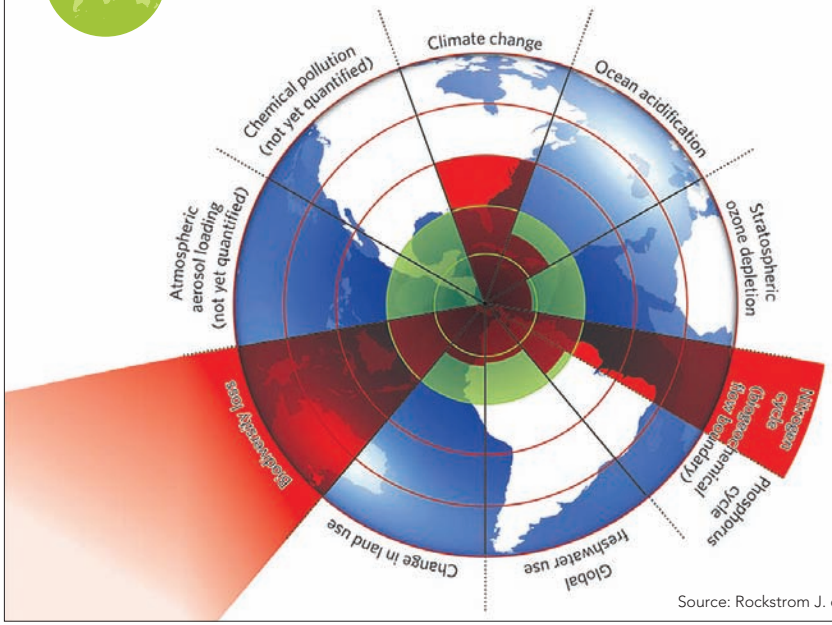
II. STRESSES ON ECOSYSTEMS

GENERAL TRENDS

Recent research published in the journal Nature defines, for eight earth biophysical subsystems or processes, "safe" threshold boundaries that should not be exceeded to avoid major environmental disruptions. Already several thresholds appear to have been exceeded, including: climate change (as measured by excess CO_2 concentration in the atmosphere); the rate of biodiversity loss (terrestrial and marine); and interference with the nitrogen cycle (N_2 is removed from the atmosphere and converted to reactive nitrogen for human use mainly for agriculture). Interference with the global phosphorous cycle, ocean acidification, global freshwater use, and change in land use are approaching their thresholds. No boundaries have yet been established for chemical pollution and atmospheric aerosol loading. Stratospheric ozone depletion is a noteworthy exception, where international environmental cooperation has yielded progress in reversing a negative trend.

Earth's biophysical subsystems or processes and their safe threshold boundaries

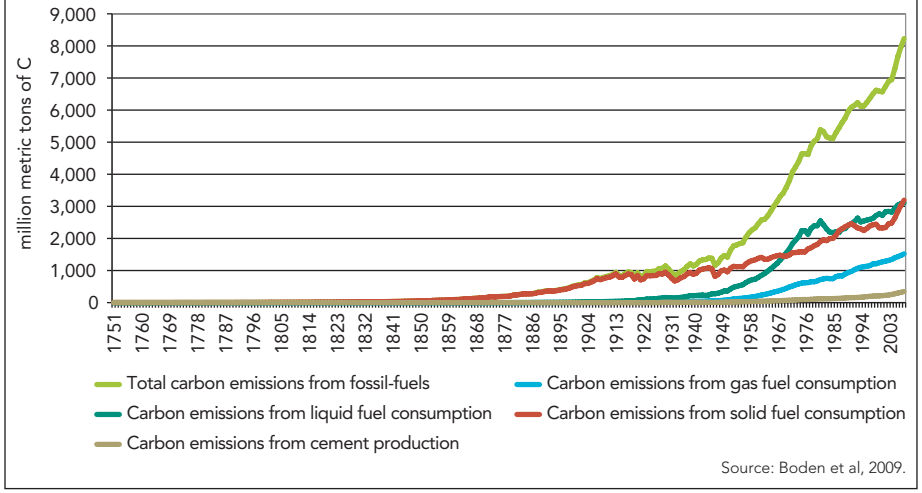


Source: Rockstrom J. et al., 2009.

CLIMATE CHANGE

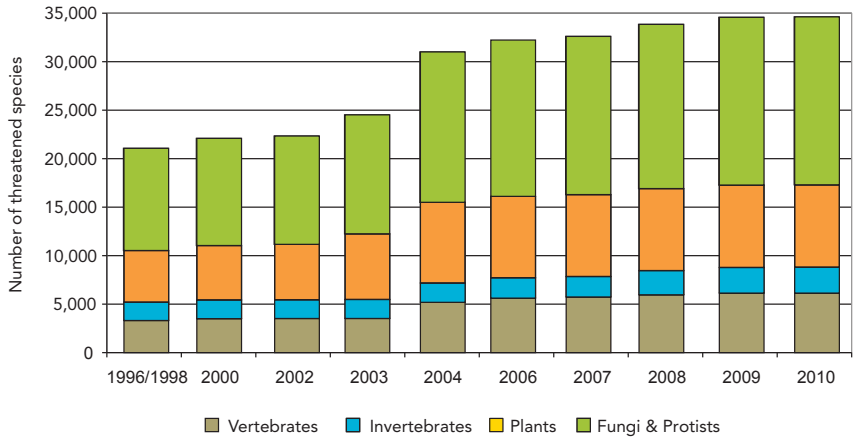
CO_2 emissions have been rising steadily: Since 1751 approximately 329 billion tons of carbon have been released to the atmosphere from the consumption of fossil fuels and cement production. Half of these emissions have occurred since the mid 1970s.

Carbon emissions from fossil-fuels, 1751–2006



Source: Boden et al, 2009.

Numbers of threatened species by major groups of organisms



Source: IUCN, 2010.

THE RATE OF BIODIVERSITY LOSS

The Millennium Ecosystem Assessment evaluated the ability of ecosystems to provide ecosystem services such as the provision of goods (e.g. food, water, fibre and fuel), the regulation of natural systems (e.g. climate, water and disease), cultural benefits (e.g. aesthetics, spiritual, recreation and education), and other supporting benefits (e.g. primary production and soil formation). The assessment concludes that humans have changed ecosystems in unprecedented ways over the last 50 years. Sixty percent of the world ecosystem services have been degraded, which is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted.[2]

The International Assessment on Agricultural Knowledge, Science and Technology for Development (IAASTD) finds that inappropriate fertilizer application has led to eutrophication and large dead zones in a number of coastal areas and some lakes, and inappropriate use of pesticides has led to groundwater pollution and loss of biodiversity. In addition, 1.9 billion hectares (and 2.6 billion people) are affected by significant levels of land degradation. The area of drylands has been growing steeply since the 1980s as a share of total land area. Very degraded soils are found especially in semi-arid areas, areas with high population pressure and in regions that are undergoing deforestation.

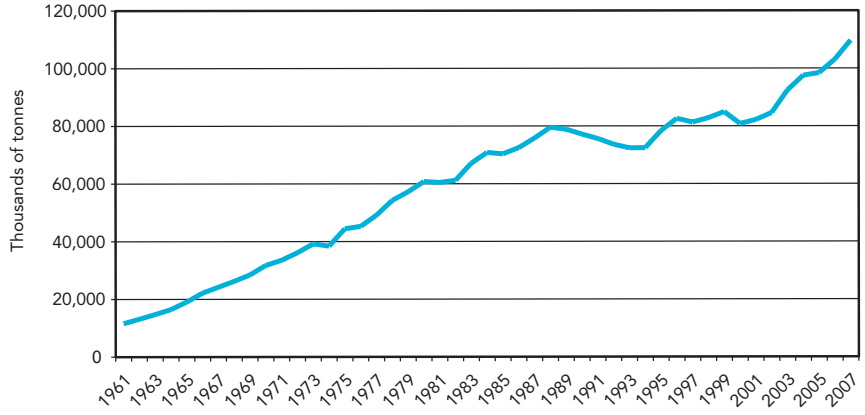
Biodiversity is highly correlated to the number and health of ecosystems. Vertebrates have been the most affected, with 10% of species threatened, followed by plant species with 3%.

INTERFERENCE WITH NITROGEN CYCLE

Nitrogen is needed to grow food but because of the inefficiencies of nitrogen uptake by plants and animals, only about 10 to 15 percent of reactive nitrogen is taken up. The rest is lost to the environment and injected into the atmosphere by combustion. This nitrogen pollutes water sources and the world's oceans, harming marine ecosystems, and contributes to global warming. Agricultural runoff and the burning of fossil fuels have boosted the supply of reactive nitrogen in the open oceans 50 percent above the normal range.[3]

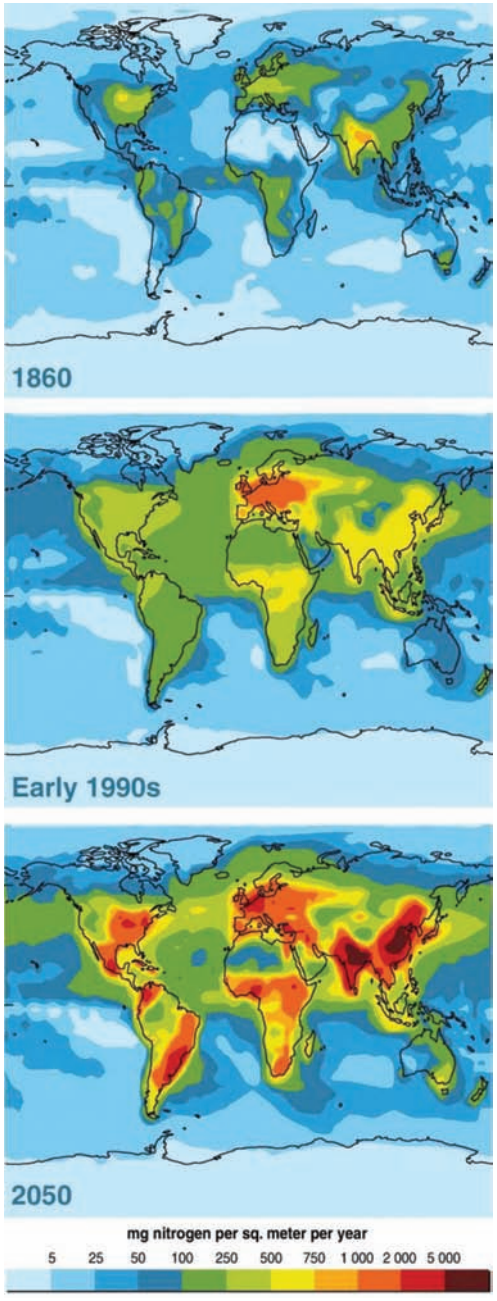
Roughly four times more nitrogen fertilizer was applied in 2000 than in 1960, and applications have increased steadily since then. This has led to increased deposition and change in the N cycle in various ecosystems. Evidence suggests very high application rates contribute to soil degradation.[4]

Consumption of nitrogenous fertilizers (N total nutrients)



Source: FAO, 2010.

Estimated total reactive nitrogen deposition from the atmosphere (wet and dry) in 1860, early 1990s, and projected for 2050



Source: UNEP/GRID-Arendal, 2005

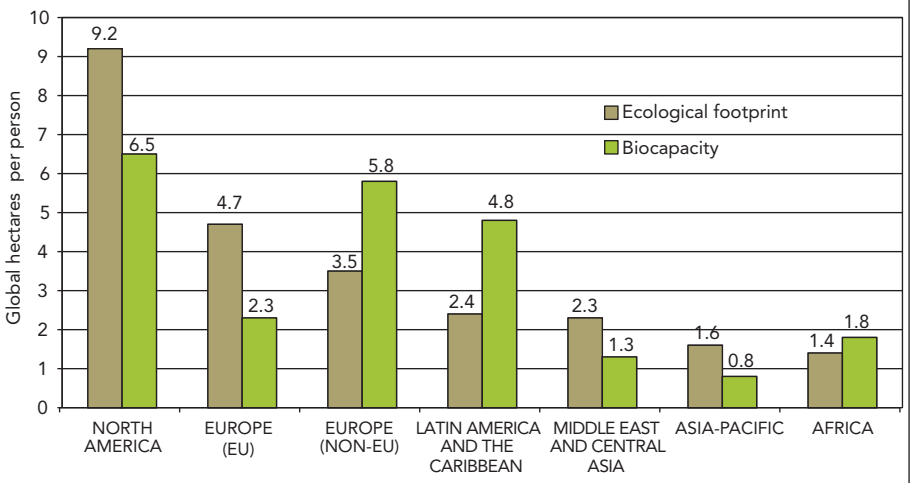
ECOLOGICAL FOOTPRINT

Ecological Footprint analysis — which compares humanity's ecological impacts to the amount of biologically productive land and sea available to supply key ecosystem services (food supply, fibre, habitat, carbon storage, etc.) — finds that the global economy started exceeding the planet's biocapacity in the 1980s, and overconsumption of resources has increased since then.

The single largest demand humanity puts on the biosphere is its carbon footprint, which has increased tenfold since 1961. The Ecological Footprint exceeds the earth capacity to regenerate by 30%. Alternatively, 1.3 planets would be needed to stay within the planet's carrying capacity.[5] This is another, simplified way of picturing planetary boundaries and ecosystem thresholds.

Under a business-as-usual scenario, 2 planets would be required by 2030 to support the world's population. This assumes a continued unequal world with 15% of the population using 50% of the resources. World Wildlife Fund (WWF) estimates that three planets would be needed now if every citizen adopted the UK lifestyle, and five planets if they adopted the average North American lifestyle.

Biocapacity and ecological footprint per capita, by region in 2005



Source: WWF, 2008.

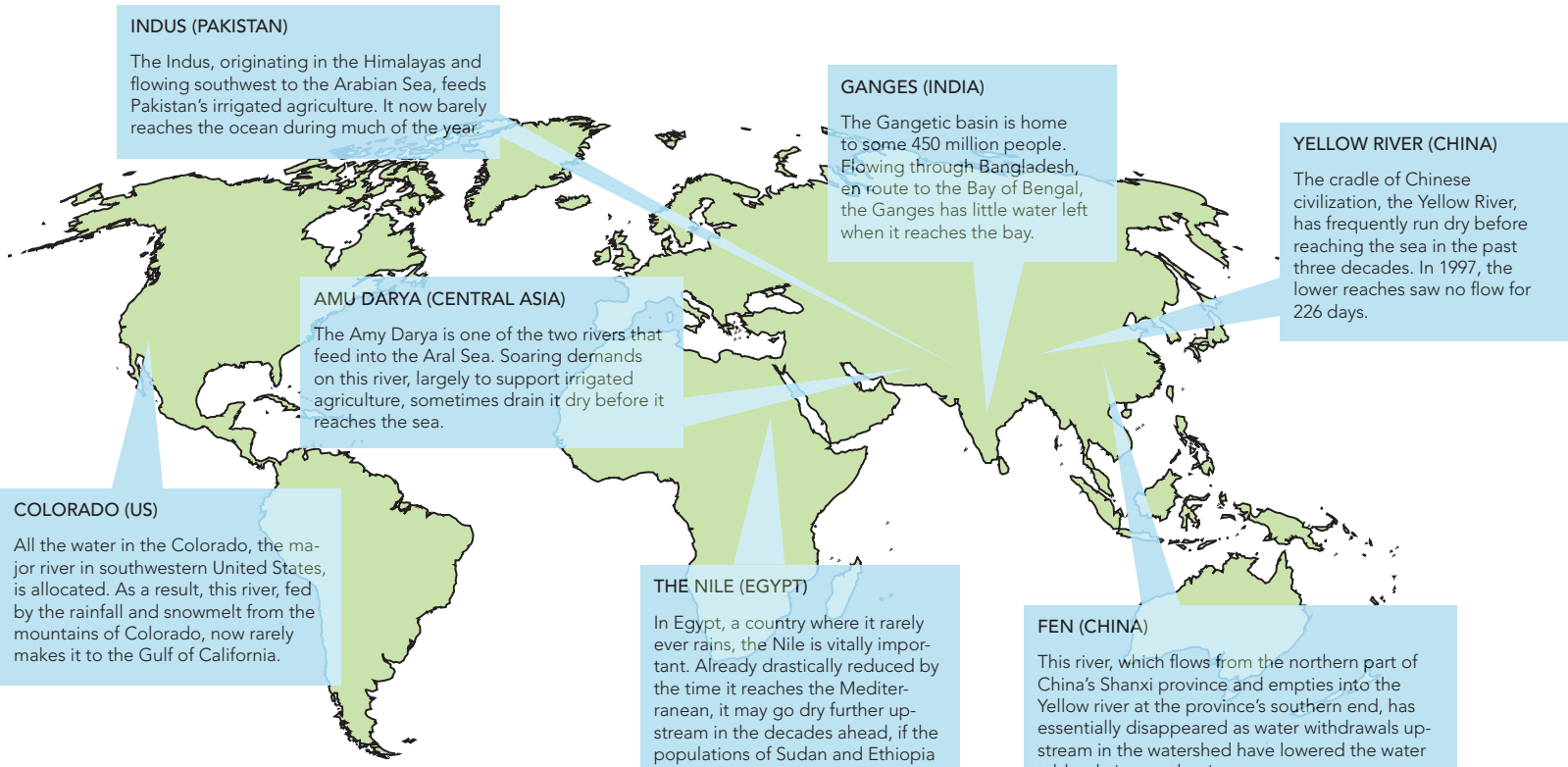
Regional differences are driven by differences in geography and climate, lifestyle, affluence, population and technological sophistication. At the regional and national level, a comparison of ecological footprints with biocapacity indicates whether countries and regions live within their biological carrying capacity (or "import" such capacity from the rest of the world).

The net balance of a country's footprint depends on its consumption compared to its biocapacity per capita.[5] Russia, Canada, the United States, Brazil, Australia, India, and Argentina have the largest biocapacity. Three of these have ecological footprints that exceed their biocapacity because of large population (China and India) or high consumption per capita (the US). Countries exceeding their biocapacity went from none in 1960 to 24 countries at present. North America, with the largest biocapacity per capita, still exceeds its biocapacity, while Africa with a relatively small biocapacity per capita and 902 million people has a biocapacity reserve.

"As ecological reserves become increasingly rare, it will become critical ... to forge new relationships and move toward policies that protect natural assets while improving health and well-being. In this game, everyone can win. Every single person will benefit from early action."

— Mathis Wackernagel, Executive Director of Global Footprint Network.

Major rivers running dry



Source: Brown L.R., 2005.

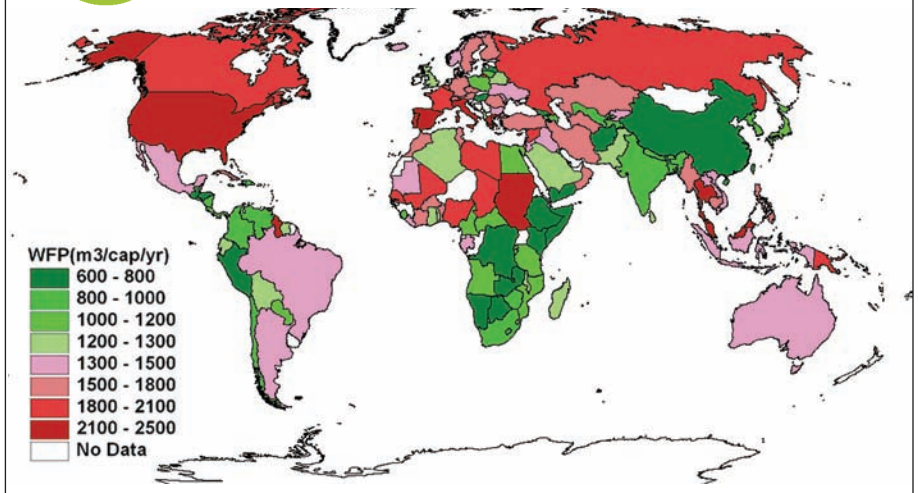
WATER FOOTPRINT

Local and regional imbalances between water availability and growing demand are a growing concern globally.

About 50 countries are already experiencing moderate to severe water stress all year round, while many others have water stresses during part of the year. Many lakes and rivers have dried out following extensive extraction and damming to irrigate agriculture.

Water-intensive agricultural products include meat, dairy products, sugar and cotton. Water use efficiency is often low, partly as a result of low water pricing or even subsidies, irrespective of scarcity. Lack of awareness of simple water saving measures among farmers and the use of water inefficient technologies also contribute. The water footprint of a country, an indicator introduced in 2002, measures the volume of freshwater used to produce the goods and services consumed by the inhabitants of a country, calculated over the product's entire global supply chain. It is composed

Average national water footprint per capita (2007)



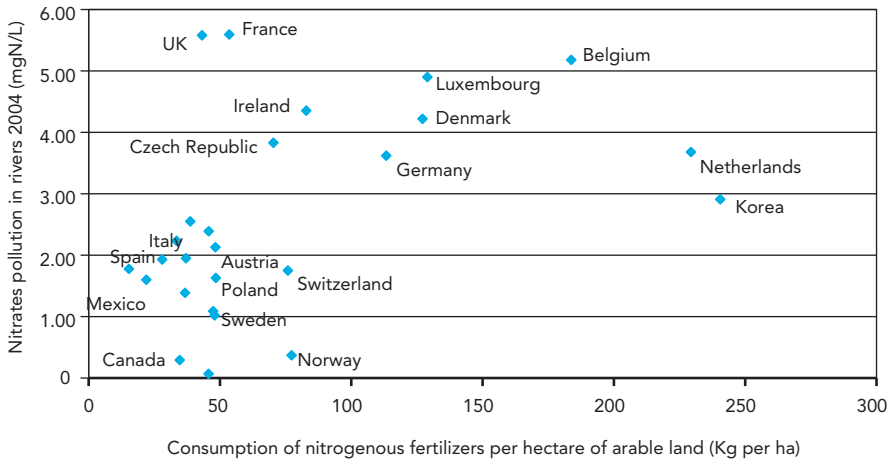
Source: Hoekstra, A.Y. & Chapagain, A.K., 2007.

of the internal and external water footprint. Internal footprint refers to the appropriation of domestic water resources and external footprint to the appropriation of water resources in other countries.

Worldwide, 27 countries have an external water footprint which accounts for more than 50 per cent of their total water consumption, that is, they depend heavily on water-embodied trade (or 'virtual water' trade).

Major rivers and lakes, which serve as sources of drinking water, are increasingly polluted from both industrial and agricultural sources, including nitrogen. Generally, river pollution increases with nitrogen use intensity, though with considerable dispersion.

The intensity of nutrient used and the pollution of rivers in OECD countries (annual mean concentrations, 1980–2004)



Source: OECD, 2010

> "You can't have sustainability if you are eating capital. Today we are consuming our natural capital."
>
> *— Pavan Sukhdev, study leader for the project on The Economics of Ecosystems and Biodiversity and the UNEP Green Economy Initiative*