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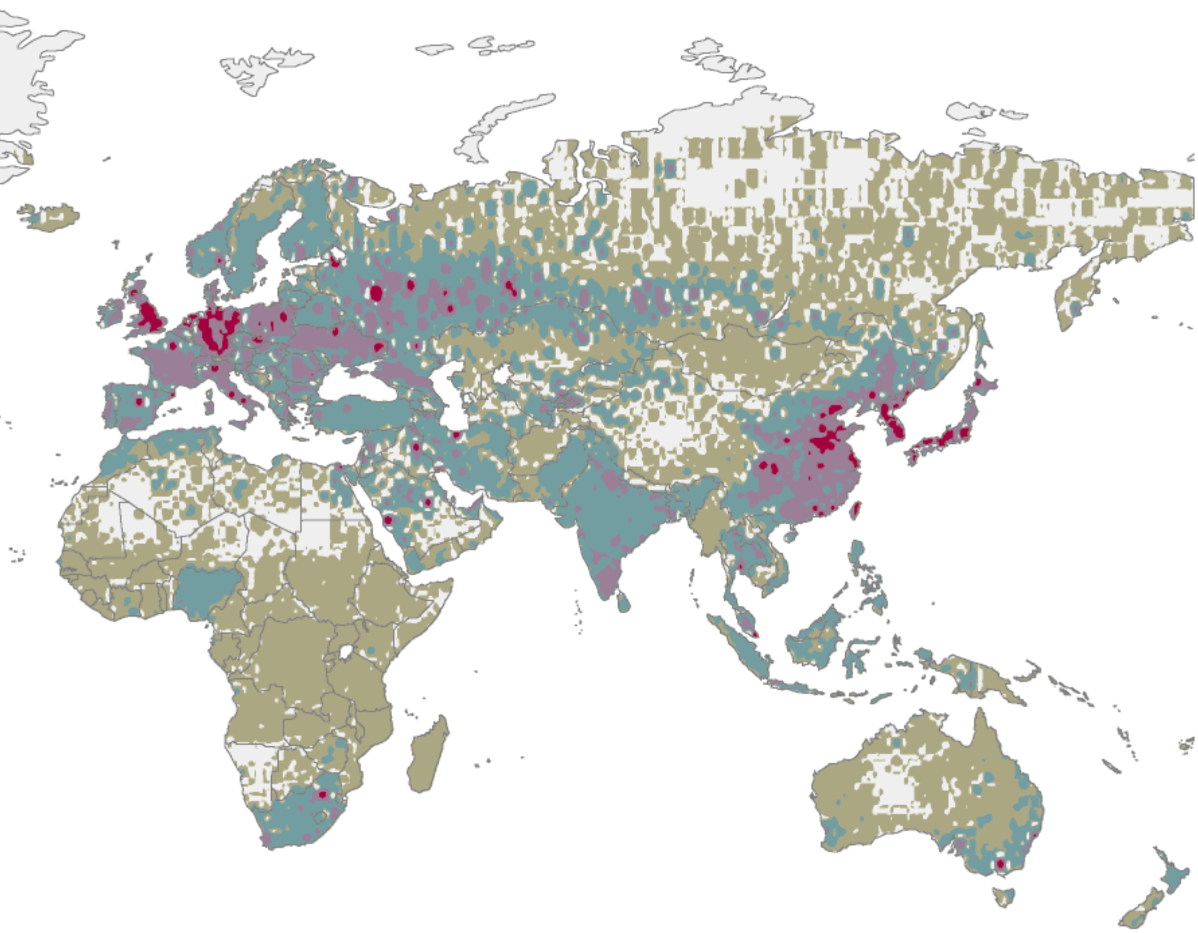
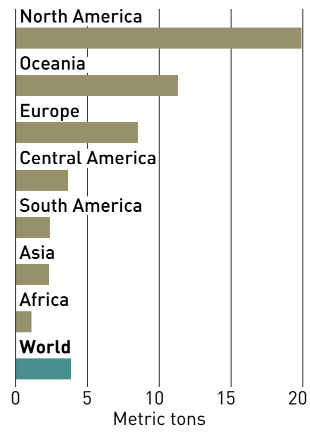


Source: CDIAC.

PER-CAPITA CO_2 EMISSIONS, 1995
By region



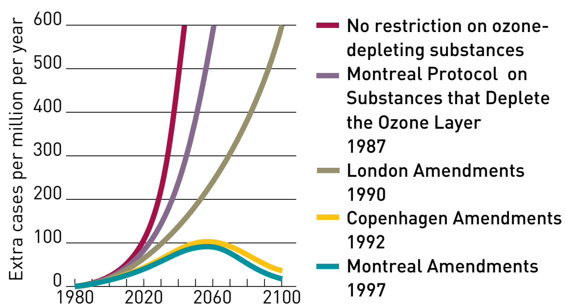
Source: WRI.

THE OZONE HOLE
South polar minimum ozone, September 10, 2000

On September 10, 2000, NASA recorded the biggest ever area of minimum Dobson units of ozone, measuring around 28.4 million square kilometers. Later that month, an all-time low of only 98 Dobson units was recorded, though over a smaller area.

Source: NASA.

OZONE DEPLETION AND SKIN CANCER
Levels of risk under the Montreal Protocol



Source: EEA.

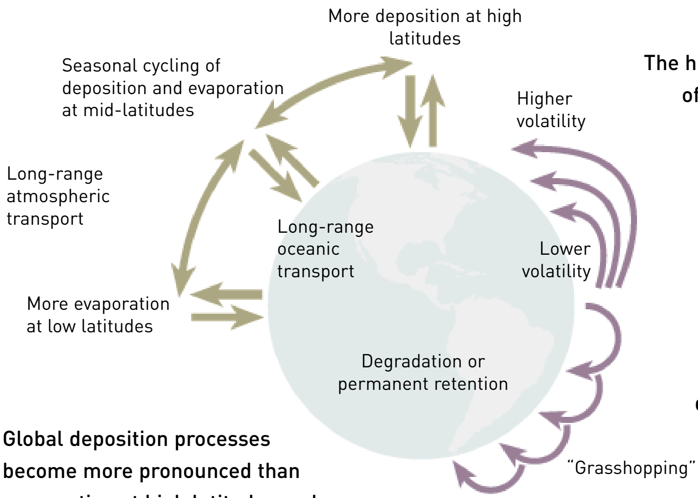
OZONE LOSSES AND UV-B INCREASES, 1998

	% ozone loss	% UV-B increase
Northern hemisphere, mid-latitudes		
winter/spring	6	7
summer/fall	3	4
Southern hemisphere, mid-latitudes		
year-round	5	6
Antarctic spring	50	130
Arctic spring	15	22

Note: Figures are approximate and assume that other factors, such as cloud cover, are constant.

Source: UNEP.

GLOBAL DISTILLATION: THE MIGRATION PROCESS OF POPs



The higher the volatility of the chemical, the more likely it is to reach the poles.

Chemicals may travel to the poles in several steps, sometimes taking decades before degrading or being permanently retained.

Global deposition processes become more pronounced than evaporation at high latitudes and lower temperatures.

Source: UNEP.

have been recognized as dangerous since the early 1960s – they are toxic, soluble in fat, and accumulate in body tissue[6]. But in the 1990s two further concerns emerged: first that they are "endocrine disrupters", disrupting hormone systems and threatening the health of both wildlife and humans[7]; and, secondly, that many are now accumulating in ecosystems globally – sometimes at higher concentrations than are present where they are first released. In a process known as "global distillation", many of these substances evaporate into the air where they are released and then preferentially settle out in the colder air of the polar regions. Though global emissions of most POPs are falling, their presence in Arctic ecosystems continues to rise and concentrations in the diets of some Arctic inhabitants exceed tolerable daily intakes[8]. POPs are currently the subject of negotiations intended to bring them under a global agreement, with some being phased out and others tightly controlled.

Chlorofluorocarbons (CFCs), halons and other chlorine and bromine compounds were identified as a potential threat to stratospheric ozone in the 1970s. By the late 1980s, they had thinned the ozone layer at all latitudes by around 5 percent, and, in the freezing air over the Arctic and Antarctic, created ozone "holes" in which 50 to 80 percent of the ozone was destroyed for several weeks each spring[9].

The current use of ozone-depleting chemicals is strongly regulated by international political agreement – notably the Montreal Protocol of 1987 – which called for production phase-out in the developed world by 1996, with a more gradual phase-out in developing countries. Though production phase-out in developed nations has been partly counterbalanced by growing production in developing nations, particularly China, production in these countries has been frozen at 1999 levels and must be phased out for most uses by 2009[10]. The ozone layer itself will take another half century to recover.

The most fundamental effect of atmospheric pollution has been on the global carbon cycle. Carbon is a key element for life. It makes up half the mass of plants and animals[11] and, as CO_2, it is a major "greenhouse gas" responsible for maintaining the atmospheric temperature at levels fit for those organisms.

In the past 150 years, human activity has released more than 350 billion tons of carbon into the air in the form of CO_2. Though up to a half is currently absorbed by oceans or terrestrial ecosystems, this has been sufficient to raise CO_2 concentrations in the air by 30 percent since pre-industrial times[12]. Carbon is also present in the second most important anthropogenic greenhouse gas, methane, produced in agricultural activities such as rice paddies, the domestication of ruminants and the clearance of natural vegetation. The industrial age has seen a 145 percent rise in methane concentrations in the atmosphere[13].

The cumulative effect of different air pollution is reducing the atmosphere's ability to cleanse itself. Most pollutants are removed from the atmosphere through oxidation by the hydroxyl radical. Some research suggests that hydroxyl levels in the atmosphere, particularly temperate northern latitudes, are falling[14]. As a result, some compounds are lasting longer in the air than before, causing ever more pollution.