WWF *for a living planet*®

EUROPE 2005
The Ecological Footprint

Global Footprint Network

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The Ecological Footprint

The European Union is firmly committed to sustainable development. It is a key principle for our policies and actions – within the EU and internationally. We want to achieve a better quality of life for all, now and in the future. This requires amongst other things safeguarding the Earth's capacity to support life in all its diversity and respecting the limits of the planet's natural resources. We need to prevent and reduce environmental pollution. We need to promote sustainable production and consumption and strike the right balance between economic growth and prosperity and the protection of environment at home and globally.

These objectives are confirmed in the Commission's recent proposal for a Declaration on Sustainable Development. Later this year this Commission will present a proposal for a new EU Sustainable Development Strategy.

I am convinced that to realise our vision, we need to engage stakeholders and citizens from across Europe and the world and get people to take real ownership of the sustainable development challenge. However, for people to do this, they need clear information on the challenges and the options available for more sustainable patterns of production, consumption and development. We also need to be able to assess progress made and target our actions which will allow all stakeholders to play their role in communicating with and engaging people. That is why I very much welcome initiatives such as this one taken by the WWF.

José Manuel Barroso
President of the European Commission

Global Footprint Network

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NOTE ON "EUROPE"

Throughout this report, except where otherwise stated, "Europe" refers to the EU-25 nations. Historical graphs referring to Europe and the EU-25 illustrate the composite of the present EU-25 nations, whether or not they were members of the EU or EEC at that time. The EU-25 nations are: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

The material and the geographical designations in this report do not imply the expression of any opinion whatsoever on the part of WWF concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries.

WWF
is one of the world's largest and most experienced independent conservation organizations, with almost 5 million supporters and a global network active in 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

GLOBAL FOOTPRINT NETWORK
promotes a sustainable economy by advancing the Ecological Footprint, a tool that makes sustainability measurable. Together with its partners, the Network coordinates research, develops methodological standards, and provides decision makers with robust resource accounts to help the human economy operate within the Earth's ecological limits.

NC-IUCN,
the Netherlands Committee for the World Conservation Union, generously provided Map 2, illustrating EU resource imports. With permission it has been modified and updated from the original (published as *The European Union and the World Ecology*) for presentation in this report.

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FOREWORD

We live on a bountiful planet, but not a limitless one. The global economy and human population continue to grow, but our planet remains the same size. Advances in technology can help us to stretch the planet's resources further – but the pace of growth in the global economy is outstripping the ability of technology to keep up.

Over 30 years ago the report *Limits to Growth* created an international controversy when its computer-generated scenarios suggested that the human economy would soon exceed the Earth's carrying capacity, leading to a decrease in industrial output and a decline in well-being in the mid-21st century.

In 2005, overshoot is no longer a hypothesis, but a reality. As shown in this report, humanity's annual demand for resources is now exceeding the Earth's regenerative capacity by more than 20 per cent, and it keeps growing. Humanity maintains this overdraft by liquidating the planet's natural resources.

Europe's demand on the biosphere plays a significant part in this. With merely 7 per cent of the world population, the European Union uses 17 per cent of the biosphere's regenerative capacity.

As a result of increasing human demand and declining ecological wealth, Europe is losing room to manoeuvre. It increasingly exports its insatiable demands for natural resources to poorer countries. To reduce this constriction and to eventually reverse these trends, we need sustainable development – which WWF defines as improving the quality of human life while living within the carrying capacity of our supporting ecosystems.

But reducing this pressure on our ecosystems is only possible if done in fair and just ways. The alternative is increasing local, regional, and global conflicts. The resource crunch may not be felt yet in Europe where resource consumption is still increasing, but many of the 5.2 billion people living in low and middle income countries – large numbers of whom struggle to meet their basic material needs – have been facing an involuntary decline in their quality of life. Addressing these growing social discrepancies will be critical to global security and all people's economic prosperity.

With a footprint more than double its own biological capacity, Europe's well-being depends on ecological capacity from elsewhere. Hence reducing its Ecological Footprint is not a philanthropic gesture, but essential for both Europe's competitiveness and its credibility as a force for international collaboration.

Time matters: the longer Europe procrastinates, the more expensive the investment required, and the greater the risk that critical ecosystems will be eroded beyond the point at which they can easily recover. As overshoot continues and Europe's and the world's ecological debt keeps accumulating, choices narrow, and present resource use becomes ever more dependent on liquidating ecological assets.

There are opportunities to break out of this downward spiral. Europe must use its undoubted intellectual, financial, social, and cultural advantages to lead the world onto a different path. The right kind of investments can encourage innovations for sustainability in the areas of food, health, nature management, mobility, and shelter. A green energy future, for instance, will not only be needed in Europe: by being ahead, Europe can guide the world with technologies that drive sustainability. Europe can build transport and city infrastructure that facilitates rather than thwarts the transition to a sustainable future.

As we embark on this new path to sustainable development we will need ways of knowing how far we have come and how far we still have to go. The measurement tools presented in this report can help us determine whether our actions get us closer to our goals.

Tony Long
Director, WWF European Policy Office

Fig. 1: **HUMANITY'S ECOLOGICAL FOOTPRINT AND BIOCAPACITY PER PERSON,** 1961–2001

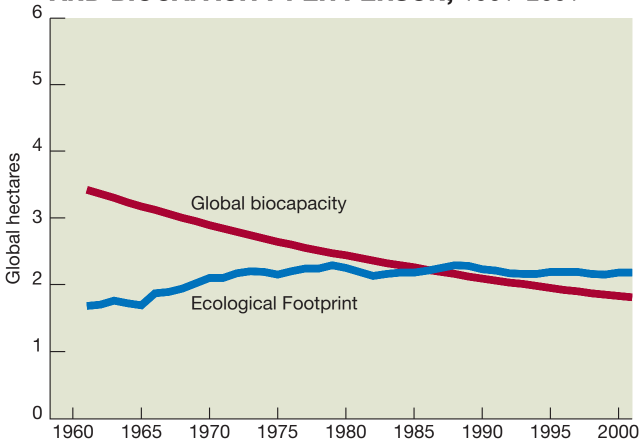


Fig. 2: **EU-25'S ECOLOGICAL FOOTPRINT AND BIOCAPACITY PER PERSON,** 1961–2001

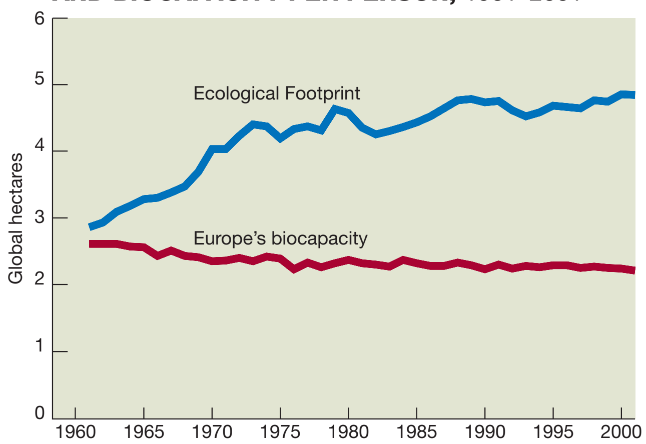


Figure 1: The Ecological Footprint measures our use of ecological resources. Biocapacity tracks the planet's biologically productive capacity. By 2001, humanity required 2.2 global hectares of productive area per person to sustain current lifestyles, 1.3 times more than in 1961. But the Earth currently has just 1.8 global hectares available per person. This overshoot of some 21 per cent depletes the Earth's natural capital, and is thus possible only for a limited period.

Figure 2: The Ecological Footprint of the EU-25 has risen by almost 70 per cent since 1961. Europeans now require 4.9 globally average hectares per person to provide for their lifestyle. As the continent can only supply 2.2 global hectares per person, Europeans rely on the rest of the world to make up this increasing deficit – effectively more than another Europe.

THE ECOLOGICAL FOOTPRINT

The Ecological Footprint measures people's demand on nature. A country's footprint is the total area required to produce the food and fibre that it consumes, absorb its waste, and provide space for its infrastructure. People consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they are on the planet. The footprint can be compared with nature's ability to renew these resources.

The global Ecological Footprint was 13.5 billion global hectares in 2001, or 2.2 global hectares per person (a global hectare is a hectare whose biological productivity equals the global average). This demand on nature can be compared with the Earth's biocapacity, based on its biologically productive area – approximately 11.3 billion global hectares, which is a quarter of the Earth's surface. The productive area of the biosphere translates into an average of 1.8 global hectares per person in 2001.

The global Ecological Footprint decreases with smaller population size, less consumption per person, and higher resource efficiency. The Earth's biocapacity increases with a larger biologically productive area and higher productivity per unit area.

In 2001, humanity's Ecological Footprint exceeded global biocapacity by 0.4 global hectares per person, or 21 per cent. This global overshoot began in the 1980s and has been growing ever since (see Figure 1). In effect, overshoot means spending nature's capital faster than it is being regenerated. Overshoot may permanently reduce ecological capacity.

Figure 3: The Ecological Footprint per person for countries with populations over 1 million.

Figure 4: Humanity's Ecological Footprint grew by about 160 per cent from 1961 to 2001, somewhat faster than population which doubled over the same period.

Figure 5: Ecological Footprint by region in 2001. The height of each bar is proportional to each region's average footprint per person, the width is proportional to its population, and the area of the bar is proportional to its total footprint.

Fig. 3: **ECOLOGICAL FOOTPRINT PER PERSON,** by country, 2001

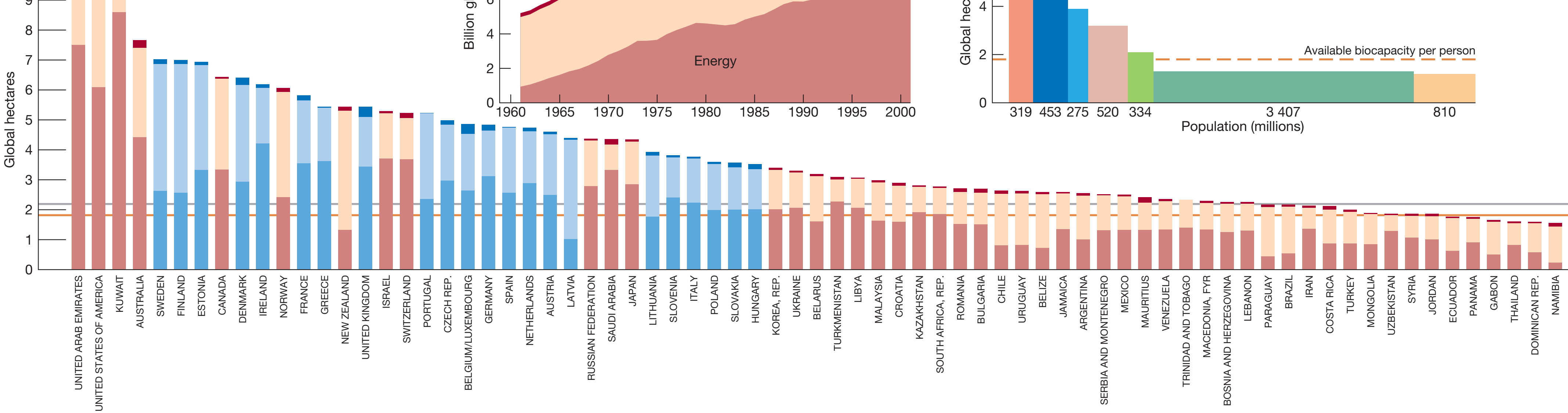


Fig. 4: **HUMANITY'S ECOLOGICAL FOOTPRINT,** 1961–2001

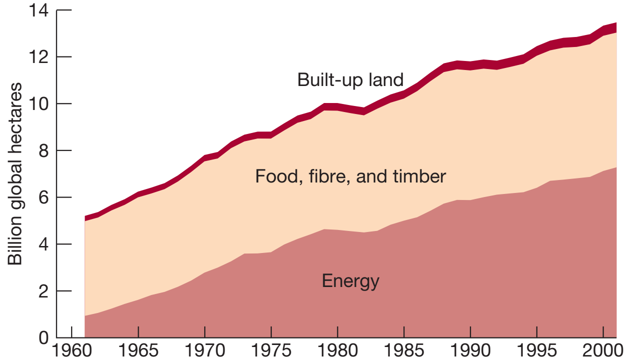
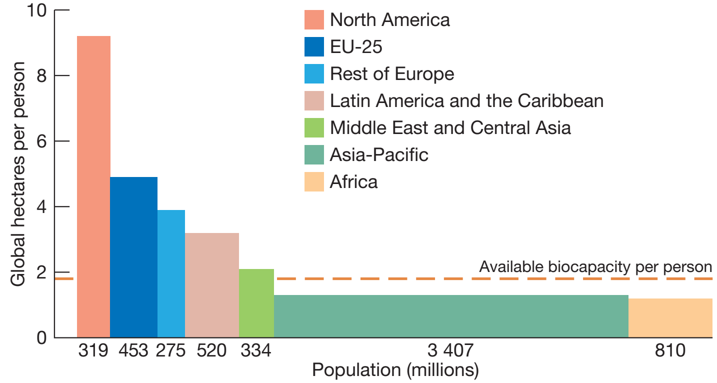
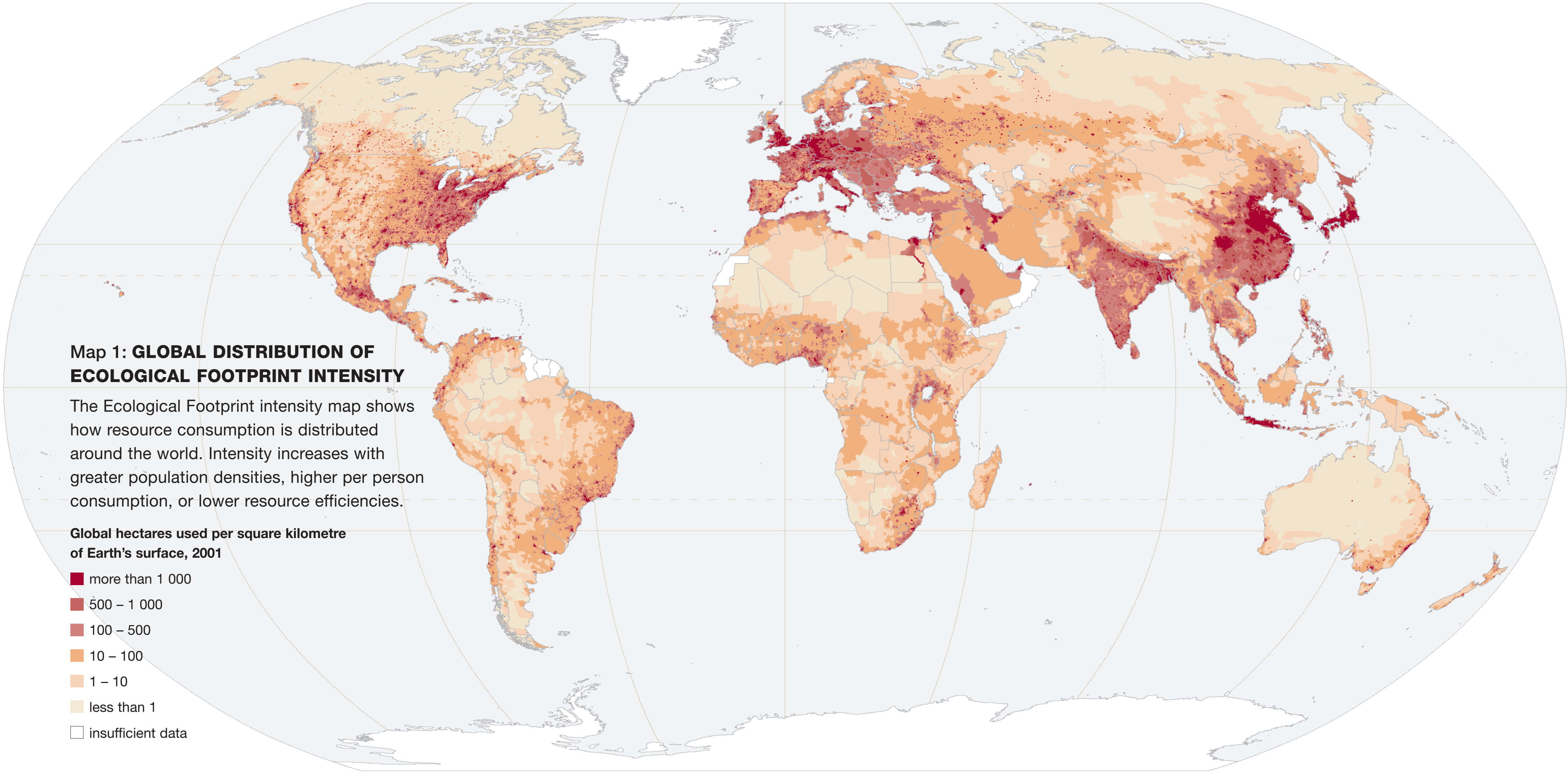


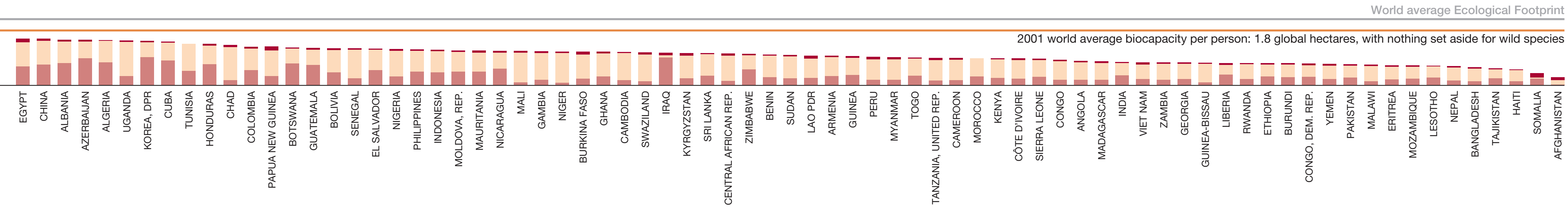
Fig. 5: **ECOLOGICAL FOOTPRINT BY REGION,** 2001



Map 1: **GLOBAL DISTRIBUTION OF ECOLOGICAL FOOTPRINT INTENSITY**

The Ecological Footprint intensity map shows how resource consumption is distributed around the world. Intensity increases with greater population densities, higher per person consumption, or lower resource efficiencies.





EUROPE'S ECOLOGICAL FOOTPRINT

Although Europe is the second smallest continent, its population density and high per person consumption make it a significant contributor to the global Ecological Footprint. Home to 7 per cent of the world population, Europe generates 17 per cent of humanity's footprint. Today, the footprint of the EU-25 is 2.2 times as large as its own biological capacity. This means that at its current rate of consumption just over twice its own land and sea space would be required to support Europe's resource demands. This compares with the situation in 1961 when the EU-25 nations' total resource demand was nearly commensurate with their biocapacity.

From an ecological perspective, trade is the mechanism that makes it possible for Europe to maintain its current way of life. It is only by importing resources and using the ecological services of other countries and the global commons that Europe can continue to increase its consumption while avoiding further liquidation of its own natural capital.

If Europe accepts global limits, it also needs to understand the impact its economy has on the rest of the planet. Globalization and trade can help developing countries prosper but excessive demand on resources may cause degradation of ecosystems in countries providing them. To achieve global sustainable development, the world community would need to decide how big the planet's ecological budget is, and how it will be shared. Or more simply put: how big is the ecological cake, and who gets which piece?

Figure 6: The height of each bar represents a nation's footprint per person. The width represents its population size. The area of each bar represents a country's total footprint.

Figure 7: The EU-25 nations are home to a decreasing percentage of the world's population. However, a continual rise in per person consumption has meant that they use an increasing amount of the world's biological capacity. In 2001, the EU-25's Ecological Footprint was 20 per cent of the planet's biocapacity, double what it was in 1961.

Fig. 6: **ECOLOGICAL FOOTPRINT BY EU-25 NATION,** 2001
Width of bar is proportional to population (shown in thousands)

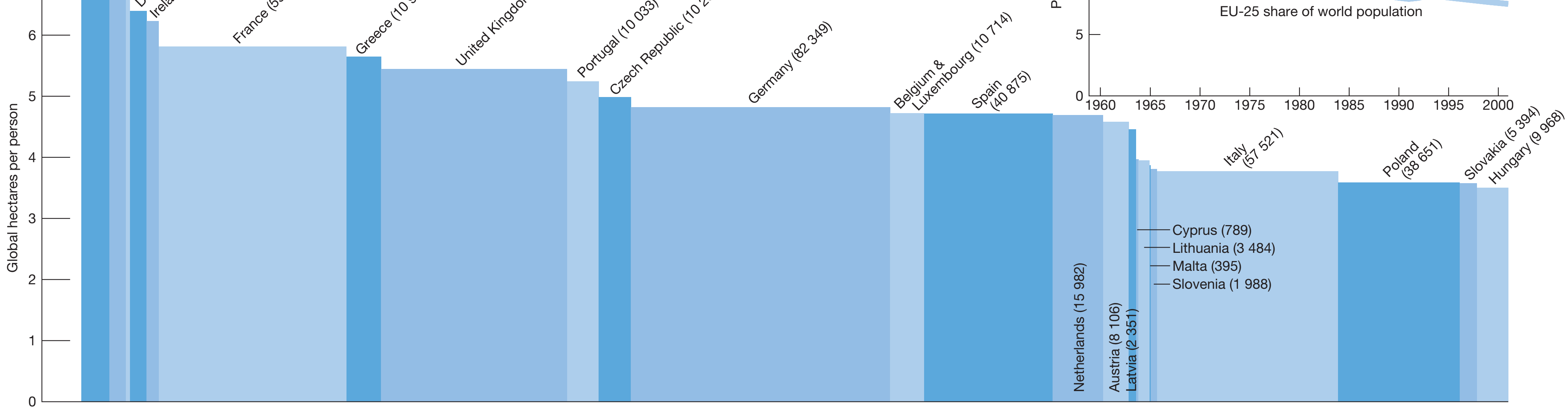
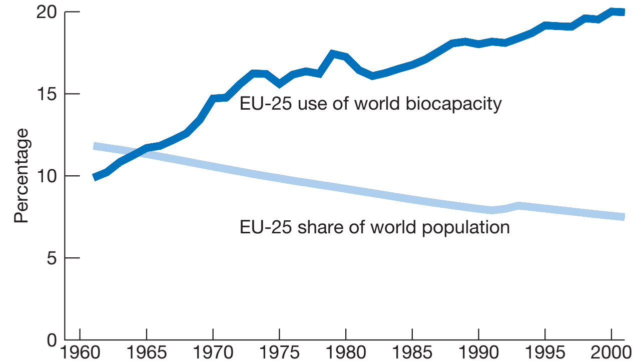
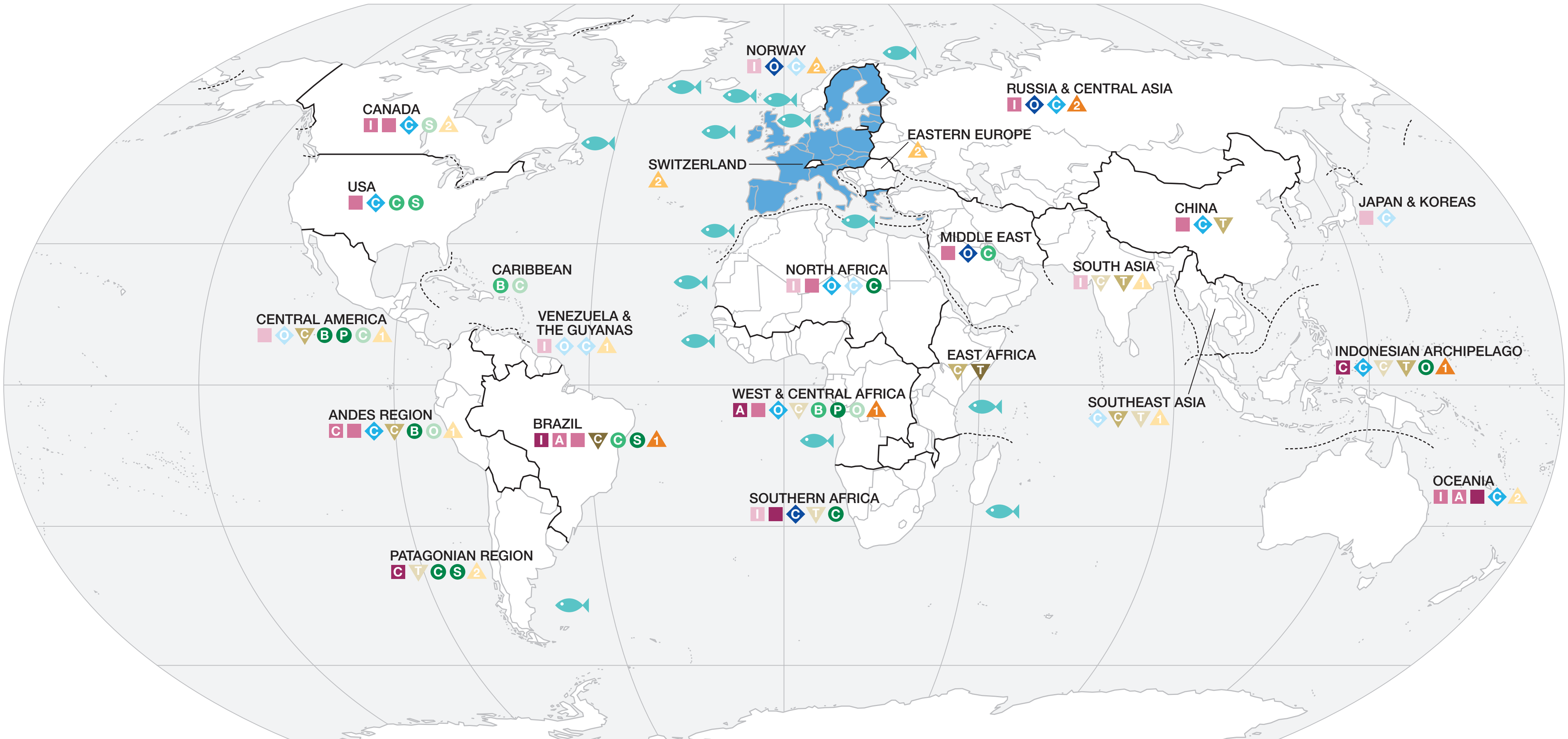


Fig. 7: **EU-25 USE OF WORLD BIOCAPACITY,** 1961–2001





Map 2: **EU-25 RESOURCE IMPORTS**

Imports of resources and commodities have extended the Ecological Footprint of the EU-25 into all corners of the world. The impact on ecosystems worldwide of production processes such as mining, logging, fishing, and farming varies by sector and geographic location.

Colour intensity indicates the imported volume of selected products in ’000 tonnes, 2003

Iron ore
- Over 5 000
- 500 – 5 000
- 150 – 500

Aluminium ore
- Over 2 500
- 1 000 – 2 500

Copper ore
- Over 900
- 100 – 900

Other metals
- Over 750
- 90 – 750
- 0.1 – 90

Oil
- Over 100 000
- 10 000 – 100 000
- 4 500 – 10 000

Coal and coke
- Over 50 000
- 5 000 – 50 000
- 250 – 5 000

Coffee
- Over 500
- 200 – 500
- 100 – 200

Tea
- Over 80
- 20 – 80
- 5 – 20

Bananas
- Over 1 000
- 100 – 1 000

Pineapples
- Over 150

Citrus fruit
- Over 300
- 75 – 300
- 25 – 75

Soy
- Over 10 000
- 5 000 – 10 000
- 350 – 5 000

Palm oil
- Over 1 000
- 100 – 1 000
- 10 – 100

Tropical wood & wood products
- Over 1 000
- 100 – 1 000
- 7.5 – 100

Temperate wood & wood products
- Over 10 000
- 1 000 – 10 000
- 50 – 1 000

Fishing grounds supplying the EU-25

FIVE COUNTRY EXAMPLES

The EU-25 countries have experienced rapid growth and transition in the past 20 years. Some countries such as Germany have begun de-coupling economic growth from their resource use; others, like Greece, are still expanding in both economic and footprint terms; while some, like Poland, have successfully “leap-frogged” to modern, resource-efficient technology. These five examples illustrate the range of environmental trends within the EU.

Yet the EU as a whole imports biological capacity from outside Europe. Furthermore, from a low of 3.5 global hectares per Hungarian to a high of just over 7 global hectares per Swede, all but three of the EU members – Sweden, Latvia, and Finland – are in ecological deficit, and all have footprints above the world’s sustainable average.

The upper graphs illustrate, for each year, a country’s total Ecological Footprint – the resources it used to meet the demands of its population. Total Ecological Footprint is the product of population multiplied by per person consumption, and reflects the efficiency with which resources are turned into consumable products.

Biocapacity – resource supply – varies each year depending on ecosystem management, agricultural practices such as fertilizer use and irrigation, ecosystem degradation, and weather.

These figures show the ratio between a country’s demand and its biocapacity in each year, and how these have changed over time.

The lower graphs track, in absolute terms, the average Ecological Footprint per person and biocapacity per person in each country over a 40-year period. As populations grow, the biocapacity per person diminishes unless measures are in force to de-couple consumption from resource use.

FRANCE

France has moved from using, in net terms, slightly less than its full domestic biocapacity in 1961 to nearly twice its own biocapacity in 2001. This parallels the EU-25 trend. Biocapacity has slightly increased with improved technology and more intensive agriculture (using more fertilizer, pesticides, and irrigation), but is outpaced by the growth of both population and consumption, and by the ecosystem degradation caused by intensive farming practices.

GERMANY

After a rapid rise of around 65 per cent between 1961 and 1971, Germany has managed, through progressive policies and reducing its use of coal, to stabilize its Ecological Footprint and to increase its biocapacity, despite a 5 per cent increase in its population. Nonetheless, Germany’s footprint is two and a half times its biocapacity and remains more than twice the world average.

Fig. 8: **FRANCE’S TOTAL ECOLOGICAL FOOTPRINT,** 1961–2001

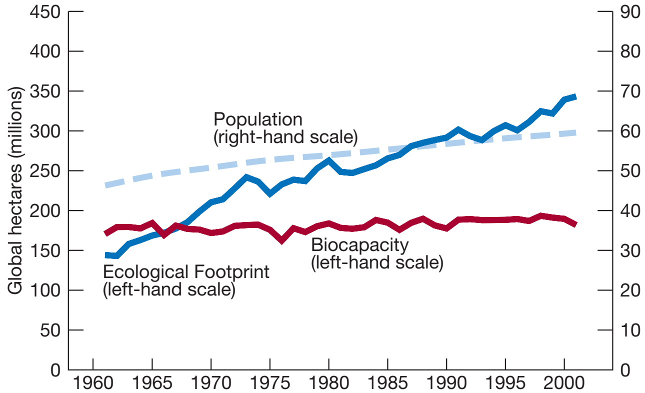


Fig. 10: **GERMANY’S TOTAL ECOLOGICAL FOOTPRINT,** 1961–2001

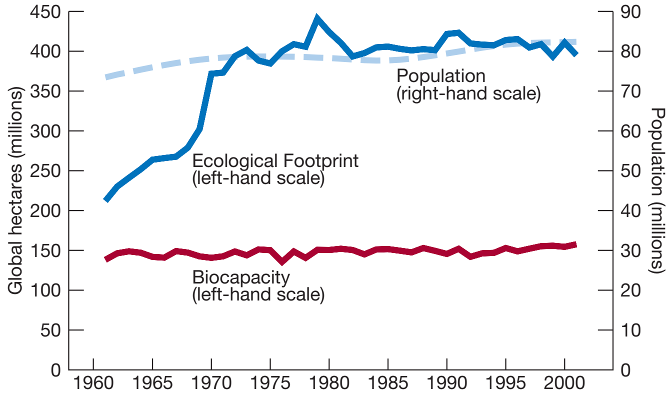


Fig. 9: **FRANCE’S ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001

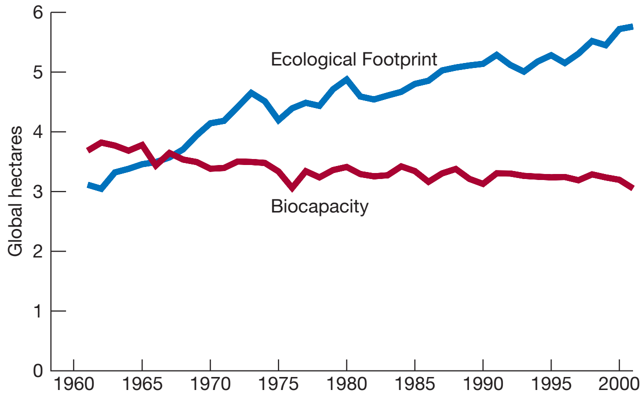
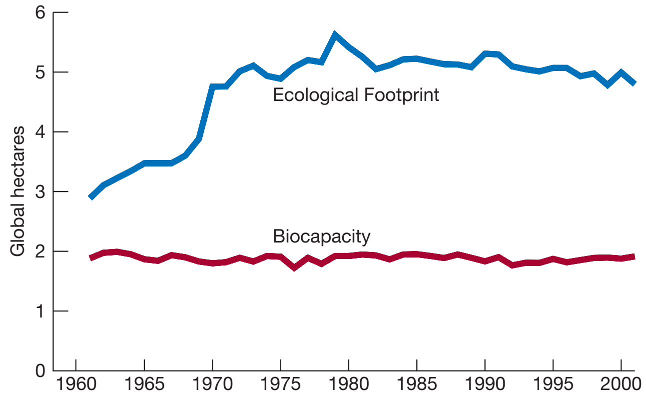


Fig. 11: **GERMANY’S ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001



GREECE

Greece has experienced both rapid economic expansion and a large increase in consumption, particularly of energy. By 2001, its footprint had increased by almost 180 per cent over the level of 40 years ago – raising it above the EU-25 average by around 11 per cent. The inflow of European regional funds has acted as an important motor of this economic expansion over the recent period.

POLAND

Although Poland's economy has expanded considerably since the break-up of the Soviet Union and the opening up of central Europe, its footprint has not. Poland has the potential to become a leading exponent of how the introduction of innovative technologies – "technological leap-frogging" – can de-couple economic growth from resource consumption. It remains to be seen if this potential will be realized.

UNITED KINGDOM

In 1961 the United Kingdom used over twice its biocapacity; by 2001 this had risen to more than three times that capacity. Although over the same period its population grew by 13.5 per cent, the UK footprint per person rose by 40 per cent – while its biocapacity per person fell by almost 22 per cent.

Fig. 12: **GREECE'S TOTAL ECOLOGICAL FOOTPRINT,** 1961–2001

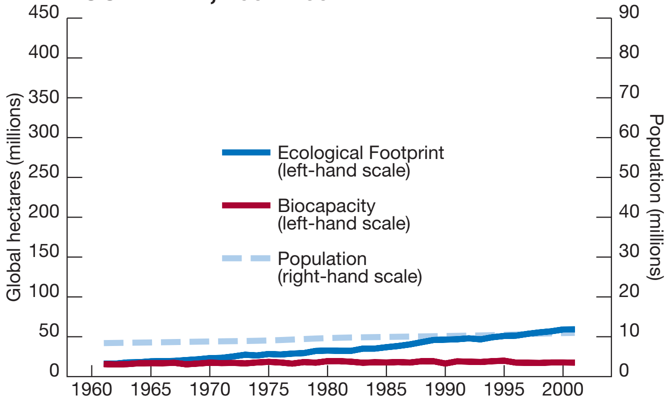


Fig. 13: **GREECE'S ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001

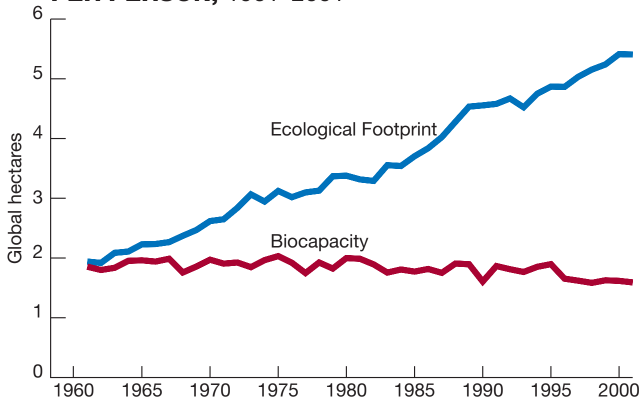


Fig. 14: **POLAND'S TOTAL ECOLOGICAL FOOTPRINT,** 1961–2001

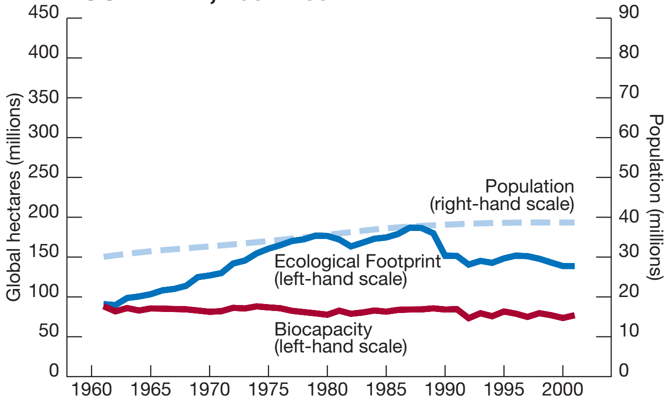


Fig. 15: **POLAND'S ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001

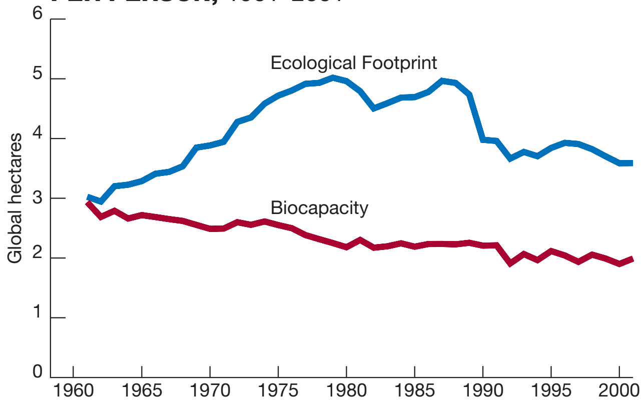


Fig. 16: **UK'S TOTAL ECOLOGICAL FOOTPRINT,** 1961–2001

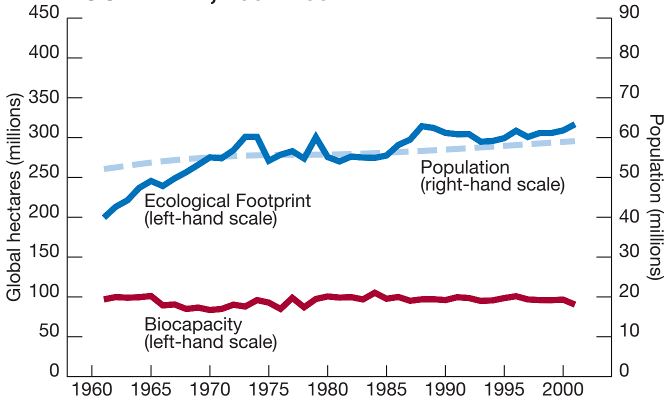
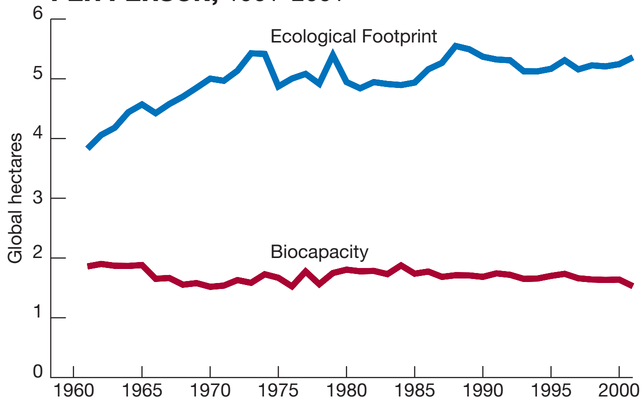


Fig. 17: **UK'S ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001



ONE PLANET LIVING

At the turn of the 21st century, the Ecological Footprints of both Europe and the world exceeded available biocapacity. For Europe this means that its current way of life depends on using biological capacity from countries outside Europe. In other words, Europe is a net importer of biocapacity.

The situation is somewhat different at the global level. Presently the Ecological Footprint of humanity exceeds available global biocapacity. But, unless we find other planets capable of supporting life, this extra capacity cannot be imported from elsewhere through trade. Instead the result is a gradual deterioration of global ecosystems. "One Planet Living" is an opportunity for countries to establish a sustainable, prosperous future for the long term.

The current overshoot will have to be eliminated for the world to become sustainable. Some of the change will come from increasing available global biocapacity. The balance must come from reducing the global footprint.

Towards One Planet Living
There are four ways to eliminate overshoot:

1. **Increasing – or at least maintaining – biocapacity.** This means protecting soil from erosion and degradation, and preserving cropland for agriculture rather than urban development. It includes protecting river basins, wetlands, and watersheds to secure freshwater supplies. It means maintaining healthy forests and fisheries. It includes actions to protect ecosystems from climate change. And it implies eliminating the use of toxic chemicals that degrade ecosystems.

2. **Improving the resource efficiency with which goods and services are produced.** Over the past 40 years, technological progress has increased the resource efficiency of production systems. As a result the average Ecological Footprint per person has held relatively constant. But although efficiency gains are critically important, they have not been enough to stop the growth of the global Ecological Footprint (Pacala and Socolow 2004).

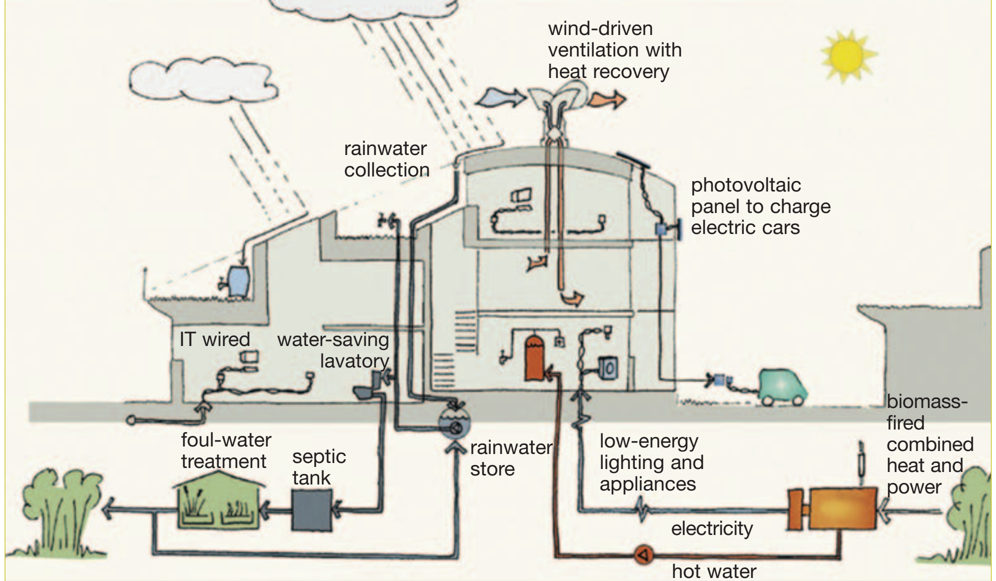
3. **Reducing the consumption of goods and services per person.** The potential for reducing per person consumption depends in part on the person's income level. People at subsistence level need to increase their consumption to move out of poverty. But wealthy individuals can shrink their footprint without compromising their quality of life, by

WHAT IS ONE PLANET LIVING?

One Planet Living aims to demonstrate how it is possible to make the challenge of living on one planet achievable, affordable, and attractive. It is also the name of a partnership between the BioRegional Development Group and WWF. One Planet Living is an initiative based on the experience of the Beddington Zero fossil Energy Development (BedZED). BedZED is a sustainable housing and work space project in London. Its homes and offices are highly energy efficient: it consumes 90 per cent less heating energy than average UK housing and less than half the water. Furthermore, it is designed so that all energy is generated in a renewable manner from wind, sun, and biomass. Construction materials are from local, recycled, or certified well-managed sources. And although it is a compact design, residents have private gardens and conservatories. Residents find BedZED a desirable place to live, contradicting the common but erroneous assumption that a smaller Ecological Footprint means a lower quality of life.

A goal is to establish One Planet Living communities on every continent by 2009, with projects under way or planned in Portugal, the United Kingdom, South Africa, North America, and China (see www.bioregional.com).

How BedZED works



Source: ARUP

cutting consumption of goods and services with a large footprint.

4. **Lowering the gobal population.** Population growth can be reduced and eventually reversed by supporting measures which lead to families choosing to have fewer children. Offering women better education, economic opportunities, and health care are three proven approaches.

Allocating biocapacity

Sustainability means living well, within the means of nature. But what does it mean for individual countries?

One solution could be to insist that each country live within its biological capacity. This could restrict trade, but there is little doubt that trade between nations – including trade in biocapacity – normally increases the well-being of all involved.

A second solution could be to allocate to each global citizen an "equal share" of global biocapacity. The "equal share" is defined as the total global biocapacity divided by the total global population. In 2001, this amounted to 1.8 global hectares per person. Living within "equal share" would ensure ecological sustainability.

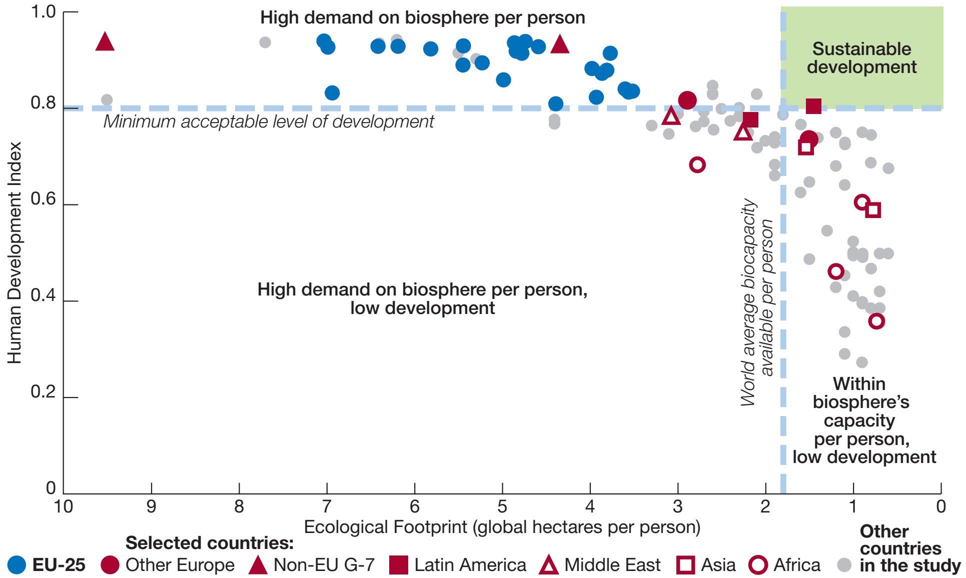
High-footprint countries would have to contract, while low-footprint countries could expand their footprints.

Sustainable well-being and footprint

In general, higher well-being is associated with a higher Ecological Footprint. But the relationship is not rigid: more efficient countries achieve high levels of well-being (as measured by the UN's Human Development Index) with relatively low footprints (as measured by the Ecological Footprint per person). The Human Development Index is a relative score that captures how conducive conditions are in a given nation for people to enjoy long, healthy, and creative lives (http://hdr.undp.org/hd). If we choose an index of 0.8 as the lowest acceptable well-being level and an "equal share" of 1.8 global hectares per person as the highest sustainable footprint, the two corresponding lines divide Figure 18 into four quadrants. Only the upper right quadrant can be deemed sustainable. No country is yet in this situation, but some are close (see table below Figure 18). One Planet Living would mean moving the average of all countries into this "sustainability quadrant" (Boutaud 2002).

Figure 18: One Planet Living – living well, within the means of nature: the challenge is how to move all countries into the "sustainable development" quadrant (Boutaud 2002).

Fig. 18: **MATCHING HUMAN DEVELOPMENT AND ECOLOGICAL FOOTPRINTS,** EU-25 and selected countries, 2001



	Human Development Index	Ecological Footprint (gha/person)
Sweden	0.94	7.0
Netherlands	0.94	4.7
United States	0.94	9.5
Belgium/Luxembourg	0.94	4.9
Japan	0.93	4.3
Finland	0.93	7.0
Denmark	0.93	6.4
Ireland	0.93	6.2
United Kingdom	0.93	5.4
Austria	0.93	4.6
France	0.93	5.8
Germany	0.92	4.8
Spain	0.92	4.8
Italy	0.92	3.8
Portugal	0.90	5.2
Greece	0.89	5.4
Cyprus	0.88	4.0
Slovenia	0.88	3.8
Malta	0.88	3.9

	Human Development Index	Ecological Footprint (gha/person)
Czech Republic	0.86	5.0
Poland	0.84	3.6
Hungary	0.84	3.5
Slovakia	0.84	3.6
Estonia	0.83	6.9
Lithuania	0.82	3.9
Croatia	0.82	2.9
Latvia	0.81	4.4
Cuba	0.81	1.4
Libya	0.78	3.1
Brazil	0.78	2.2
Lebanon	0.75	2.3
Albania	0.74	1.5
China	0.72	1.5
South Africa	0.68	2.8
Morocco	0.61	0.9
India	0.59	0.8
Nigeria	0.46	1.2
Ethiopia	0.36	0.7

EUROPE CAN CHOOSE

Europe wants to be competitive in the short and the long term. But growth at the expense of depletion or degradation of natural resources and environment is not sustainable. Choices Europe makes today will ensure its prosperity for present and future generations. This list identifies possible options that can reduce Europe's demand on nature while maintaining or improving its competitiveness.

1. New economics

- Incorporate socio-economic (market and non-market) values of ecosystems and their services in management decisions.
- Integrate ecosystem management goals in sectors such as agriculture, forestry, finance, transport, trade, and health.
- Promote agricultural technologies that enable increased yields without practices harmful to the environment like excessive use of water, nutrients, or pesticides.
- Give higher priority to ecosystem restoration and conservation investments as the basis of development, recognizing, for instance, forests' contribution to human health and wetlands which provide humanity with services worth 60 billion euros annually.
- Adopt an ecosystem-based management approach for marine and fisheries policies that provides for a sustainable fisheries sector and protects vulnerable species and habitats such as over-harvested fish species, cold-water coral reefs, and seamounts.
- Account in economic terms for the elimination of negative impacts of chemicals on human health and environment to encourage higher development, growth, and innovation.
- Make deployment of EU funds for regional or national development conditional on the conservation of nature and ecosystem services.

2. Better regulation

- Provide accurate and relevant information to decision makers and the public about the social and economic value of functioning ecosystems.
- Develop certification systems to ensure the sustainability of product manufacturing and resource use.
- Educate the public about the challenges and opportunities of sustainability, addressing issues such as climate change, forests, and fisheries.
- Eliminate perverse subsidies having adverse social, economic, and environmental effects.

3. Trade and development

- Agree on a binding time frame for increasing the EU's official development assistance to at least 0.5% of gross national income (GNI) by 2009, and 0.7% of GNI by 2015, as proposed by the UN Secretary-General.
- Establish a transparent system to monitor subsidies, lending, and grant mechanisms. Integrate conservation and sustainable use of natural resouces in European Commission development programmes through country and regional strategy papers.
- Ensure that development and aid policy is coherent with other policies, particularly in regard to environmental impacts occurring in developing countries.

4. Green infrastructure

- Work with nature, not against it. Functioning ecosystems provide us with "natural infrastructures". Wetlands, for example, naturally manage flood risk and treat water.
- Make transport pricing reflect the full social and environmental costs of road, water, and air travel, and encourage public transport over private car use.
- Implement comprehensive waste reduction systems, giving priority to controlling hazardous substances.
- Introduce building design requirements and incentives that reduce waste, and water and energy use.

5. Climate change

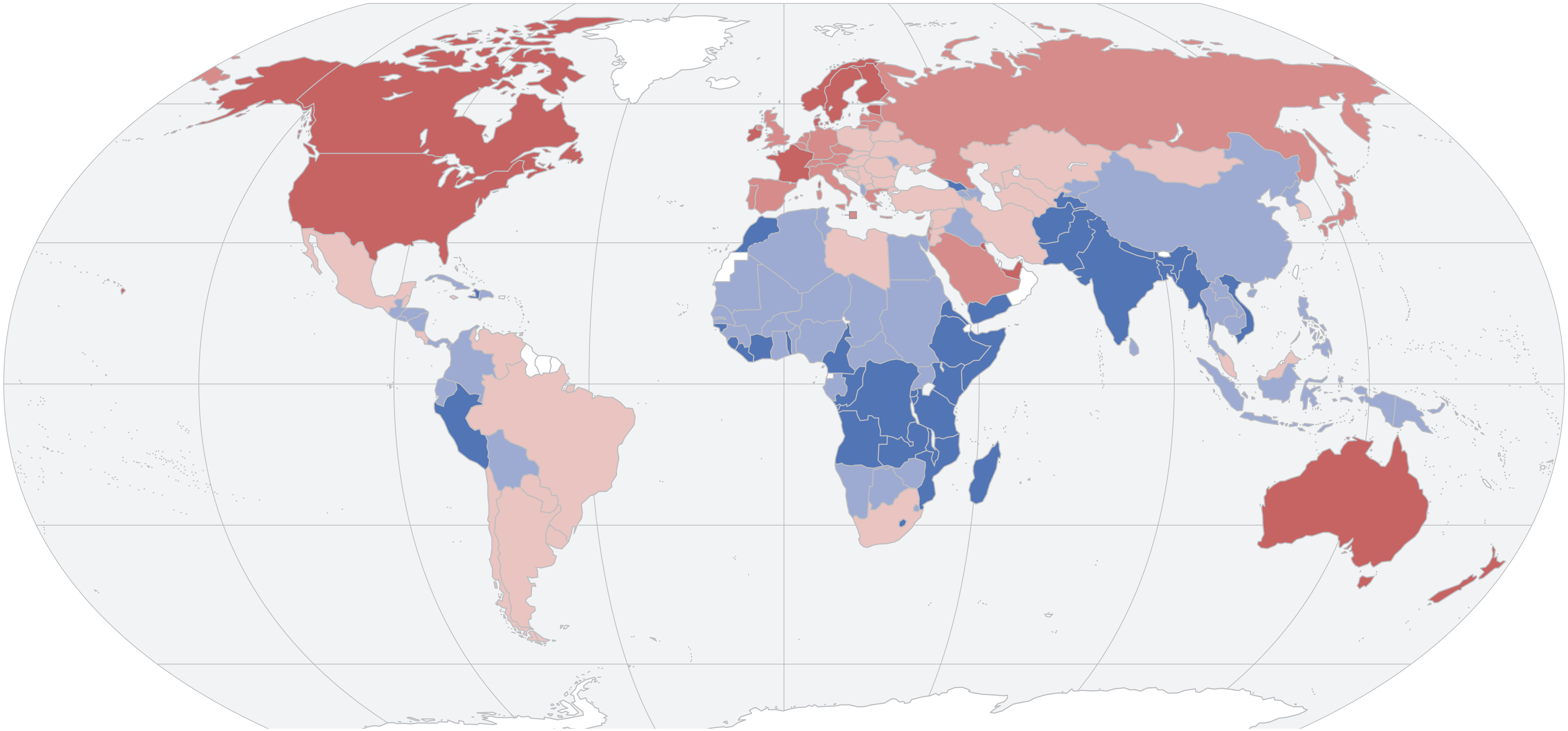
- Get out of CO_2, without shifting the burden onto the biosphere. The challenge of moving from a fossil fuel economy is investing in alternatives that truly reduce humanity's footprint, rather than putting more demand on other ecosystems.
- Develop certification criteria for non-fossil energy sources to ensure these sources reduce, rather than merely shift, the environmental burden of energy use.
- Build energy systems that free Europe from the high cost of fossil fuel imports while advancing European innovation and know-how in new energy technologies (see box).

INNOVATIVE ACTION

New coalitions of business leaders, members of governments, and civil society can develop innovative models for tackling the challenges of living within the capacity of one planet. These actors have the power to bring sustainable development to the centre stage. Consider for example the power sector. Significant CO_2 savings could be made by switching to green electricity or reducing energy demand through basic energy efficiency measures. These alternatives could become attractive more rapidly if the price for electricity generated from fossil fuel reflected its full costs. Action is possible at all levels:

- **Individual** …if consumers bought green electricity where it was available, it would encourage utilities to produce more clean energy.
- **Corporate** …if utilities paid the true cost of fossil fuel it would encourage them to switch to less carbon-intensive energy sources.
- **Governmental** …governments could encourage the building of cleaner power plants by setting robust carbon caps in emissions trading systems.
- **International** …if governments make sure that loopholes do not undermine international agreements, and move even further than the Kyoto Protocol, the challenge of climate change can be met.

For more about options and proven solutions to reverse climate change, visit www.panda.org/climate



Map 3: **LIVING ON LESS, LIVING ON MORE**

2001

The average resident in 69 countries, out of the 150 countries analysed, uses more biological capacity than is available per person worldwide. In 33 countries, the average resident uses more than double, in 13 countries more than three times. Even if the average footprint in a country is less than what is available per person globally, the country's total footprint may exceed its own biocapacity. As global ecological overshoot increases, countries with large footprints may realize the risks associated with a high resource demand.

- **Countries using more than three times the worldwide average biocapacity available per person**
- **Countries using between twice and three times the worldwide average biocapacity available per person**
- **Countries using between the entire and twice the worldwide average biocapacity available per person**
- **Countries using between half and the entire worldwide average biocapacity available per person**
- **Countries using less than half the worldwide average biocapacity available per person**
- **Insufficient data**

ECOLOGICAL FOOTPRINT: FREQUENTLY ASKED QUESTIONS

What is included in the Ecological Footprint? What is excluded?

To avoid exaggerating human demand on nature, the Ecological Footprint includes only those aspects of resource consumption and waste production that are potentially sustainable, and for which there are data that allow this demand to be expressed in terms of the area required.

Since nature has no significant absorptive capacity for heavy metals, radioactive materials such as plutonium, or persistent synthetic compounds (e.g. chlordane, PCBs, CFCs, PVCs, dioxins), sustainability requires eliminating the release of such substances into the biosphere. Also, the impacts of many other waste flows are poorly captured by the present Ecological Footprint accounts. For example, accurate data on the reduction of biocapacity due to acid rain are not yet available, and so are not included in the accounts.

Water is addressed only indirectly in Ecological Footprint accounts. Overuse of freshwater affects present and future plant growth, reflected as changes in biocapacity. Further, the Ecological Footprint includes the energy needed to supply and treat water, and the area occupied by reservoirs.

Ecological Footprint accounts provide snapshots of past resource demand and availability. They do not predict the future. Thus, the Ecological Footprint does not estimate future losses caused by present degradation of ecosystems, be it soil salination or loss, deforestation, or destruction of fisheries through bottom trawling. These impacts will, however, be reflected in future Ecological Footprint accounts as a loss of biocapacity. Footprint accounts also do not indicate the intensity with which a biologically productive area is being used. Intensity can lead to degradation, but not always. For example, in China, yields of cultivated rice have remained stable for more than a thousand years. While the Ecological Footprint captures overall demand on the biosphere, it does not pinpoint specific biodiversity pressures. It only summarizes the overall risk biodiversity is facing. Lastly, the Ecological Footprint does not evaluate the social and economic implications of sustainability.

How is fossil fuel accounted for?

The Ecological Footprint measures humanity's past and present demand on nature. Although fossil fuels such as coal, oil, and natural gas are extracted from the Earth's crust and not regenerated in human time scales, their use still requires ecological services. Burning these fuels puts pressure on the biosphere as the resulting CO_2 accumulates in the atmosphere, contributing to global warming. The Ecological Footprint includes the biocapacity needed to sequester this CO_2, less the amount absorbed by the ocean. One global hectare can absorb the CO_2 released from consuming 1 450 litres of gasoline per year.

The fossil fuel footprint does not suggest that carbon sequestration is the key to resolving global warming. Rather, it points out the lack of ecological capacity for coping with excess CO_2, and underlines the importance of reducing CO_2 emissions. The sequestration rate used in Ecological Footprint calculations is based on an estimate of how much human-induced carbon emissions the world's forests can currently remove from the atmosphere and retain. This rate approaches zero as the forests mature, so sequestration is time limited. Further, global warming may turn forests from carbon sinks to carbon sources, reducing sequestration even more. Hence, carbon "credits" from forests may be deceptive since they do not always permanently remove carbon from the atmosphere but only delay fossil fuels' carbon emission to the atmosphere.

Energy efficiency may be the most cost-effective way to reduce the energy footprint. On the supply side, renewable energy technologies such as biomass, solar thermal and photovoltaic, wind, hydropower, ocean thermal, geothermal, and tidal power have the potential to reduce the size of the energy footprint significantly too. With the exception of firewood and hydroelectricity (which is close to saturation in industrialized countries), renewables provide collectively less than 1 per cent of global power (Aitken 2004, Hoffert et al. 2002). Biomass can produce carbon-neutral fuels for power plants or transportation, and has a huge potential in industrialized as well as developing countries. But since photosynthesis has a low power density, it requires a large surface area. In contrast, photovoltaic cells, thermal solar collectors, and wind turbines take up less land, and it need not be biologically productive land. However, the present costs and the intermittent nature of these energy resources make them less attractive in most of today's markets.

Are current biological yields likely to be sustainable?

In calculating the national footprints, yields for forests and fisheries as reported by the Food and Agriculture Organization of the United Nations (FAO) are used. These are estimates of the maximum amount of a single species stock that can be harvested without reducing the stock's productivity over time. With many fisheries in decline, there are strong indications that the reported fishery yields are too optimistic. In fact, research suggests that fisheries exploited above 75 per cent capacity risk becoming unstable (Roughgarden and Smith 1996).

If current overuse leads to lower yields in the future, this will be reflected in future biocapacity assessments. Harvesting at or below the maximum level that can be regenerated is a necessary condition for sustainability. Yet it is not sufficient. Taking less than the "maximum sustainable yield" can still cause ecological damage if harvests cause unintended damage to ecosystems, if there is local overuse, or if insufficient area is protected for wild species.

How is international trade taken into account?

The Ecological Footprint accounts calculate each country's net consumption by adding its imports to its production, and subtracting its exports. This means that the resources used for producing a car that is manufactured in Germany, but sold and used in France, will contribute to the French, not the German, footprint.

The resulting "apparent consumption" can be distorted since the waste generated in making products for export is insufficiently documented. This can exaggerate the footprint of countries whose economies produce largely for export, and understate that of importing countries. Similarly, because relevant data are unavailable, resource demands associated with tourism are included in the destination country's footprint. These demands should instead be assigned to the tourist's country of residence. While these misallocations distort the national averages, they do not bias the overall global Ecological Footprint.

What about built-up land?

The area required to accommodate infrastructure for housing, transport, industrial production, and hydropower occupies a significant portion of the world's bioproductive land. In 2001, the footprint for built-up area was 0.44 billion global hectares, but the accuracy of this calculation is limited by uncertainties in the underlying data. For instance, in urban areas are gardens differentiated from paved-over surfaces? How much of a road's shoulder and corridor is included? Even high-resolution satellite images cannot adequately distinguish between these different types of surface.

Since historically cities have been located in fertile agricultural areas with moderate climates and access to freshwater, Ecological Footprint accounts assume that built-up area occupies average cropland. This may underestimate the footprint of built-up area, since many cities are in fact located on the best farmland, with higher than average productivity. However, this may be balanced out again by built-up area on marginal land. While the physical compactness of infrastructure directly affects the footprint for built-up area, it also influences other footprint components. For example, larger homes on larger plots require more resources and energy for heating, cooling, and furnishing, and this low density housing typically increases private car use and makes public transport systems less efficient.

Figure 19: The EU-25 nations' total Ecological Footprint doubled from 1961 to 2001. Population increased by around 25 per cent over the same period.

Figure 20: Range of footprints of renewable energy technologies in comparison with fossil fuels. The size of the energy footprint of biofuels varies widely depending on the amount of energy needed to convert the crop into a fuel.

Figure 21: In middle and low income countries the average person's footprint has changed little over the past 40 years, and declined by 8 per cent in the ten years before 2000. The trend among high income countries, which the EU-25 closely follows, is a continually rising footprint. The EU-25's growth in footprint since 1990 has been 3 per cent, slower than the average of 8 per cent for high income countries.

Table 1: **POPULATION AND FOOTPRINT**
1961-2001

	Population (millions)	Total footprint (billion global ha)	Footprint per person (global ha/person)
High income countries			
1961	670	2.58	3.8
1981	805	4.37	5.4
2001	920	5.89	6.4
EU-25			
1961	365	1.05	2.9
1981	410	1.79	4.4
2001	453	2.22	4.9
Middle and low income countries			
1961	2 319	3.30	1.4
1981	3 685	5.76	1.6
2001	5 197	7.60	1.5

Fig. 19: **ECOLOGICAL FOOTPRINT OF THE EU-25,** 1961–2001

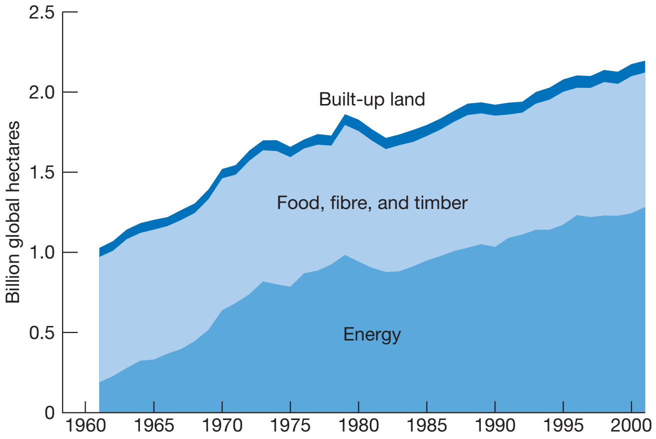


Fig. 20: **COMPARING THE FOOTPRINTS OF ENERGY TECHNOLOGIES**

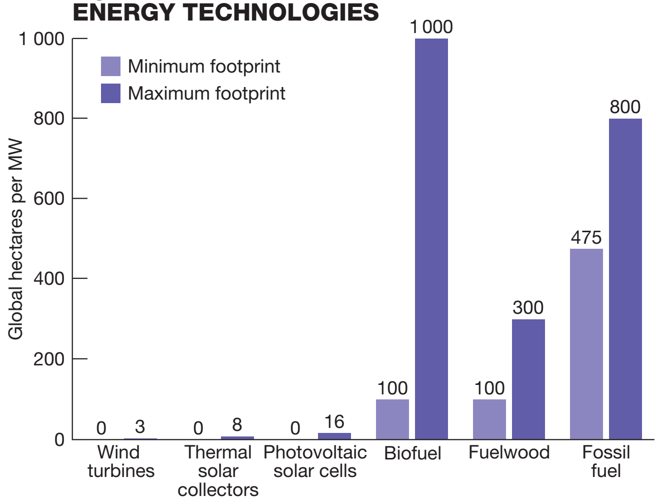


Fig. 21: **ECOLOGICAL FOOTPRINT PER PERSON,** 1961–2001

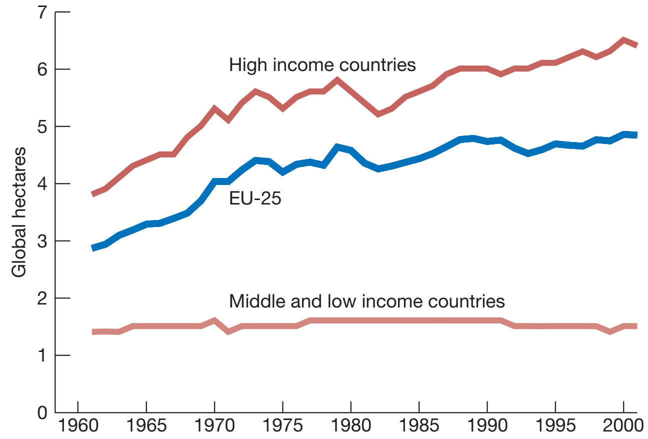


Table 2: ECOLOGICAL FOOTPRINT AND BIOCAPACITY

2001 data	Population	Total Ecological Footprint	Total food, fibre, and timber footprint	Included in total food, fibre, and timber: Cropland	Forest	Grazing land	Fishing ground	Total energy footprint	Included in total energy: CO_2 from fossil fuels	Fuelwood	Nuclear	Hydro
See notes on pages 18-21	(millions)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)	(global ha/person)
WORLD	**6 148.1**	**2.2**	**0.9**	**0.49**	**0.18**	**0.14**	**0.13**	**1.2**	**1.03**	**0.06**	**0.09**	**0.00**
High income countries	**920.1**	**6.4**	**2.2**	**0.82**	**0.80**	**0.26**	**0.33**	**4.0**	**3.44**	**0.02**	**0.49**	**0.01**
Middle income countries	**2 970.8**	**1.9**	**0.9**	**0.50**	**0.12**	**0.15**	**0.15**	**0.9**	**0.85**	**0.05**	**0.02**	**0.00**
Low income countries	**2 226.3**	**0.8**	**0.5**	**0.35**	**0.03**	**0.03**	**0.09**	**0.3**	**0.20**	**0.09**	**0.00**	**0.00**
EU-25	**453.3**	**4.9**	**1.9**	**0.86**	**0.56**	**0.18**	**0.26**	**2.8**	**2.41**	**0.02**	**0.41**	**0.01**
Austria	8.1	4.6	2.0	0.84	0.92	0.13	0.14	2.5	2.36	0.07	0.00	0.06
Belgium & Luxembourg	10.7	4.9	1.9	0.90	0.67	0.08	0.24	2.6	1.68	0.01	0.94	0.00
Cyprus*	0.8	4.0	2.1	0.93	0.40	0.48	0.24	2.3	2.33	0.00	0.00	0.00
Czech Republic	10.3	5.0	1.9	0.91	0.67	0.14	0.14	3.0	2.71	0.02	0.24	0.00
Denmark	5.3	6.4	3.2	1.14	1.77	0.06	0.26	2.9	2.92	0.01	0.00	0.00
Estonia	1.4	6.9	3.5	1.12	1.51	0.57	0.30	3.3	3.07	0.25	0.00	0.00
Finland	5.2	7.0	4.3	0.87	2.78	0.20	0.46	2.6	1.34	0.15	1.04	0.03
France	59.6	5.8	2.1	0.89	0.58	0.30	0.33	3.6	2.18	0.01	1.35	0.01
Germany	82.3	4.8	1.5	0.79	0.46	0.14	0.14	3.1	2.68	0.01	0.42	0.00
Greece	10.9	5.4	1.8	1.04	0.23	0.20	0.31	3.6	3.59	0.03	0.00	0.00
Hungary	10.0	3.5	1.3	0.81	0.31	0.10	0.10	2.0	1.67	0.04	0.30	0.00
Ireland	3.9	6.2	1.9	0.78	0.63	0.23	0.21	4.2	4.21	0.00	0.00	0.00
Italy	57.5	3.8	1.5	0.80	0.35	0.10	0.21	2.2	2.21	0.02	0.00	0.01
Latvia	2.4	4.4	3.3	0.90	1.30	0.98	0.14	1.0	0.88	0.13	0.00	0.00
Lithuania	3.5	3.9	2.0	1.02	0.38	0.36	0.28	1.8	1.03	0.10	0.63	0.00
Malta	0.4	3.9	2.1	0.76	0.23	0.09	1.02	1.6	1.62	0.00	0.00	0.00
Netherlands	16.0	4.7	1.7	0.92	0.53	0.10	0.19	2.9	2.83	0.00	0.06	0.00
Poland	38.7	3.6	1.5	1.05	0.37	0.09	0.04	2.0	1.98	0.01	0.00	0.00
Portugal	10.0	5.2	2.9	0.85	0.53	0.22	1.25	2.4	2.33	0.01	0.00	0.02
Slovakia	5.4	3.6	1.4	0.74	0.50	0.11	0.07	2.0	1.31	0.01	0.67	0.01
Slovenia	2.0	3.8	1.3	0.74	0.46	0.12	0.03	2.4	2.36	0.04	0.00	0.00
Spain	40.9	4.8	2.2	1.03	0.43	0.09	0.61	2.6	2.24	0.01	0.31	0.01
Sweden	8.9	7.0	4.2	0.86	2.66	0.42	0.29	2.6	0.89	0.12	1.62	0.00
United Kingdom	59.1	5.4	1.7	0.69	0.44	0.27	0.25	3.4	3.13	0.00	0.31	0.00
OTHER NATIONS												
China	1 292.6	1.5	0.8	0.44	0.08	0.11	0.16	0.7	0.65	0.03	0.00	0.00
United States of America	288.0	9.5	3.0	0.96	1.35	0.44	0.23	6.1	5.47	0.04	0.57	0.01

NOTES
World: Total population includes countries not listed below.
0.0 = less than 0.05
Totals may not add up due to rounding
High income countries: Australia, Austria, Belgium & Luxembourg, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Rep. Korea, Kuwait, Netherlands, New Zealand, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States of America.
Middle income countries: Algeria, Argentina, Belarus, Belize, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Cuba, Czech Rep., Dominican Rep., Ecuador, Egypt, El Salvador, Estonia, Gabon, Georgia, Guatemala, Hungary, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Latvia, Lebanon, Libya, Lithuania, FYR Macedonia, Malaysia, Mauritius, Mexico, Morocco, Namibia, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia and Montenegro, Slovakia, Rep. South Africa, Sri Lanka, Syria, Thailand, Trinidad and Tobago, Tunisia, Turkey, Ukraine, Uruguay, Uzbekistan, Venezuela.

Built-up land** (global ha/person)	Total biocapacity (global ha/person)	Included in total biocapacity: Cropland (global ha/person)	Grazing land (global ha/person)	Forest (global ha/person)	Fishing ground (global ha/person)	Ecological deficit*** (global ha/person)	Ecological Footprint change per capita (% change 1991-2001)	Biocapacity change per capita (% change 1991-2001)	Human Development Index†	Gross domestic product (euros/person)	2001 data *See notes on pages 18-21*
0.07	**1.8**	**0.53**	**0.27**	**0.81**	**0.13**	**0.4**	**-2%**	**-12%**	**0.72**	**5 800**	**WORLD**
0.23	**3.3**	**1.12**	**0.33**	**1.57**	**0.31**	**3.1**	**8%**	**-7%**	**0.91**	**-**	**High income countries**
0.07	**2.0**	**0.51**	**0.30**	**1.07**	**0.13**	**-0.1**	**-5%**	**-10%**	**0.68**	**-**	**Middle income countries**
0.05	**0.7**	**0.32**	**0.19**	**0.13**	**0.07**	**0.1**	**-11%**	**-16%**	**0.44**	**-**	**Low income countries**
0.16	**2.1**	**0.86**	**0.08**	**1.04**	**0.12**	**2.76**	**3%**	**-7%**	**0.91**	**19 400**	**EU-25**
0.07	3.5	0.71	0.10	2.64	0.00	1.1	4%	-7%	0.93	26 200	Austria
0.33	1.2	0.39	0.04	0.42	0.01	3.7	10%	-4%	0.94	25 800	Belgium & Luxembourg
0.01	0.4	0.30	0.00	0.04	0.10	3.5	n/a	n/a	n/a	10 100	Cyprus*
0.15	2.8	1.06	0.02	1.56	0.01	2.2	1%****	0%****	0.86	5 300	Czech Republic
0.24	3.5	2.02	0.00	0.46	0.78	2.9	7%	-14%	0.93	26 600	Denmark
0.11	5.7	1.06	0.09	4.22	0.22	1.2	25%	1%	0.83	3 500	Estonia
0.13	12.4	1.08	0.00	10.93	0.24	-5.4	16%	-6%	0.93	26 000	Finland
0.16	3.1	1.45	0.14	1.21	0.10	2.8	4%	-8%	0.93	24 800	France
0.20	1.9	0.78	0.06	0.85	0.03	2.9	-3%	1%	0.92	25 200	Germany
0.05	1.6	1.02	0.01	0.27	0.24	3.9	19%	-15%	0.89	12 000	Greece
0.17	2.4	1.34	0.07	0.80	0.01	1.1	-10%	-18%	0.84	4 600	Hungary
0.12	4.7	1.33	0.96	0.70	1.60	1.5	25%	-9%	0.93	29 400	Ireland
0.07	1.1	0.58	0.01	0.38	0.05	2.7	5%	-12%	0.92	21 200	Italy
0.06	6.5	1.97	0.19	4.21	0.09	-2.1	-21%	1%	0.81	2 800	Latvia
0.12	3.9	1.51	0.14	2.12	0.02	0.0	-29%	1%	0.82	3 000	Lithuania
0.15	0.6	0.07	0.00	0.00	0.36	3.3	n/a	n/a	n/a	8 000	Malta
0.12	0.8	0.31	0.05	0.11	0.16	4.0	7%	-8%	0.94	26 800	Netherlands
0.07	2.0	0.97	0.08	0.86	0.01	1.6	-9%	-10%	0.84	4 200	Poland
0.02	1.6	0.41	0.06	1.08	0.08	3.6	33%	-7%	0.90	12 300	Portugal
0.15	2.9	0.81	0.04	1.94	0.00	0.6	-28%****	0%****	0.84	3 400	Slovakia
0.07	2.9	0.29	0.06	2.45	0.01	0.9	40%	0%	0.88	8 700	Slovenia
0.03	1.6	0.92	0.04	0.57	0.04	3.2	21%	-7%	0.92	16 000	Spain
0.17	9.8	1.11	0.04	8.32	0.12	-2.7	6%	-3%	0.94	21 800	Sweden
0.34	1.5	0.49	0.15	0.19	0.36	3.9	-1%	-12%	0.93	21 500	United Kingdom
											OTHER NATIONS
0.07	0.8	0.35	0.12	0.17	0.05	0.8	14%	-7%	0.72	1 000	China
0.45	4.9	1.76	0.28	2.01	0.36	4.7	7%	-11%	0.94	39 100	United States of America

Low income countries: Afghanistan, Albania, Angola, Armenia, Azerbaijan, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Rep., Chad, Congo, Dem. Rep. Congo, Côte d'Ivoire, Eritrea, Ethiopia, The Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, Honduras, India, Kenya, DPR Korea, Kyrgyzstan, Lao PDR, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Rep. Moldova, Mongolia, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Swaziland, Tajikistan, United Rep. Tanzania, Togo, Turkmenistan, Uganda, Viet Nam, Yemen, Zambia, Zimbabwe.

* The Cyprus footprint and biocapacity results exclude the Turkish Cypriot Area.

** Note that built-up land is part of both Ecological Footprint and biocapacity.

*** If number for ecological deficit is negative, country has an ecological reserve.

**** For the Czech Republic and Slovakia, 2001 country averages are compared with the Czechoslovakia per person averages.

† High/medium/low income country classifications for the Human Development Index are taken from UNDP 2003.

TECHNICAL NOTES

ECOLOGICAL FOOTPRINT and BIOCAPACITY

1. The Ecological Footprint

The **Ecological Footprint** is a measure of how much **biologically productive** land and water **area** an individual, a city, a country, a region, or humanity uses to produce the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management schemes. This land and water area can be anywhere in the world.

This report documents national per person footprints for consumption. Footprints can be calculated for any activity of organizations and populations, or for urban development projects, services, and products.

The Ecological Footprint is measured in global hectares. A **global hectare** is 1 hectare of biologically productive space with world average productivity. In 2001 (the most recent year for which consistent data are available), the biosphere had 11.3 billion hectares of biologically productive area corresponding to roughly one quarter of the planet's surface. These 11.3 billion hectares include 2.3 billion hectares of water (ocean shelves and inland water) and 9.0 billion hectares of land. The land area is composed of 1.5 billion hectares of cropland, 3.5 billion hectares of grazing land, 3.9 billion hectares of forest land, and 0.2 billion hectares of built-up land.

In this report, the Ecological Footprint is calculated for each **country**. This includes the resources contained within the goods and services that are consumed by people living in that country, as well as the associated waste. Resources consumed for the production of goods and services that are exported to another country are added to the footprint of the country where the goods and services are actually consumed, rather than of the country where they are produced.

The **global Ecological Footprint** is the area of productive biosphere required to maintain the material throughput of the human economy, under current management and production practices. Typically expressed in global hectares, the Ecological Footprint can also be measured in number of planets, whereby one planet represents the biological capacity of the Earth in a given year. Results could also be expressed, for example, in Austrian or Danish hectares, just as financial accounts can use different currencies.

The analysis is based primarily on **data** published by the Food and Agriculture Organization of the United Nations (FAO), the International Energy Agency (IEA), the UN Statistics Division (UN Commodity Trade Statistics Database – UN Comtrade), and the Intergovernmental Panel on Climate Change (IPCC). Other data sources include studies in peer reviewed science journals or thematic collections.

2. Biocapacity and bioproductivity

Biocapacity (biological capacity) is the total usable biological production capacity in a given year of a biologically productive area, for example within a country. It can be expressed in global hectares.

Biologically productive area is land and sea area with significant photosynthetic activity and production of biomass. Marginal areas with patchy vegetation and non-productive areas are not included. There are 11.3 billion global hectares of biologically productive land and sea area on the planet. The remaining three-quarters of the Earth's surface, including deserts, ice caps, and deep oceans, support comparatively low levels of bioproductivity, too dispersed to be harvested.

Bioproductivity (biological productivity) is equal to the biological production per hectare per year. Biological productivity is typically measured in terms of annual biomass accumulation.

Biocapacity available per person is calculated as follows. Dividing the 11.3 billion global hectares of biologically productive area by the number of people alive – 6.15 billion in 2001 – gives the average amount of biocapacity that exists on the planet per person: 1.8 global hectares.

3. Assumptions underlying the calculations

Ecological Footprint calculations are based on the following assumptions:

- It is possible to keep track of most of the resources people consume and the wastes they generate.
- Most of these resource and waste flows can be measured in terms of the biologically productive area necessary to maintain these flows. Those resource and waste flows that cannot be measured are excluded from the assessment. As a consequence, this assessment tends to underestimate the true Ecological Footprint.
- By weighting each area in proportion to its usable resource productivity (that is, its annual production of usable resources and services), the different areas can be converted from *hectares* and expressed in a (different) number of *global hectares* of average productivity. "Usable" refers to the portion of biomass used by humans, reflecting the anthropocentric assumptions of the Ecological Footprint measurement.
- Since these areas stand for mutually exclusive uses, and each global hectare represents the same amount of biomass production potential for a given year, they can be added up. This is the case for both the aggregate human demand (the Ecological Footprint) and the aggregate supply of biocapacity.
- Human demand expressed as the Ecological Footprint and nature's supply expressed in global hectares of biocapacity can be directly compared.
- Area demand can exceed area supply. For example, the footprint of forest products harvested from a forest at twice its regeneration rate is twice the size of the actual forest. Use that exceeds the regeneration rate of nature is called **ecological overshoot**.

4. What is NOT counted

The results presented tend to underestimate human demand on nature and overestimate the available biocapacity by:

- choosing the more optimistic bioproductivity estimates when in doubt (e.g. carbon absorption)
- excluding human activities for which there are insufficient data (e.g. acid rain)
- excluding those activities that systematically erode nature's capacity to regenerate. They consist of:
  - uses of materials for which the biosphere has no apparent significant assimilation capacity (e.g. plutonium, polychlorinated biphenyls (PCBs), dioxins, chlorofluorocarbons (CFCs))
  - processes that irreversibly damage the biosphere (e.g. species extinction, fossil-aquifer depletion, deforestation, desertification).

For consistency and to keep the global hectares additive, each area is only counted once as both Ecological Footprint and biocapacity, even if an area provides two or more ecological services at the same time. As mentioned, the accounts include the productivity of cropland at the level of current yields, with no deduction for possible degradation; however, if degradation takes place it will show up as reductions in future biocapacity assessments. The energy use for agriculture, including fertilizers, is included in the energy footprint.

Ecological Footprint calculations avoid double counting – that is, counting the same area twice. Consider bread: wheat is farmed, milled, and baked, then finally eaten as bread. Economic data can track these sequential processes and report the amounts and financial values at each stage. However, it is the same wheat grain throughout the production process, finally ending up as human consumption. To avoid double-counting, the wheat is counted at only one stage of the process, while energy consumed at each stage of the process is added to the footprint.

This report provides the consumption footprint. Globally, the consumption footprint equals the production footprint. At the national scale, trade must be accounted for, so the consumption footprint = production footprint + imports – exports (assuming no significant change in stocks).

5. Methodology

The Ecological Footprint methodology is in constant development, adding detail and better data as they become available. Coordination of this task is being led by the Global Footprint Network. This report uses the most current national accounts methodology, building on Monfreda et al. (2004). An electronic copy of a sample data sheet and its underlying formula and a detailed description of the methodology, are available at www.footprintnetwork.org. New features for 2004 include:

- a simplification of the pasture calculation that assumes full use of existing pasture areas unless livestock density is lower than half the carrying capacity of the pasture, calculated from net primary productivity estimates
- refined calculation of CO_2 sequestration and forest productivity using FAO's Global Fibre Supply Model (FAO 2000) and complementary FAO sources
- a more complete data source for CO_2 emissions (IEA 2003)
- new data sources for built-up area (FAO/IIASA 2000, EEA 1999).

A nation's consumption is calculated by adding imports to, and subtracting exports from, domestic production. Domestic production is adjusted for production waste and, in the case of crops, the amount of seed necessary for growing the crops in the first place.

This balance is computed for all countries that are represented in UN statistical data, back to 1961, with approximately 3 500 data points and 10 000 calculations per year and country. More than 200 resource categories are included, among them cereals, timber, fishmeal, and fibres. These resource uses are translated into global hectares by dividing the total amount consumed in each category by its global average productivity, or yield. Biomass yields, measured in dry weight, are taken from statistics (FAO 2004).

To relate the productivity of sea area to that of land area, the ability of fisheries to provide protein is compared with the productivity of pastures.

CO_2 emissions from fossil fuel, minus the percentage absorbed by oceans, are divided by the carbon assimilation capacity of world average forests. Some of the resource categories are primary resources (such as raw timber and milk), while others are manufactured products derived from primary resources (such as paper and cheese).

For example, if 1 tonne of pork is exported, the amount of cereals and energy required to produce this tonne of pork is translated into a corresponding biologically productive area, then subtracted from the exporting country's footprint and added to that of the importing country.

Despite these adjustments for trade and because relevant data are currently unavailable, some consumption activities, such as tourism, are attributed to the country where they occur rather than to the consumer's country of origin. This distorts the relative size of some countries' footprints, but does not affect the global result.

6. Area types of the Ecological Footprint and biocapacity accounts

The accounts include six main bioproductive area types. Once the human impacts are expressed in global hectares, these components are added together.

Cropland

Growing crops for food, animal feed, fibre, and oil occupies cropland, the most productive land type. FAO estimates that there are about 1.5 billion hectares of cropland worldwide (FAO 2004). Using FAO harvest and yield data for 74 major crops, the use of cropland for crop production was traced (FAO 2004). These accounts may underestimate long-term productivity, since other impacts from current agricultural practices, such as long-term damage from topsoil erosion, salination, and contamination of aquifers with agro-chemicals, are not yet accounted for. Still, such damage will affect future bioproductivity as measured by these accounts.

Grazing land

Grazing animals for meat, hides, wool, and milk requires grassland and pasture area. Worldwide, there are 3.5 billion hectares of natural and semi-natural grassland and pasture. It is assumed that 100 per cent of pasture is utilized, unless pasture produces more than twice the feed requirement necessary for the grass-fed livestock. In this latter case, pasture demand is counted at twice the minimum area requirement. This means that the pasture footprint per unit of animal product is capped at twice the lowest possible pasture footprint per unit of animal product. This may lead to underestimating pasture demand since, even in low productivity grasslands, people usually allow grazing animals full range and thus create human demand on the entire available grassland. Diet profiles are created to determine the mix of cultivated food, cultivated grasses, fish products, and grazed grasses consumed by animals in each country. Each source of animal food is charged to the respective account (crop feed to the cropland footprint, fish-based feed to the fishing ground footprint, etc.). The embodied cropland and pasture is used with FAO trade data (FAO 2004) to charge animal product footprints to the consuming country.

The dividing line between forest areas and grasslands is not sharp. For instance, FAO has included areas with 10 per cent of tree cover in the forest categories, while in reality they may be primarily grazed. While the relative distribution between forest and grassland areas may not be accurate, the accounts are constructed to ensure no area is counted in more than one category of land.

Forest area

Harvesting trees for timber and paper-making, and gathering fuelwood require natural or plantation forests. Worldwide there are 3.9 billion hectares of forests according to FAO's most recent survey (FAO 2003). Forest productivities were estimated using a variety of sources (FAO 1997b, FAO 2000, FAO/UNECE 2000). Consumption figures for timber and fuelwood also come from FAO (2004). The footprint of fuelwood consumption is calculated using timber growth rates that are adjusted upward to reflect the fact that more forest biomass than merely roundwood is used for fuel, and that less mature forests with higher productivity can be used for fuelwood production.

Fishing ground

Fishing requires productive fishing ground. Most of the ocean's productivity is located on continental shelves. Excluding inaccessible or unproductive waters, these comprise 1.9 billion hectares. Although a mere fraction of the ocean's 36.3 billion hectares, they provide more than 95 per cent of the marine fish catch (Postma and Zijlstra 1988). Inland waters consist of an additional 0.4 billion hectares, making 2.3 billion hectares of potential fishing grounds out of the 36.6 billion hectares of ocean and inland water that exist on the planet. FAO fish catch figures (FAO 2004, FAO 2002) were used, and compared with FAO's "sustainable yield" figure of 93 million tonnes per year (FAO 1997a). The accounts include both fish catch for fishmeal and

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fish for direct human consumption. Also, bycatch was added to each country's reported fish catch to account for discarded fish.

Built-up land

Infrastructure for housing, transportation, industrial production, and capturing hydroelectric power occupies built-up land. This space is the least documented, since low-resolution satellite images are not able to capture dispersed infrastructure and roads. Data from CORINE (EEA 1999), GAEZ (FAO/IIASA 2000), and GLC (JRC/GVM 2000) were used. Best estimates indicate a global total of 0.2 billion hectares of built-up land. Built-up land is assumed to have replaced cropland, as human settlements are predominantly located in the most fertile areas of a country. For this reason the 0.2 billion hectares of built-up land appear in the Ecological Footprint accounts as 0.44 billion global hectares.

"Energy land"

Burning **fossil fuel** adds CO_2 to the atmosphere. The footprint of fossil fuel is calculated by estimating the biologically productive area needed to sequester enough CO_2 to avoid an increase in atmospheric CO_2 concentration. Since the world's oceans absorb about 1.8 Giga tonnes of carbon every year (IPCC 2001), only the remaining carbon emission is accounted for in the Ecological Footprint. The current capacity of world average forests to sequester carbon is based on FAO's Global Fibre Supply Model (FAO 2000) and corrected where better data are available from other FAO sources such as FAO/UNECE 2000, FAO 1997b, and FAO 2004. Sequestration capacity changes with both the maturity and composition of forests, and with shifts in bioproductivity due to higher atmospheric CO_2 levels and associated changes in temperature and water availability. Other possible methods to account for fossil fuel use would result in even larger footprints (Wackernagel and Monfreda 2004; Dukes 2003).

Each thermal unit of **nuclear energy** is counted as equal to a unit from fossil energy. This parity was chosen to reflect the possibility of a negative long-term impact from nuclear waste.

The **hydropower** footprint is the area occupied by hydroelectric dams and reservoirs, and is calculated for each country using the average ratio of power output to inundated reservoir area for the world's 28 largest dams (Table 5).

The net **embodied energy in trade** (which by definition balances for the globe as a whole) is calculated with the COMTRADE database from the United Nations Statistical Department, classified by 4-digit SITC code with 609 product categories. The energy intensities (embodied energy per unit) used for each category stem from a variety of sources (IVEM 1999, Hofstetter 1992). This calculation is based on averages for the 1990s. **Embodied energy** is the energy used during a product's entire life cycle for manufacturing, transportation, product use, and disposal.

Table 5: **THE WORLD'S LARGEST HYDRO DAMS**

Aguamilpa, Mexico	Guri, Venezuela	Sayanskaya, Russian Federation
Akosombo, Ghana	Ilha Solteira, Brazil	Sobradinho, Brazil
Aswan High Dam, Egypt	Itaipu, Brazil and Paraguay	Three Gorges, China
Balbina, Brazil	Jupia, Brazil	Três Marias, Brazil
Brokopondo, Suriname	Kariba, Zimbabwe and Zambia	Tucurui, Brazil
Carbora Bassa, Mozambique	Paredao, Brazil	Urra I and II, Colombia
Churchill Falls, Canada	Paulo Alfonso, Brazil	
Curua-una, Brazil	Pehuenche, Chile	
Furnas, Brazil	Rio Grande II, Colombia	
Grand Coulee, USA	Samuel, Brazil	
Guavio, Colombia	Sao Simao, Brazil	

Source: Goodland 1990 and WWF International 2000.

7. Normalizing bioproductive areas

Cropland, forest, grassland, and fishing grounds vary in bioproductivity. In order to produce Ecological Footprint results in a single measure – global hectares – the calculations normalize bioproductive areas across nations and area types to account for differences in land and sea productivity. Equivalence factors and yield factors are used to convert the actual areas in hectares of different land types into their equivalents in global hectares. These factors are applied to both footprints and biocapacities.

Equivalence factors relate the average primary biomass productivities of the different types of land (i.e. cropland, pasture, forest, fishing ground) to the global average primary biomass productivity in a given year. A hectare with world average productivity has an equivalence factor of 1.

Each year has its own set of equivalence factors, since the relative productivity of land-use types varies due to variations in technology and resource management schemes. For example, for 2001 (see Table 6), every hectare of pasture has an equivalence factor of 0.48 since, on average, pasture in that year was about half as productive as the average bioproductive hectare of the Earth's surface. The equivalence factors are the same for all countries in a given year.

Yield factors account for the difference in productivity of a given type of land across different nations. For example, a hectare of pasture in New Zealand will produce more meat on average than a hectare of pasture in Jordan; therefore the yield factor for New Zealand pasture is higher than that for Jordanian pasture. The yield factor of world average land of any type, in this case pasture, is 1. Each country and each year has its own set of yield factors. Yield factors compare national productivity with world productivity, grouped by land type. For example, Table 7 shows that, hectare by hectare, Guatemala's forests are 1.4 times as productive as world average forests.

To calculate the **biocapacity** of a nation, each of the different types of bioproductive area within that nation's borders – cropland, forest area, inland fisheries, ocean fisheries, pasture/grazing, and built-up land – is multiplied by the equivalence factor for that type (the same for every country in a given year) and the yield factor for that type (specific for each country in a given year).

The **productivity adjusted area** is biologically productive area expressed in world average productivity. It is calculated by multiplying the physically existing area by the yield and equivalence factors, thus expressing the result in global hectares. Worldwide, the number of biologically productive hectares and the number of global hectares is the same.

Table 6: **EQUIVALENCE FACTORS,** 2001

Area type	Equivalence factor (global ha/ha)
World average productivity	*1.00*
Primary cropland	2.19
Marginal cropland	1.80
Forest	1.38
Pasture	0.48
Marine	0.36
Inland water	0.36
Built-up land	2.19

Table 7: **SAMPLE YIELD FACTORS FOR SELECTED COUNTRIES,** 2001

	Primary cropland	Forest	Pasture	Ocean fisheries
World average yield	*1.0*	*1.0*	*1.0*	*1.0*
Algeria	0.5	0.1	0.7	0.7
Guatemala	1.0	1.4	2.9	0.2
Hungary	1.5	2.9	1.9	1.0
Japan	1.6	1.6	2.2	1.4
Jordan	0.9	0.0	0.4	0.7
Laos	0.8	0.2	2.7	1.0
New Zealand	1.8	2.4	2.5	0.2
Zambia	0.5	0.3	1.5	1.0

8. Water withdrawals

National footprint and biocapacity accounts do not presently include freshwater use and availability because withdrawal of a cubic metre of freshwater affects local biocapacity differently depending on local conditions. Removing one cubic metre from a wet area makes little difference to the local environment, while in arid areas every cubic metre removed directly compromises local bioproductivity. Hence, water assessments need very specific data on local circumstances. Such data are not available for global comparison.

In the current Ecological Footprint accounts, freshwater use is reflected only to the extent that overuse or lack of freshwater eventually leads to reduced biocapacity.

9. Natural accounting

Natural capital is the stock of natural assets that yield goods and services on a continuous basis. Main functions include resource production (such as fish, timber, or cereals), waste assimilation (such as CO_2 absorption, sewage decomposition), and life support services (UV protection, biodiversity, water cleansing, climate stabilization).

Ecological deficit is the amount by which the Ecological Footprint of a population exceeds the biocapacity of the population's territory. The national ecological deficit measures the amount by which a country's footprint exceeds its biocapacity. A national deficit is covered through trade or offset through loss of national ecological capital. But a global ecological deficit cannot be offset through trade; it is equal to a global **ecological overshoot**.

Ecological debt is the accumulated annual global deficit. Debts are expressed in planet-years – one **planet-year** being the annual production of the biosphere.

Ecological reserve is biocapacity in a territory that is not used for consumption by the population of that territory: the opposite of an ecological deficit. Countries with footprints smaller than their locally available biocapacity have an ecological reserve. This reserve is not necessarily unused by people – it may be occupied by the footprints of other countries (through production for export).

10. Contraction & Convergence and Shrink & Share

Contraction & Convergence (C&C) as proposed by Aubrey Meyer from the Global Commons Institute (Meyer 2001) provides a simple framework for globally allocating the right to emit carbon in a way that is consistent with the physical constraints of the biosphere. The approach rests on two simple principles:

- contraction: reducing humanity's emissions to a rate that the biosphere can absorb
- convergence: distributing total emissions in a way that is considered fair to all.

Although C&C focuses exclusively on CO_2 emissions, which are responsible for about 50 per cent of humanity's Ecological Footprint, the C&C framework can be extended to other demands on the biosphere.

We call this Shrink & Share. Shrinkage would occur when nations, organizations, and individuals reduce their footprints so that consumption, production, investment, and trade activities do not exceed the regenerative capacity of the globe's life-supporting ecosystems. Sharing occurs if these reductions were allocated in ways considered equitable by the participants. This includes many possibilities: for example, it might imply that consumption, production, investment, and trade patterns change such that the per person footprints in various nations deviate less and less from each other, that there is a more equitable distribution of the rights to use resources, or that resource consumption rights are more closely tied to the resources a region or nation has available.

Further discussion on Shrink & Share and how this can support risk assessments and eco-insurance schemes can be found in Lovink et al. (2004) and in the *Living Planet Report: 2004* (WWF 2004).

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MAP SOURCES

Map 1

Global Footprint Network and SAGE, University of Wisconsin. Distribution builds on Gridded Population of the World (version 2) from CIESIN at Columbia University (http://sedac.ciesin.columbia.edu/plue/gpw/index.html?main.html&2). 1995 population distribution is scaled to each country's 2001 population.

Map 2

NC-IUCN – Netherlands Committee for the World Conservation Union, 2004. *The European Union and the World Ecology*. Amsterdam, the Netherlands. Map 2 is based on a more detailed map that can be found at http://www.nciucn.nl/nederlands/programmas/neth_worldecology/ewe/index.htm

Map 3

Global Footprint Network, 2004. *Ecological Debtors and Creditors*. www.footprintnetwork.org

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