Topic 7
Ecological Footprint

(1–2 lessons)

Students will read, interpret, and produce graphical representations of statistics; skim and scan articles for information; classify items according to criteria; draw inferences; compare viewpoints; synthesize information from several sources; and conduct an informal interview.

Outcomes	Instructional and Learning Sequence
SLO 1.5 Examine and interpret various visual media… **SLO 1.6** Interpret a range of texts… **SLO 6.2.7** Use elaboration… **SLO 6.3.1** Use questioning for clarification… **SLO 6.3.2** Use co-operation…	**Sequence 1** **Activation** Review the purpose of political cartoons. Together, analyze a political cartoon related to human consumption for situation, what or who is being satirized, and what the message is. **Language Features** — **Vocabulary**: consume, consumption, words relevant to cartoon, per capita, GDP, renewable, non-renewable
SLO 1.1 Engage with increasingly difficult oral and/or visual texts… **SLO 2.1.1** Analyze and edit texts… **SLO 2.1.3** Use developing control of grammatical features… **SLO 5.1** Identify common themes and symbols… **SLO 6.1.5** Use selective attention… **SLO 6.1.6** Use self-monitoring to check… **SLO 6.2.2** Use repetition to imitate a language model… **SLO 6.2.8** Use imagery in the form of mental or actual pictures…	As a class, examine and discuss **Handout 2-38:** "Consumption Charts" to find the consumption of resources in various nations. Notice the title of the charts and structural features that communicate information. Note the countries with the highest and lowest consumption: were students surprised? It is also important to note that the second chart shows the highest growth in consumption rates. What could explain the growth? Model one or two statements about the information. Then students write statements and share with the class. **Language Features** — **Structures**: **Expressions of possibility—**modals: must, could, might, may; adverbs: probably, likely, perhaps; passive voice

Student Learning Tasks

Analyze the political cartoon for situation, what or who is being satirized, and what the message is. (**C**)

Look at **Handout 2-38:** “Consumption Charts” and contribute to the discussion. (**C**)

Write one or two statements about the information to share with the class. (**I**)

Teacher Notes and References

Political cartoon related to human consumption (teacher-provided)

Appendix 11: How to Analyze Editorial Cartoons

Handout 2-38: “Consumption Charts”

Outcomes

SLO 1.1 Engage with increasingly difficult oral and/or visual texts…

SLO 1.2 Respond to texts with increasing independence…

SLO 1.3 Develop and express a personal position in a variety of ways…

SLO 1.7 Evaluate a given text…

SLO 2.1 Show sufficient control over linguistic structures…

SLO 2.2 Use several visual techniques…

SLO 4.1 Use language to encourage…

SLO 6.1.1 Use advanced organization…

SLO 6.1.5 Use selective attention…

SLO 6.1.6 Use self-monitoring to check…

SLO 6.2.12 Use inferencing to guess the meanings…

Instructional and Learning Sequence

Skim Handout 2-39: "Natural Resources and Wastes." What is the main topic? (renewable and non-renewable resources)

Preview the focus questions:

- What two human activities affect our environment?
- What is a renewable resource? Non-renewable?
- Why is the human impact on renewable resources even greater than on non-renewable resources?
- What is the writer's view of the danger of overusing our natural resources?
- What does the writer believe is the greatest threat to the environment? Why?

Have students scan article for answers to the questions.

Discussing the answers together.

Language Features	Vocabulary **From AWL:** adaptation, affect, apparent, available, categories, constant, constantly, constrained, consumers, consumption, decades, declined, derive, despite, dramatic, economical, ensured, exploit, extract, final, focus, generated, global, impact, indication, issued, major, mechanism, mechanisms, modify, occupy, percent, projected, recoverable, remove, research, resource, substitutes, sufficient, technology, traditionally, ultimately

Student Learning Tasks

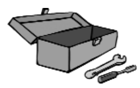
Assignment

a) Skim reading to preview:
- What two human activities affect our environment?
- What is a renewable resource? Non-renewable?
- Why is the human impact on renewable resources even greater than on non-renewable resources?
- What is the writer's view of the danger of overusing our natural resources?
- What does the writer believe is the greatest threat to the environment? Why?

b) Scan article for answers to the questions. (**I**)

c) Discuss answers. (**C**)

Teacher Notes and References



Handout 2-39: "Natural Resources and Wastes"

This reading uses many words from AWL.

Outcomes	Instructional and Learning Sequence
SLO 2.2 Use several visual techniques… **SLO 4.1** Use language to encourage… **SLO 6.2.2** Use co-operation… **SLO 6.2.3** Use grouping of items to classify… **SLO 6.2.8** Use imagery in the form of mental or actual pictures…	**Follow-up Activity** With a partner, have students look around the room or the school, or chart daily activities, and classify as many items as possible as renewable or non-renewable resources. Then students estimate a percentage for each, represent graphically, and compare charts. **Language Features** — **Academic Language Functions**: classifying; estimating; comparing
SLO 1.3 Develop and express a personal position in a variety of ways… **SLO 4.1** Use language to encourage… **SLO 6.2.8** Use imagery in the form of mental or actual pictures… **SLO 6.2.7** Use elaboration… **SLO 6.2.12** Use inferencing to guess the meanings…	**Sequence 2** Have students discuss with a partner, then with the class, what a footprint represents (that a living being was present; gone now, but left a footprint as evidence; may cause damage; can follow them). Ask students: How do you think human beings leave footprints in the environment? **Language Features** — **Vocabulary**: footprint

Student Learning Tasks

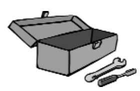
Assignment

With a partner, look around the room or the school, or chart daily activities, and classify as many items as possible as renewable or non-renewable resources. Estimate a percentage for each, represent graphically, and compare charts with the class. (**P**) (**C**)

Assignment

Discuss with a partner, and then with the class, what a footprint represents. (**P**) (**C**)

Teacher Notes and References



Visual: Cut-out of footprint or picture of footprints in the sand or on trail (teacher-provided)

Literal and perhaps metaphoric meanings may come out here. It is not a problem if students don’t understand the symbolism.

Outcomes	Instructional and Learning Sequence

SLO 1.2 Respond to texts with increasing independence…

SLO 6.1.1 Use advanced organization…

SLO 6.2.12 Use inferencing to guess the meanings…

Choose one or both of: **Handout 2-40:** "Our Footprints—They're All Over the Place" and/or **Handout 2-41:** "Humanity's Footprint."

Preview focus questions for Handout 2-40: "Our Footprints—They're All Over the Place"**:** How does the writer define "ecological footprint?" How many acres of productive land are needed to support the average North American lifestyle? What is the writer's view of the possible dangers of overusing natural resources? What does the writer see as the solution to the problem?

Scan and skim for answers to the preview questions. Follow with a more detailed reading, if desired.

AND/OR

Preview focus questions for Handout 2-41: "Humanity's Footprint."

Questions:

- What is the problem in the world context?
- What are the causes of the problem?
- What are the dangers?
- What is the suggested solution?
- Do you think the reading reflects one side of the issue? Could there be another side?

Language Features

Vocabulary

From Handout 3: replenished, shortages, stimulates, dump, exhaustion, famines

From Handout 4: aside, assets, budgeting, buildup, essential, hectare, liquidate, overcome, overuse, solution, tracking, trapping

From AWL: accurate, area, available, capacity, challenge, collapsing, economy, estimated, global, impacts, individuals, job, percentage, predictions, range, resources significant survival, sustainability, vary

Academic Language Functions

skimming and scanning

Student Learning Tasks

Scan and skim for answers to the preview questions for the articles.

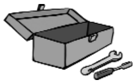
Preview focus questions for **Handout 2-40:** "Our Footprints—They're All Over the Place":

- How does the writer define "ecological footprint?"
- How many acres of productive land are needed to support the average North American lifestyle?
- What is the writer's view of the possible dangers of overusing natural resources?
- What does the writer see as the solution to the problem? (I)

Preview focus questions for **Handout 2-41:** "Humanity's Footprint":

- What is the problem in the world context?
- What are the causes of the problem?
- What are the dangers?
- What is the suggested solution?
- Do you think the reading reflects one side of the issue? Could there be another side?

Teacher Notes and References



Handout 2-40: "Our Footprints—They're All Over the Place"

Handout 2-41: "Humanity's Footprint"

Outcomes	Instructional and Learning Sequence

SLO 2.2 Use several visual techniques…

SLO 3.1 Seek, organize, and synthesize information…

SLO 6.2.8 Use imagery in the form of mental or actual pictures…

Comparison of Two Passages: Use a graphic organizer that allows for comparison of viewpoints. Compare the viewpoints expressed in **Handout 2-40:** "Natural Resources and Wastes," **Handout 2-40:** "Our Footprints—They're All Over the Place," and **Handout 2-41:** "Humanity's Footprint."

Language Features	
	Academic Language Functions
	synthesizing information

SLO 2.3 Produce a variety of short and extended text forms…

SLO 2.4 Use the steps of the writing process…

SLO 3.1 Seek, organize, and synthesize information…

SLO 3.3 Quote from or refer to sources…

SLO 6.1.4 Use functional planning…

SLO 6.1.5 Use selective attention…

SLO 6.2.1 Use resourcing to access…

SLO 6.2.7 Use elaboration…

SLO 6.2.12 Use inferencing to guess the meanings…

SLO 6.2.13 Use recombination..

SLO 6.3.1 Use questioning for clarification…

Sequence 3

Writing Task

Have each student choose one of the articles: "Population and Natural Resources" or "The Scale of Our Presence." Both discuss human impact on the earth.

Have students combine the information from the graphic organizer with examples from this article to write a paragraph explaining the concept of "ecological footprint." Remind students that when referring to the idea or words from one of the articles, they must name the writer or the title of the article, as shown.

Language Features	
	Discourse Features
	attributive tags (e.g., according to x,…; in x's view,…; x says,…)
	citation format
	Academic Language Functions
	synthesizing

Student Learning Tasks

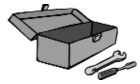
Assignment

Use a graphic organizer to compare the viewpoints expressed in Handouts 2-40, 2-41, and 2-42. (**C**)

Assignment

Choose **Handout 2-42:** “Population and Natural Resources” or **Handout 2-43:** “The Scale of Our Presence.” Combine the information from the graphic organizer with examples from this article to write a paragraph explaining the concept of “ecological footprint.” (**I**)

Teacher Notes and References

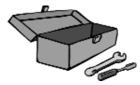


Venn diagram (see Teaching and Learning EAL in the Senior Years section)

Handout 2-39: “Natural Resources and Wastes”

Handout 2-40: “Our Footprints—They’re All Over the Place”

Handout 2-41: “Humanity’s Footprint”



Handout 2-42: “Population and Natural Resources”

Handout 2-43: “The Scale of Our Presence”

If students are unfamiliar with a standard North American documentation system, such as MLA, this is an opportunity to introduce it.

Outcomes	Instructional and Learning Sequence

SLO 4.1 Use language to encourage…

SLO 6.1.4 Use functional planning…

SLO 6.3.1 Use questioning for clarification…

Sequence 4

Preparation for Recycling Lesson

Have students interview one or two older adults (e.g., a parent or grandparent) about the items they threw out when they were young. Why did they discard the items? Where did they dispose of them? What differences do they see in today's trash?

Language Features	Structures
	question forms, time clauses (review)

SLO 1.2 Respond to texts with increasing independence…

SLO 6.1.8 Use self-evaluation to check…

Follow-up

If students have Internet access, they can take the Ecological Footprint Quiz. Read and discuss ways to "Take Action."

Student Learning Tasks

Assignment

Interview one or two older adults (e.g., a parent or grandparent) about the items they threw out when they were young. Why did they discard the items? Where did they dispose of them? What differences do they see in today's trash? (**I**)

Take the Ecological Footprint Quiz. Read and discuss ways to "Take Action."

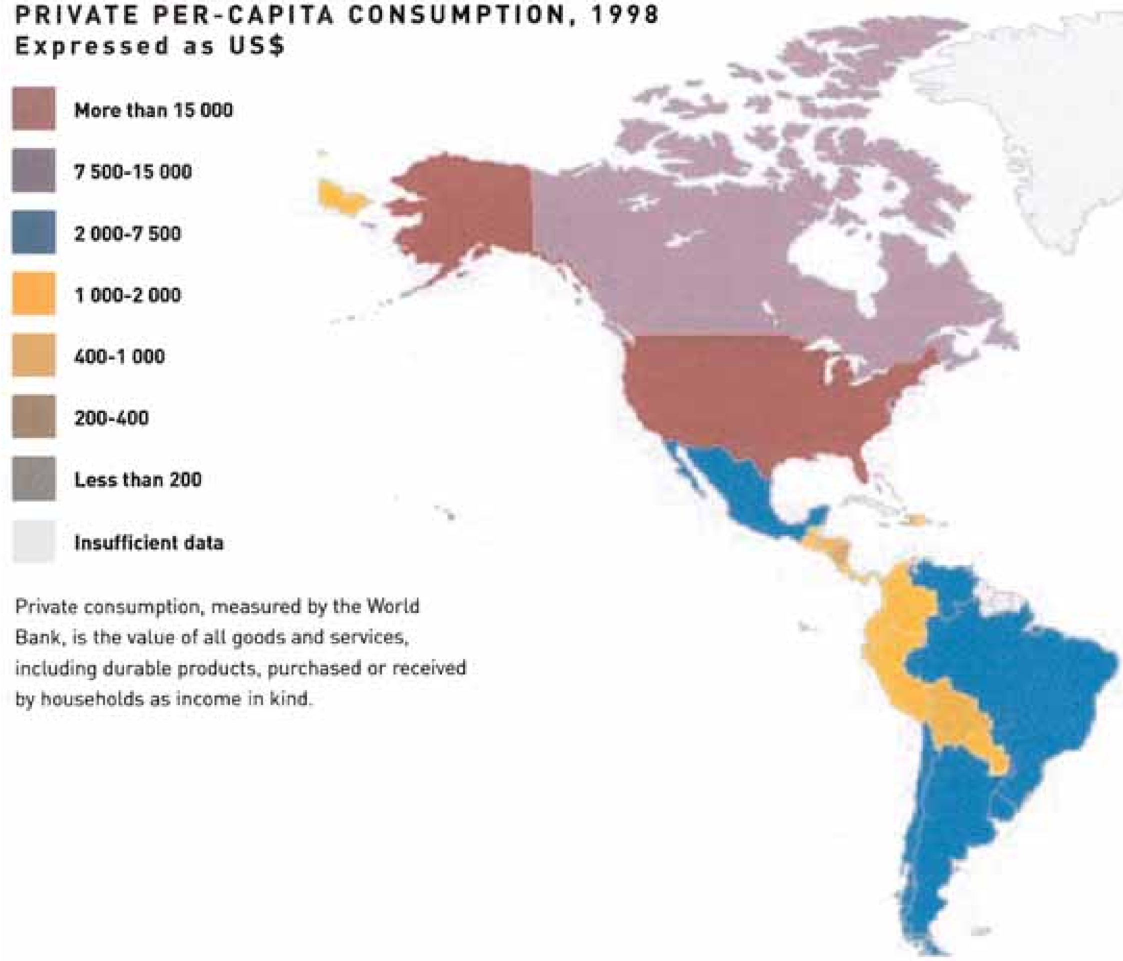
Teacher Notes and References

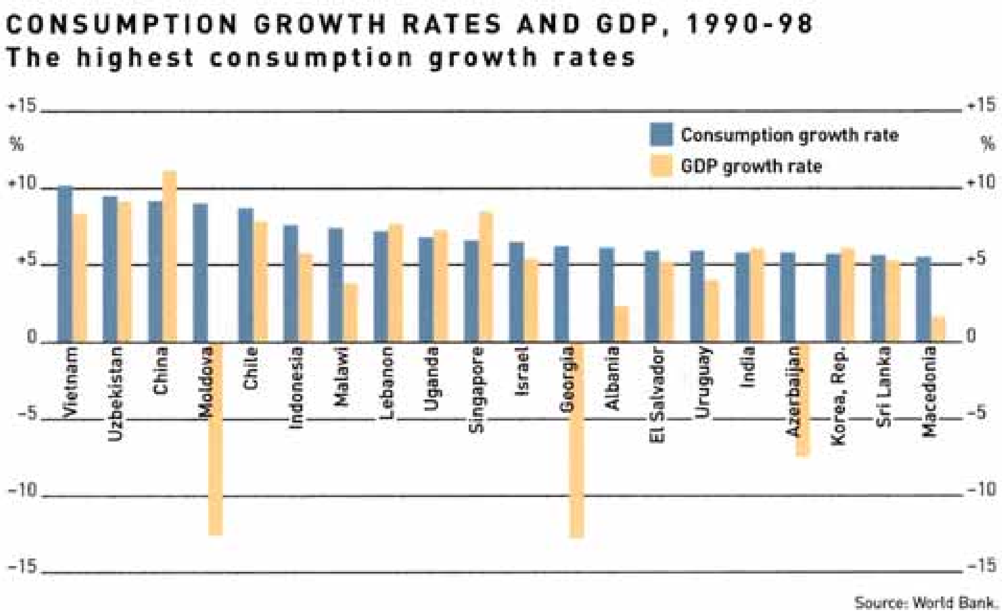
The interview will likely be in the students' first language, but they will have to report on it in English.

Ecological Footprint Quiz at: <www.earthday.net/footprint/index.asp>

Further information about the human impact on water, biodiversity, forests, energy, and equity and the environment can be found at the Earthday website.

Consumption Charts





Natural Resources and Wastes

Natural resources and wastes

POPULATION, consumption and technology impact on the environment by way of two major types of human activity. First, we use resources. We occupy or pre-empt the use of space, and so modify or remove entirely the habitats of many wild species. We extract resources – growing food, catching fish, mining minerals, pumping groundwater or oil. This affects the stock of resources available for humans and for other species in the future.

Resources fall into two main categories. Renewable resources like water or fish are replenished naturally. Non-renewable resources like oil or iron ore have a limited stock that is not replenished, except on geological timescales of millions of years.

Second, we dump wastes – not just those that consumers throw away, but all the waste solids, liquids and gases that are generated from raw material to final product. These affect the state of land, groundwater, rivers, oceans, atmosphere and climate.

Resources have traditionally been the main focus of concern about the impact of population and consumption on the environment. Frequent warnings were issued that we faced massive famines, or that we would "run out" of essential fuels and minerals. More recently it has become apparent that more serious, more immediate and more intractable problems lie in the global threats that derive from our wastes.

NON-RENEWABLE RESOURCES

Ultimately, all non-renewable resources on Earth are limited: if used constantly they must sooner or later run out. So far, however, the threatened exhaustion of non-renewable resources has not happened, thanks to market mechanisms which have ensured successful adaptation.

When shortages of any mineral resource begin to be felt, prices rise. This stimulates more exploration and research, and makes it economical to develop more expensive technology, and to exploit reserves that are more costly to work. Manufacturers find ways of making do with less, recycling increases, and cheaper substitutes are found.

Due to these mechanisms, the projected lifespan of many minerals has remained more or less level or in some cases grown with time, despite dramatic increases in use. In 1989, for example, recoverable reserves of oil and natural gas liquids were enough to cover 41 years of production at current rates. Nine years later they were enough to cover 43 years. Recoverable reserves of natural gas were enough to cover only 23 years of production in 1989; by 1998 this had grown to 57 years. Recoverable reserves of coal did fall, but were still sufficient for more than two centuries of production[1].

Prices are a good indication of impending shortage, and the prices of minerals have declined in real terms over the past four decades. In constant prices, between 1980 and 1996 the price of metals and minerals fell by an average 41 percent, while that of oil fell by 65 percent[2].

Of course, this conjuring trick cannot go on forever. But in modern times the human race has not run into shortages of any key non-renewable resource that has actually constrained the end use to which that resource was put. The mechanism of adaptation, based on free markets, resourceful

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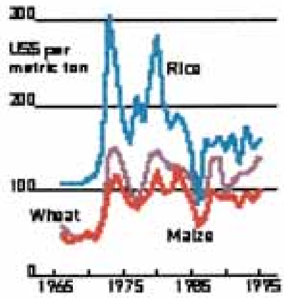
Natural Resources and Wastes (continued)

OVERVIEW **Natural resources and wastes**

CEREAL PRICES



Source: FAO.

Despite shrinking amounts of land per person and continuing soil erosion, food availability has improved in most parts of the world and cereal prices have not risen.

companies, continual research and canny consumers, has worked very well in this sphere, and there is no strong reason to believe it will not continue to do so.

This is not to say that our use of non-renewable resources is problem-free, but the major difficulties arise from the wastes created in producing and consuming these resources. Extracting and processing fossil fuels and other mineral resources on an increasing scale produces water and air pollution as well as solid wastes.

RENEWABLE RESOURCES

Renewable resources like freshwater, soil or wild fish stocks are much more problematic than non-renewable resources, because most of them are vulnerable to human overuse or pollution.

By definition, renewable resources are replenishable by nature – yet replenishment is not guaranteed. Renewal occurs only if they are given the chance to renew. If we exploit them faster than they can renew themselves, they deplete or degrade. The majority of renewable resources, including the most basic ones needed for human survival – land, food and water – are now affected by human overexploitation or pollution.

Food and land

The oldest question about human population and the environment was posed by Malthus. Can agricultural production keep up with potential human population growth? Malthus' answer was no: agricultural production can only increase arithmetically (3+3+3=9) whereas population can increase geometrically (3x3x3=27).

It followed, Malthus argued, that the human population would always be kept in check by the food supply. In reality, the reverse has usually been the case: market mechanisms have worked to expand the food supply in line with demand, and this expansion has more than matched the growth of the human population.

Land availability

Malthus' basic outlook still dominates the popular view, and some recent trends provide material for renewed concern.

In most parts of the world, cultivated land has not been expanding in line with population growth, so the amount of farmland per person has been declining. The area per person has declined only slowly in developed countries, from 0.65 hectares in 1965 to 0.51 hectares 30 years later. In developing countries, where population growth is faster, the area per person fell from 0.3 to 0.19 hectares over this same period[3].

The steepest fall was in Africa, where the extension of the farmed area has lagged far behind population growth. In 1965, Africa had half a hectare of cultivated land per person, but this dropped dramatically to a mere 0.28 hectares in 1995. If expansion continues at the same rate as it did between 1965 and 1995, and the UN's medium population projection is realized, then by the year 2040 Africa will have only 0.15 hectares of farmland per person. This is less than Asia had in 1995, and Asia has fewer problem soils and climates, and far more potential for irrigation. Many parts of Central, Southern-Central and West Africa still have abundant land, but much of this is subject to severe soil, climate or disease constraints. It seems likely that many African countries will run into serious land shortages[4].

Food availability

Overall, cereal production has not been keeping pace with population growth for the past decade and a half. The amount of grain available per person rose fairly steadily from 135 kilos in 1961 to 160 kilos in 1992, but since then has averaged about 157 kilos[5].

We must be cautious before concluding that we are seeing the harbingers of a coming global food crisis. If these developments were really reducing the ability of farmers to meet market demand then we would expect to see rising food prices and declining food intakes.

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Natural Resources and Wastes (continued)

Yet neither of these things is happening. On the contrary, allowing for inflation, the prices of most cereals have been on a falling, not a rising, trend. In constant 1990 US dollars, the prices of wheat and maize in 1996 were 40 percent lower than in 1980 and 50 percent lower than in 1960[6].

Nor was there any overall decline in average food intakes per person. Average daily calorie intake in 1998 was 2,790 calories[7], the highest on record, following fairly steady growth from 2,295 in 1963. Average daily protein intake was 74.9 grams, again the highest on record, up from 63 grams in 1961[8].

Improvements were notched up in all developing areas, most rapidly in Asia, but also in Africa, even though average calorie and protein intakes remained low.

How can we explain the simultaneous drop in cereal production per person and the rise in dietary intakes? The simple answer is that people do not live by bread alone: calorie intakes from cereals have been more or less static since 1984[9]. The increase has come rather from meat and fish, oils and other vegetable products. Global meat intake per person grew steadily from 24 kilos per person in 1963 to 37 kilos in 1998[10].

Within the cereal sector it is likely that cereals are being used more efficiently at every stage, with lower losses in storage and processing between harvest and table. Cereals used for livestock feed are increasingly being replaced by soybeans, and soybean production has been growing rapidly[11].

The continued improvement is a sign that markets are by and large matching production with effective demand. People are also adapting their diets as a result of health and environmental concerns. For example, all the 1963-98 increase in meat consumption per person came from pork (up 71 percent) and poultry (up 237 percent). It takes considerably less cereal and land to produce a kilo of chicken or pork than a kilo of beef[12].

Moreover, people's need for dietary energy is, on average, declining. Farming has the highest calorie requirements, followed in turn by heavy industry, light industry, services, and then non-employment. The general trend in all societies is to have higher and higher percentages of people represented in sectors with lower food energy needs.

Barring severe climatic change, it is very unlikely that we face catastrophic food shortages at global level. Research has shown that with relatively modest improvement in regionally specific agricultural practices, the world could feed 10 billion people with current land and technology levels[13].

Persistent problems

The agricultural sector has been very successful in raising food production since 1945 to meet growing populations and consumption levels, but this has often been at the cost of exporting problems to other ecosystems. High levels of fertilizer application have caused water pollution and eutrophication. The expansion of farmland has been to the detriment of wildlife habitat and biodiversity, which has been further harmed by pesticide use.

Population growth is directly implicated in all of these trends. For example, the area of land needed for any given crop is the product of population, multiplied by consumption per person, multiplied by the area needed to produce each unit of consumption. This latter element is the result of farming technology. Where this has been able to increase yield faster than the growth in population multiplied by consumption, the area needed for farming has fallen over time. But where yield has not kept pace, the area of farms and pastures has increased at the expense of forests and other wild habitats.

Unsustainable soil and water management practices have caused land degradation. A major assessment found that by 1990 soils had degraded on 38 percent of the world's cropland, 21 percent of pasture and 18 percent of forests[14]. Productivity has declined significantly on 16 percent of agricultural land in developing countries[15]. One recent estimate suggested that cropland productivity is 12.7 percent lower than it would have been without human-induced soil degradation[16].

Serious problems of food production will also continue in localized areas and in individual countries. These include many countries in sub-Saharan Africa and some individual countries outside Africa such as Bolivia, Haiti and Afghanistan. Many countries that cannot produce enough food

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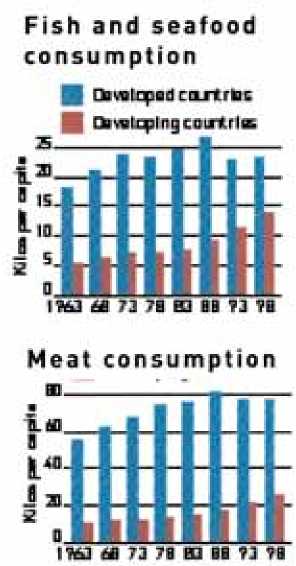
THE CLOSING GAP

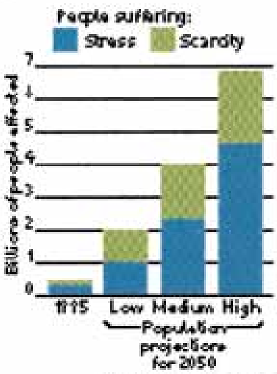


Source: FAO.

Natural Resources and Wastes (continued)

OVERVIEW **Natural resources and wastes**

FRESHWATER SCARCITY



Source: Population Action International.

The number of people in countries facing freshwater shortages, around 436 million in 1995, is set to rise steeply over the next half century, but will vary enormously depending on the rate of population growth.

for their own needs can pay for food imports by exporting manufactured goods or services. But many marginal areas, and many poor food-deficit or landlocked countries, especially in Africa, are badly placed to develop competitive industries or services.

There are millions of people who do not get enough food for a healthy, active and productive life. The estimated incidence of malnutrition in developing countries has halved from 35 percent of the population in 1969-71 to 17 percent in 1995-97, but because of the growth in population the absolute drop in numbers, from 917 million to 790 million, has been much more modest[17].

The numbers of malnourished will probably continue to decline slowly, while still remaining unacceptably high. However, malnutrition is not a sign that not enough food is available at global or even national level. It is a symptom of poverty and inequality – the poor lack enough money to buy, or enough good land to grow, sufficient food for the needs of their families.

Reducing the number of malnourished means taking measures to create jobs, redistribute land more equitably, and increase the productivity of small and marginal farms through targeted agricultural training, crop breeding, and soil and water conservation programs. Once the poor's own resources have been boosted, they themselves will grow, or the world market will produce, enough food to meet their effective demand.

Freshwater

We live on a planet whose surface is mainly ocean, but freshwater is a much more limited resource. Some 97 percent of all water is salty, currently useless for drinking or agriculture.

Most freshwater is locked up in ice and snow and in aquifers too deep to tap, and the rest is very unevenly distributed. Equatorial regions and some northern latitudes have a surfeit. Dry areas in between, including much of Africa, have supplies that are too scarce or too uncertain.

Freshwater is crucial for survival, for health, for agriculture, for industry, and for comfort and leisure. But the freshwater resources of any country are limited. There is only so much to go round: the larger the population, the less there is for each person.

In some countries, shortages are already biting. According to Swedish hydrologist Malin Falkenmark, a minimum of 1,700 cubic metres of renewable freshwater is needed per person per year to avoid serious problems. Below this level, a country is in a situation of water stress, when water supply problems may become chronic and widespread. There may be a need for long-distance water transfers, reuse of treated waste water, or supply interruptions in dry periods.

Where supplies fall below 1 000 cubic meters per person per year, a situation of water scarcity applies, and a society will face difficult choices between agriculture, industry, personal health and convenience which will hamper development[18].

In 1995 some 436 million people were already suffering water scarcity or stress. Even these levels of water shortage are causing severe development problems in some areas. There are conflicts among farmers and between farming and urban needs, and heightening tensions between countries dependent on the same resources, such as Israel and Jordan; Turkey, Syria and Iraq; India and Bangladesh; Sudan and Egypt[19]. Saudi Arabia, Israel and the whole of North Africa from Egypt to Mauritania are already withdrawing groundwater faster than it can replenish itself. Yet these countries face population increases of between 52 and 152 percent over the next 50 years[20].

Different population futures make a considerable difference to water futures. An analysis of the UN's 1996 population projections has estimated numbers likely to be suffering water shortage in the future. By 2050, on the medium projection, the number of people in countries suffering water stress or scarcity will have risen to 4 billion[21]. If the UN's low population projection could be achieved, then the total population in countries facing water scarcity or stress would amount to only 2 billion. By contrast, if the world were to hit the high projection, this total would be 6.8 billion.

POLLUTION AND WASTES

Perhaps the most intractable threats to the globe today relate as much to what we waste as to what we consume. Pollution places a mounting burden on local and planetary ecosystems. Ultimately it is

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Natural Resources and Wastes (continued)

exported to the global commons: the oceans and atmosphere, where our understanding of interactions is still inadequate. Sustainable management strategies are complex to devise and politically difficult to introduce.

In the process of making the end products we actually use, our machines dig up, churn over, swallow up and spew out gigatons of material. One study found that some 93 percent of materials used in production do not end up in saleable products but in waste, while 80 percent of products are discarded after a single use[22].

The result is a veritable avalanche of materials. In 1995, for example, the world produced 1.42 billion tons of cement – about a quarter of a ton for every man, woman and child on Earth. Some 2.57 billion tons of sand and gravel were produced in the 52 countries for which data are available[23].

Figures on carbon dioxide (CO_2) illustrate how the waste deluge has grown. Back in 1750, the human race produced only 11 million tons of CO_2 from fossil-fuel burning and cement production. A century later this had grown 18-fold to 198 million tons, and in another century a further 30-fold to around 6 billion tons. By 1995 our annual CO_2 output had multiplied by another four times to reach almost 24 billion tons[24].

These material flows have left deepening scars on the planet. The solid wastes that are not incinerated deface or pollute localized areas and water courses. Liquid and gaseous pollutants are more insidious and spread invisibly across the whole globe.

Humans raised the level of CO_2 in the air from 280 parts per million in pre-industrial times to 363 parts per million in 1996. Over this same period we raised methane concentrations by 145 percent. There were no gaseous chlorines in the atmosphere before industrial times. By 1996 there were 2,731 parts per trillion, most of these produced in the 20th century[25].

Significant traces of organic and metallic pollutants are now found in the deepest marine sediments, in the remotest glaciers and icecaps, and in the fat of arctic mammals. Studies of human breast milk have found traces of more than 350 contaminants, including 87 dioxin and dioxin-like compounds and 190 volatile compounds[26].

The rise of pollution and waste is not inexorable. Water and air pollution usually increase in the early stages of economic development, but once a certain income threshold has passed, people tend to value environmental quality more highly and have the resources to pay for protection measures. In most developed countries there have been significant reductions in emissions of lead, sulfur dioxide (SO_2) and particulates (smoke), and widespread improvements in water quality in rivers and around beaches. These are cases of immediate hazard, or easily noticeable local problems, or substances that have been the subject of intense media publicity, where political pressure for change is strong[27].

But even in rich countries waste emissions with less immediate, less visible or less dramatic effects have not been the subject of effective controls. The same is true where the costs are exported over a vast area or over the whole globe, or where remedial action would be costly and might affect powerful business interests or important groups of voters. These include, for example, emissions of the greenhouse gases CO_2 and methane.

Population is always a factor in waste and pollution, along with consumption and technology. The level of production of wastes or pollutants is the product of the number of people, the amount each person consumes, and the amount of waste created for each unit of consumption in the whole process from production and packaging to the consumer and his or her dustbin or sewage outlet.

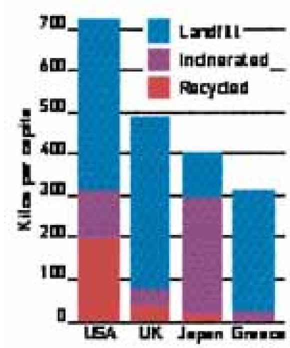
Several efforts have been made to identify the relative shares of responsibility for rising pollution. Environmentalist Barry Commoner studied examples from the United States between 1946 and 1968. Population growth accounted for only 14 to 18 percent of the increase in synthetic organic pesticides, in nitrogen oxides and in tetraethyl lead from vehicles. It was responsible for only 7 percent of the increase in non-returnable beer bottles and a mere 3 percent of the increase in phosphorus from detergents. In almost every case, technology was the dominant factor. A later study by Commoner of nitrates, cars and electricity in 65 developing countries came to similar conclusions[28].

(continued)

Waste

In the mid-1990s the rich countries belonging to the Organisation for Economic Co-operation and Development produced 1.5 billion tons of industrial waste and 579 million tons of municipal waste – an annual total of almost 2 tons of waste for every person. The United States alone produced 214 million tons of hazardous waste – almost half a kilo for every dollar of GDP[21].

MUNICIPAL WASTE PRODUCTION AND DISPOSAL, MID-1990s



Source: OECD.

In developed countries each person produces five to ten times their body weight in municipal waste per year. There are huge variations: the average Japanese produces 45 percent less waste than the average American. Industrial, mining and construction wastes are many times greater than municipal. The shares going to recycling, incineration or landfill also vary widely.

Natural Resources and Wastes (continued)

OVERVIEW **Natural resources and wastes**

Clearly, technology is always implicated, and in many cases it may be the prime culprit. However, Commoner chose only cases where technological change was rapid. There are other cases where population or consumption are dominant, such as increased methane emissions from livestock or paddy fields. In more and more cases, technological change is a downward pressure, working to reduce our output of wastes, while growth in population and consumption continues to gear it upwards.

Studies of changes in air pollutants (SO_2, nitrogen oxides, smoke and CO_2) in countries of the Organisation for Economic Co-operation and Development (OECD) between 1970 and 1988 showed technology as a downward pressure in all four cases – mainly through increased energy efficiency in the case of CO_2 and nitrogen oxides, and through cleaner technology in the case of SO_2 and smoke. Population growth was responsible for a quarter of the upward pressure on emissions, while consumption was responsible for three quarters[30].

Our Footprints—They're All Over the Place

By David Schaller

The word "footprint" offers us many richly symbolic images: Neil Armstrong's "one small step"; Crusoe's Friday; the fog that comes "on little cat feet"; the Olduvai tracks of "Lucy;" and yes, even the caution expressed by my elementary school teacher to stay away from "Big Feet"—the junior high kids on the playground who loved to torment first and second graders.

Let's now look at another dimension of footprint, one equally symbolic and full of meaning to those concerned about environmental protection. If asked who had the bigger "footprint"—an adult female living somewhere in the developing world or your average eight-year-old American child—most of us would select the adult female. Now, insert the word "ecological" in front of "footprint" and repeat the question. The answer—in a moment.

The concept of an "ecological footprint" is an almost intuitive measure of the impact of individuals or societies on nature. It provides a simple yet elegant accounting tool that can help us see the impact of human consumption patterns on the earth. What we do about this information, of course, is the essence of a much larger policy debate.

As we live out our lives, we consume resources and we discard wastes. Each bit of consumption and generation of waste demands a certain amount of productive land and water. The amount of productive land and water needed to support the production of resources we consume and absorb the wastes we create can be considered as our Ecological Footprint. Individuals, households, cities, regions, nations—all can be measured as to their Ecological Footprint.

In their compelling book, *Our Ecological Footprint*, William Rees and Mathis Wackernagel lay out the approach and apply the methodology that is changing the way we look at broad issues of sustainability, ecological carrying capacity, environmental protection, and even social justice. Here, in a nutshell, is the essence of Ecological Footprint analysis applied to the world in which we currently live.

The ecologically productive land of the world currently totals some 3.6 acres for each of the 5.95 billion people now living. The average North American lifestyle currently requires almost 10 acres of ecologically productive lands to supply its resources and absorb its wastes. This tells us immediately that the ecological demands of average citizens in rich countries exceed per capita supply by a factor of three. Someone, lots of someones, somewhere are going without.

Said another way, if everyone currently alive were to consume resources and generate wastes at the pace of the average citizen in the United States (or Canada, or Western Europe, or Japan) we would need three planets in order to live "sustainably." For the projected global population of nearly 10 billion people in the year 2040 to enjoy the North American lifestyle of today, *a total of six planet Earths* would

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Our Footprints—They're All Over the Place (continued)

be needed. Neither scenario seems likely. These projections assume that there will be no improvements in either resource use efficiency or waste elimination techniques. However, we know that improvements in both are happening. The big question is whether they are happening fast enough!

It is, of course, in the inefficiency of resource production that wastes are created and our "environmental" problems manifested. But if we are not looking hard at how and where our "footprint" is being placed, we are missing the chance to do something about those inefficiencies. In looking at the resource consumption and waste generation practices of the average North American, it becomes clear that via trade and technology we have appropriated the ecological capacity of large areas outside our own national boundaries. We have, in fact, exported much of our "footprint." In their book, Rees and Wackernagel take us through the number crunching and data sources used to calculate footprints for our cities, our nations, and us. If anything, they significantly understate the resource demands needed to support consumption patterns and waste disposal practices.

The challenge posed to all of us is to find the means, and quickly, to reverse the "overshoot" condition we are already in with respect to human impact on the planet. Some would prefer to start with that hypothetical adult female in the developing world whose fertility promises/threatens to add billions more footprints to the earth's surface in the coming decades. The accounting tool of Ecological Footprints suggests, however, that the place to begin is with the resource consuming, waste generating "average" inhabitant of North America, western Europe, and Japan. The answer to the question posed earlier? It is the eight-year-old child (not to mention his parents, neighbours...) who now has the "Big Feet."

Humanity's Footprint

Today, humanity's Ecological Footprint is already over 30 percent larger than what the world can offer. This means we are overusing the planet and liquidating its ecological assets. Examples of our overuse include deforestation, collapsing fisheries, and the buildup of heat-trapping carbon in the atmosphere. At the same time, a significant percentage of the world's people do not have enough resources to meet basic survival needs.

To overcome this sustainability challenge, we need to do a better job of budgeting our planet's limited resources. Nature provides an average of 2.1 hectares (5.3 acres) of biologically productive space for every person in the world. By 2050 that available space will be reduced to 1.4 hectares (3.5 acres) per person if predictions of global population are accurate. Also, some of this area must be set aside for the estimated 10 million other species on the planet.

On average, people use 2.8 hectares (6.9 acres), but there is a wide range. In some countries, the average is as low as 0.5 hectares (1.2 acres), while others use as much as 13 hectares (32 acres) per person. Even within any given country, individuals' footprints vary widely.

By more carefully tracking human impacts on the Earth's resources, we can learn what needs to be done in order to protect our natural assets. We can all be part of the solution. Together, we can reshape the global economy in a way that will allow all people to meet their essential needs without destroying the limited capacity of our planet.

Population and Natural Resources

Population and natural resources

WHILE many of the environmental impacts of humankind closely map demographic indicators, this leaves out one vital component: consumption. The per-capita consumption of key natural resources varies hugely around the world. Typically, but not universally, the citizens of rich industrialized nations use more of the world's resources and produce more waste. Sometimes they thereby deplete their own environments; sometimes other people's.

For many resources, the United States of America is the world's largest consumer in absolute terms. For a list of 20 major traded commodities, it takes the greatest share of 11 of them: corn, coffee, copper, lead, zinc, tin, aluminum, rubber, oil seeds, oil and natural gas. For many more it is the largest per-capita consumer.

A typical example is meat. China, with the world's largest population, is the highest overall producer and consumer of meat, but the highest per-capita consumption in the world is that of the United States. The average United States citizen consumes more than three times the global average of 37 kilos per person per year. Africans consume less than half the global average, and South Asians consume the least, at under 6 kilos per person per year[1].

Other resources are used much more variably, depending on local circumstances. Fish, for instance, has been a cheap source of protein for hundreds of millions of poor people wherever it has been available. The highest consumption levels are in some of the world's poorest states, such as the Maldives or Kiribati, where fish is plentiful. Per-capita consumption is also very high in rich nations with well-established fishing traditions – 91 and 66 kilos per capita in Iceland and Japan respectively; way above the global average of 16 kilos per capita per year[2].

Some consumption patterns reflect the rate of industrial, urban and infrastructure development rather than simply current wealth. Cement, for instance, has in recent years been used in greatest quantities in the rapidly growing Asian economies. The top three places for per-capita use in 1996 were occupied by the Republic of Korea, Taiwan and Malaysia. Each used more than twice as much cement per capita as the United States and four times as much as a typical established industrial nation with well-developed infrastructure, such as the United Kingdom[3].

Water is also heavily used in a number of developing countries. It is a key strategic resource whose location is largely fixed, like land, but for which many countries rely on their neighbors. Egypt, for instance, relies for 97 percent of its water on flows that originate outside the country, mostly upstream on the Nile. Sudan, also on the Nile, is in a similarly vulnerable position, as are the Netherlands at the mouth of the Rhine, Cambodia on the Mekong, and Syria and Iraq on the Euphrates. All rely on foreign sources for the bulk of their water[4].

Water use is often as high or higher in poor, arid countries as in rich nations. When precipitation is lowest, demand for crop irrigation is typically highest, and where water-hungry cash crops are grown as well as food, the demands are higher still. When the country is in a poor state of

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Population and Natural Resources (continued)

development, with dilapidated infrastructure, then water use can be immensely inefficient, producing the highest water use of all, as illustrated by the rates in the arid, cotton-growing central Asian states of the former Soviet Union. During the 1990s Turkmenistan withdrew more than 5,000 cubic meters per person per year, with Uzbekistan, Kyrgyzstan, Kazakhstan, Tajikistan and Azerbaijan all withdrawing 2,000 cubic meters or more per person per year. By comparison, per-capita withdrawals in the United States were around 1,800 cubic meters, in France 650 and in the United Kingdom 200[5].

But for some resources, consumption depends upon the end use to which that resource is put, as typified by wood. While rich nations use more of it in the form of paper and packaging, poor predominantly rural nations rely on wood to a greater extent for construction and particularly for fuel. Finland, which produces large quantities of paper, is the greatest per-capita user of raw timber, but African and Asian countries are the largest users of fuelwood. Japan, though widely criticized for its harvesting of tropical timbers from Southeast Asian rainforests, lies well down the global list of timber consumers.

Two trends are causing nations, corporations and individuals to reassess their use of natural resources. Since the 1970s, there has been an increasing realization that many resources, notably metals and fossil fuels, will one day run out. And since the 1980s in particular, there has been growing concern about the environmental downside of their profligate exploitation, largely with respect to pollution and the degradation and conversion of land.

Some stories of inefficiency and extravagance have become notorious. It takes the mining of 6 tons of rock to produce a pair of typical gold rings. Only 2 to 3 percent of the energy produced by burning coal in a power station is eventually used to light a bulb or boil a kettle, because of inefficiencies at every stage of its conversion to electricity, its transmission and ultimate use. The average European uses 130 kilos of paper a year – the equivalent of two trees. The average American uses more than twice as much – a staggering 330 kilos a year. The paper and board industry is the United States' third largest source of pollution, while its products make up 38 percent of municipal waste[6].

Both governments and companies are now increasingly adopting strategies to reduce their environmental "footprint" on the world. They are doing this by reducing the amount of materials and energy used in providing their services (whether a car or a kilowatt of energy, a meal or a megabyte of information), and by reusing and recycling materials where possible. Much has been done. The gasoline consumption of the average automobile in the United States has halved since the 1970s. During the same period most European homes have been insulated to reduce heat loss by 50 percent or more. Some commercial farmers, particularly in the United States, have doubled the crops they grow with a given amount of irrigation water by using sub-surface drip irrigation.

Much more could be done at no extra cost. Modern technologies – plastic and carbon fibre, optical fibres, e-mail, drip irrigation, electronic systems controls – can all aid the process by making manufacture and communications more efficient and by substituting abundant materials for scarce ones.

Organized recycling, while not invariably energy-efficient, can also be beneficial. Growing concern at the damage to natural forests from paper production has led to a surge in paper recycling. Globally, 43 percent of paper fibre is recycled, a figure that rises to 46 percent in the United States and to 72 percent in Germany[7]. In Britain the film processing industry reuses 5 million film cassettes a year, retailers reuse 40 million clothes hangers, and the aluminum industry recycles some 2 billion cans a year. The latter saves sufficient electricity, which would otherwise go to smelting new aluminum, to power all the nation's television sets for a one-hour show every night of the year.

The Scale of Our Presence

The scale of our presence

HUMANS are perhaps the most successful species in the history of life on Earth. From a few thousand individuals some 200,000 years ago, we passed 1 billion around 1800 and 6 billion in 1999. Our levels of consumption and the scope of our technologies have grown in parallel with, and in some ways outpaced, our numbers.

But our success is showing signs of overreaching itself, of threatening the key resources on which we depend. Today our impact on the planet has reached a truly massive scale. In many fields our ecological "footprint" outweighs the impact of all other living species combined.

We have transformed approximately half the land on Earth for our own uses – around 11 percent each for farming and forestry, and 26 percent for pasture, with at least another 2 to 3 percent for housing, industry, services and transport[1]. The area used for growing crops has increased by almost six times since 1700, mainly at the expense of forest and woodland[2].

Of the easily accessible freshwater we already use more than half. We have regulated the flow of around two thirds of all rivers on Earth, creating artificial lakes and altering the ecology of existing lakes and estuaries[3].

The oceans make up seven tenths of the planet's surface, and we use only an estimated 8 percent of their total primary productivity. Yet we have fished up to the limits or beyond of two thirds of marine fisheries and altered the ecology of a vast range of marine species. During this century we have destroyed perhaps half of all coastal mangrove forests and irrevocably degraded 10 percent of coral reefs.

Through fossil-fuel burning and fertilizer application we have altered the natural cycles of carbon and nitrogen. The amount of nitrogen entering the cycle has more than doubled over the last century, and we now contribute 50 percent more to the nitrogen cycle than all natural sources combined. The excess is leading to the impoverishment of forest soils and forest death, and at sea to the development of toxic algal blooms and expanding "dead" zones devoid of oxygen[4].

By burning fossil fuels in which carbon was locked up hundreds of millions of years ago, we have increased the carbon dioxide content of the atmosphere by 30 percent over pre-industrial levels. We have boosted methane content by 145 percent over natural levels[5].

Through mining and processing we are releasing toxic metals into the biosphere that would otherwise have remained safely locked in stone. We are producing new synthetic chemicals, many of which may have as yet undetermined effects on other organisms.

We have thinned the ozone layer that protects life on Earth from harmful ultra-violet radiation. Most scientists agree that human activities are contributing to global warming, raising global temperatures and sea levels.

These processes affect the habitats and environmental pressures under which all species exist. As a result, we have had an incalculable effect on the Earth's biodiversity. The 484 animal and 654 plant species recorded as extinct since 1600 are only the tip of a massive iceberg[6].

We have become a major force of evolution, not just for the "new" species we breed and genetically engineer, but for the thousands of species whose habitats we modify, consigning many to

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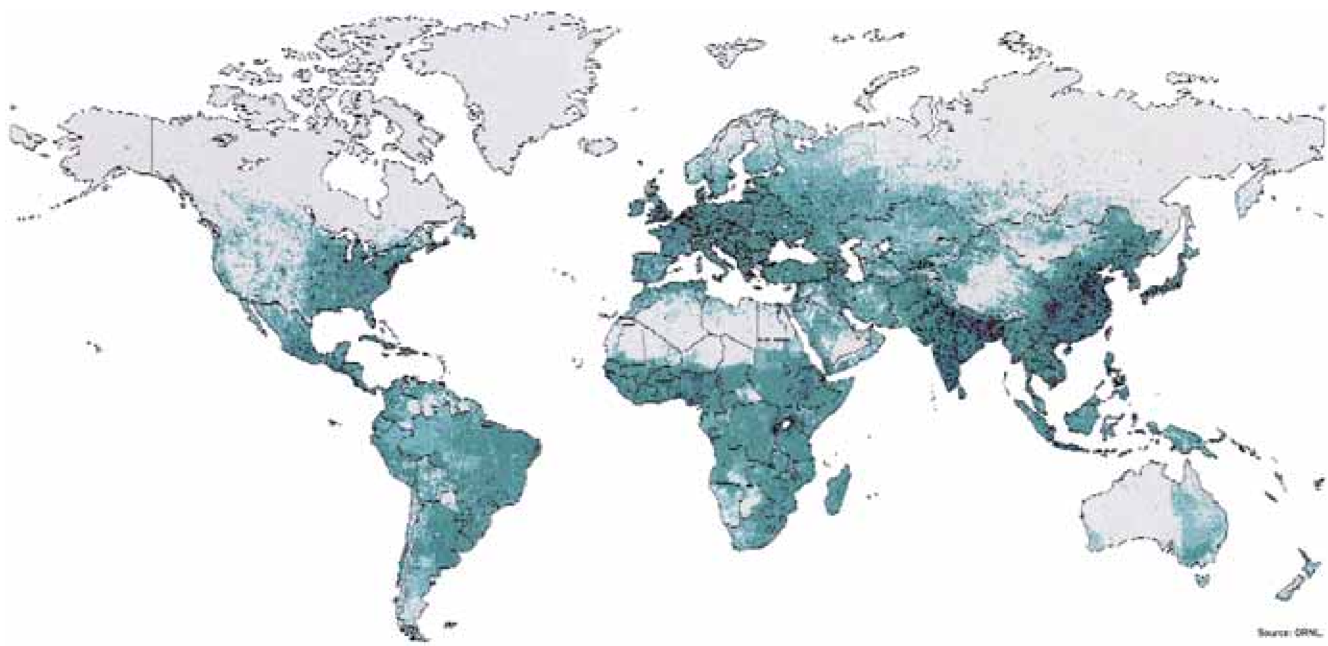
The Scale of Our Presence (continued)

OVERVIEW **The scale of our presence**



The scale of human activities

The scale of human activities can be represented partly by observing population density, both over the globe and over time.

POPULATION DENSITY, 1998
Per square kilometre

- 0
- Less than 1
- 1-45
- 45-100
- 100-300
- 300-500
- More than 500

Note: At the end of the 20th century the world average population density was 45 people per square kilometre.

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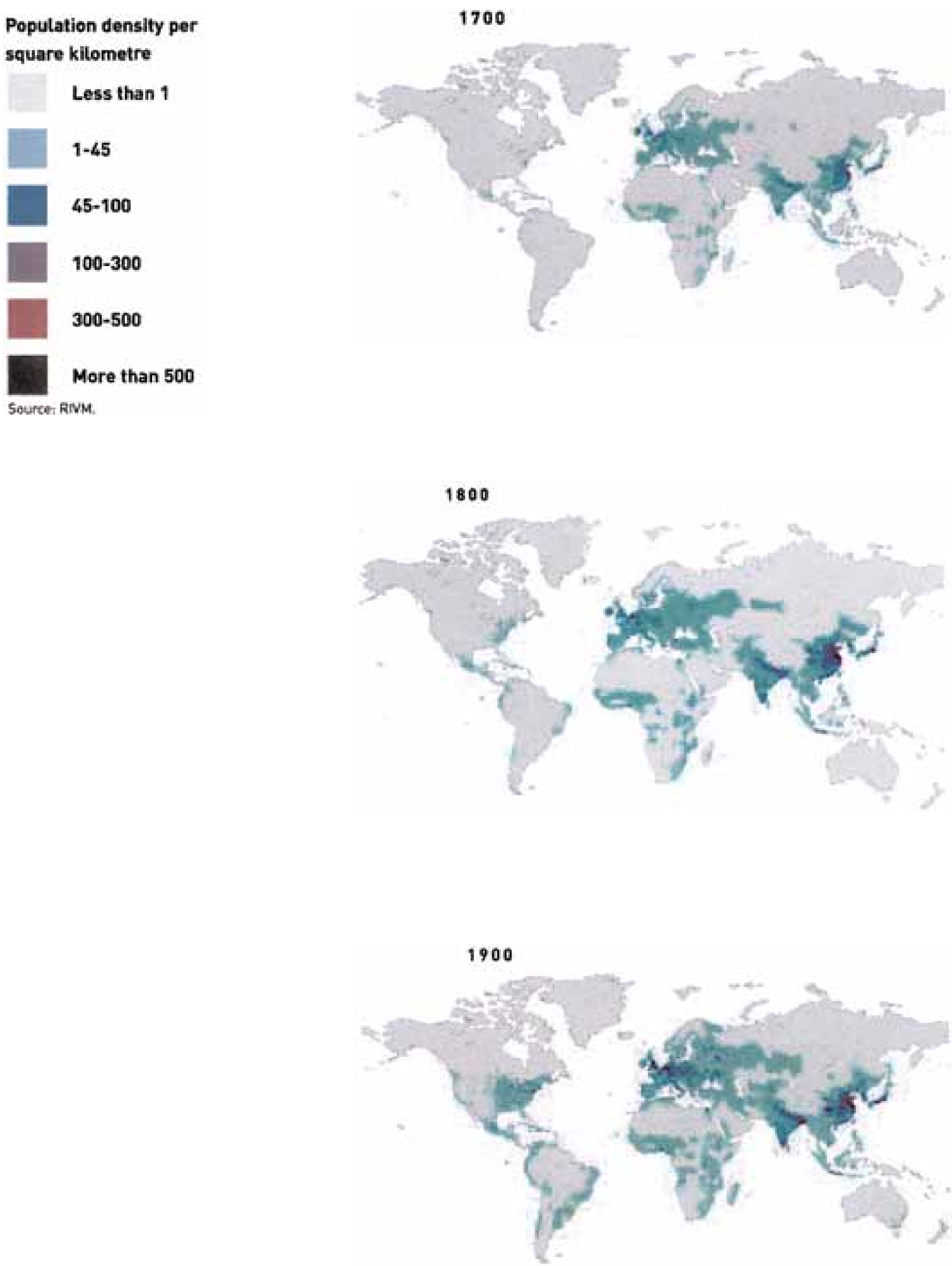
The Scale of Our Presence (continued)

OVERVIEW **The scale of our presence**



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The Scale of Our Presence (continued)

OVERVIEW **The scale of our presence**

extinction; compelling others to evolve and adapt to our pressures. We have become a force of nature comparable to volcanoes or to cyclical variations in the Earth's orbit.

The scale of our activities depends on our population numbers, our consumption and the resource or pollution impact of our technologies – and all three of these factors are still on the increase. The maps on the previous pages illustrate the increasing spread and density of the human population over the last three centuries.

As we enter the third millennium, the destiny of the planet is in our hands as never before, yet they are inexperienced hands. We are modifying ecosystems and global systems faster than we can understand the changes and prepare responses to them. All the factors in this vast equation affect each other constantly. In a globalized world the elements of human activity interact with each other and with local and planetary environments.

In this unprecedented situation, the need to be fully aware of what we are doing has never been greater. We need to understand the way in which population, consumption and technology create their impact, to review that impact across the most critical fields, and to find ways of using our understanding of the links to inform policy.