

Frontiers in Environmental Toxicology

Principles of Environmental Toxicology
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Learning Objectives

- Review the course outline.
- Examine the global environmental outlook.
- Examine major emerging env. issues.
- Discuss the present and near future “full scale” environmental emergencies.
- Explore key env. successes, data gaps, root problems, and new approaches.
- Understand the future challenges of environmental toxicology.

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Course Review

- “Silent Spring”
- Concepts of toxicology
- Pesticide residues
- Dose-response relationships
- Absorption of toxicants
- Distribution and storage
- Biotransformation, elimination
- Target organ toxicity
- Ter-. mut-, carcino-genesis
- Dioxins, related compounds
- Risk assessment
- Biogeochemistry of Se; As in Drinking Water
- Ecological biochemistry
- Abiotic transformation
- Environmental c.dynamics
- Environmental transport
- Environmental chemicals
- Socrates Award Lecture
- Endocrine disruption
- Monitoring chemicals
- Regulating chemicals

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Global Resource Sustainability?



Image over is the most detailed true-color image of the entire Earth available in March 2002. Many months of satellite-based observations of the land surface, oceans, sea ice, and clouds were pieced together into a seamless, mosaic of every square kilometer the Earth

Source: NASA Goddard Space Flight Center image (UNEP Geo 3)

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Sustainable Development

Development to meet the needs of the present without compromising the ability of future generations to meet their own needs.

The Brundtland Commission, 1987

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Millennium Ecosystem Assessment 2005

- In the past 50 years, humans have changed ecosystems more rapidly than at any other comparable time.
- As a result, 15 of 24 ecosystem services that support life on earth are being degraded or used unsustainably
 - The study involved 1360 experts from 95 countries over four years

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Ancient Environmental History

- Greek philosophers such as Aristotle see the "imitation of nature" as the key to understanding life.
- Early observations of environmental change.
 - Aristotle 350 BC *Meteorologica*:
 "(change) has happened in Greece to the land about Argos and Mycenae. In the time of the Trojan Wars, Argos was marshy and could support only a small population, whereas the land of Mycenae was in good condition and thus superior."
 "Now the opposite is the case... the land of Mycenae has become dry and barren, while the Argive land has become fruitful. Now the same process that has taken place in this small district must be supposed to be going on over whole countries and on a large scale."



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Greek Mythology

- Greek mythology links the concepts of justice and nature.
 - For instance, Themis, the goddess of law, was the daughter of Gaia, the goddess of earth.



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The Barbarians

- Greek playwright Aeschylus 525-456 BC refers to barbarians in *Prometheus Bound*:
 - "Though they had eyes to see, they saw to no avail; they had ears, but understood not. But like shapes in dreams, throughout their time, without purpose they wrought all things in confusion. They lacked knowledge of houses turned to face the sun, dwelling beneath the ground like swarming ants in sunless caves."



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Classical Greece

- 500 BC - forward - Greek coastal cities become landlocked after deforestation, which causes soil erosion. The siltation fills in the bays and mouths of rivers.
 - One river of ancient Greece, the Maender, becomes so silted that its twists and turns come to represent a river wandering – or *meandering*.
- Greek philosopher Plato (427 – 347 BC) compared hills and mountains of Greece to the bones of a wasted body.
 - "All the richer and softer parts have fallen away and the mere skeleton of the land remains."

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Herodotus' *History* 450 BC

Croesus and Solon

- *Who is the happiest and blessed of all humankind?*
 - "Of course, it is impossible for one who is human to have all the good things together, just as there is no one country that is sufficient of itself to provide all good things for itself. But whoso possesses most of them, continuously, and then ends his life graciously, he, my lord, may justly win the name you seek – at least in my judgment."
 "But one must always look to the end of everything. For to many, the god has shown a glimpse of blessedness only to extirpate them in the end."

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Sustainability Principles

- Efficiency
 - Do more with less.
- Conservation
 - Use fewer resources.
- Resource Substitution
 - Use plentiful, safe resources.
- Resource Recycling
 - Extend life-cycle.
- Promote Sufficiency
 - Sustainable consumption.

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Core Features of Sustainable Development

- Anthropocentric
- Generational equity (future orientation)
- Economic development with global equity
- Precautionary (physical sustainability)

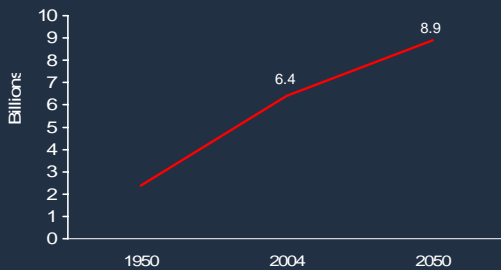
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Basic Problem

$$\text{Population} \times \text{Affluence} \times \text{Technology} = \text{Impact}$$

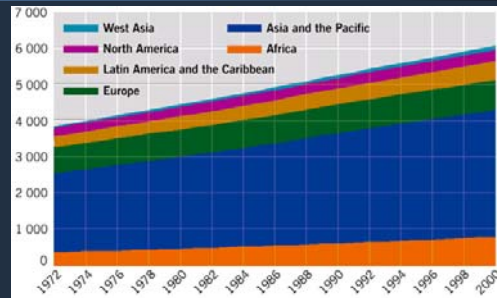
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Population



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Population Pressure

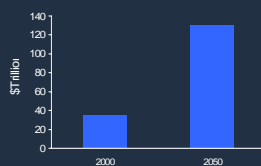


World population is currently growing at 77 million a year, with two-thirds of the growth in Asia and the Pacific
 Source: compiled from United Nations Population Division 2001(GEO 3)

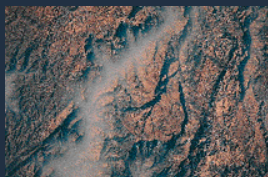
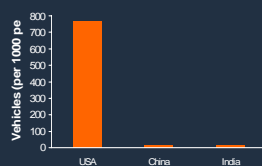
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Affluence

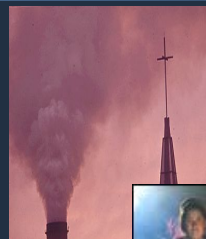
World GDP



Vehicle Ownership



Technology



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Environmental Policy

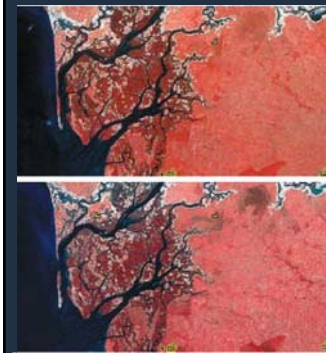
Government → Direct Regulation* → (Laws...)

Government → Economic Instruments
(Market-Based Incentives) → (Fees...)

Governance → Multiple Tools → (EMS...)

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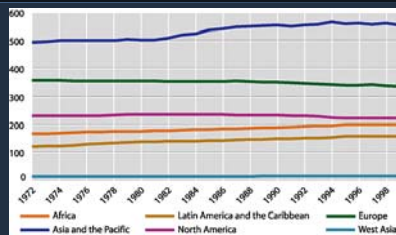
Land Impacts



Landsat images of the Saloum River, Senegal, on 5 November 1972 (top) and 31 October 1992 show how much of the mangrove forest (dark red areas) has disappeared in 20 years, even in a protected area
Source: Landsat 2001 (GEO 3)

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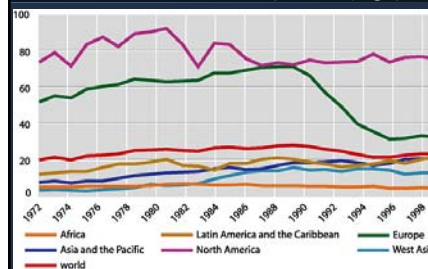
Area Under Arable and Permanent Crops (M ha)



Source: compiled from FAOSTAT 2001 and United Nations Population Division 2001 (GEO 3)

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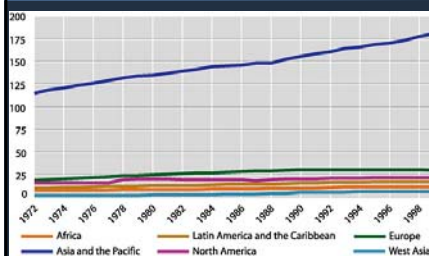
Fertilizer Consumption (kg per capita/yr)



Source: compiled from FAOSTAT 2001 and United Nations Population Division 2001 (GEO 3)

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Area Under Irrigation (M ha)



Source: compiled from FAOSTAT 2001 and United Nations Population Division 2001 (GEO 3)

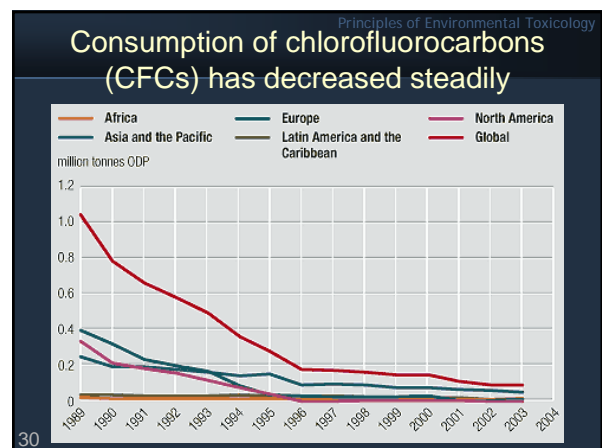
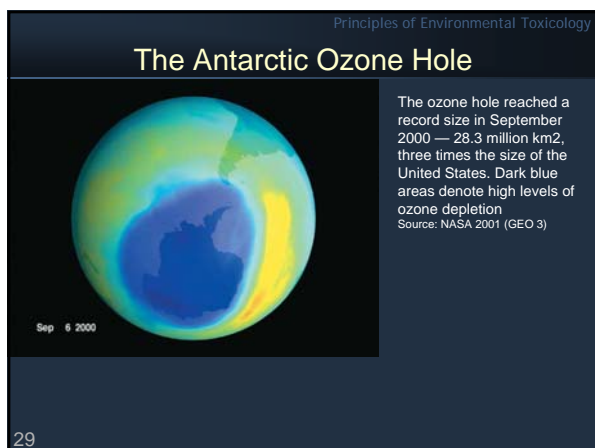
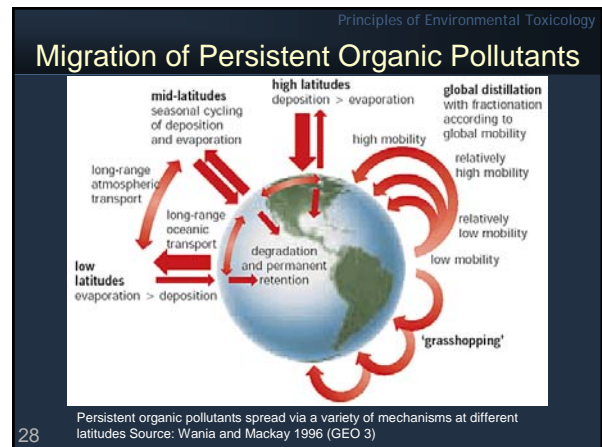
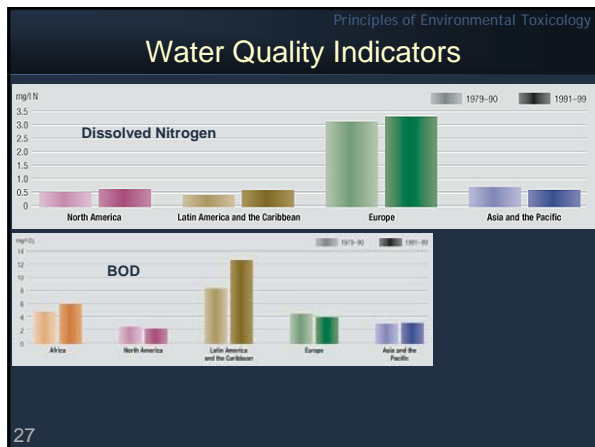
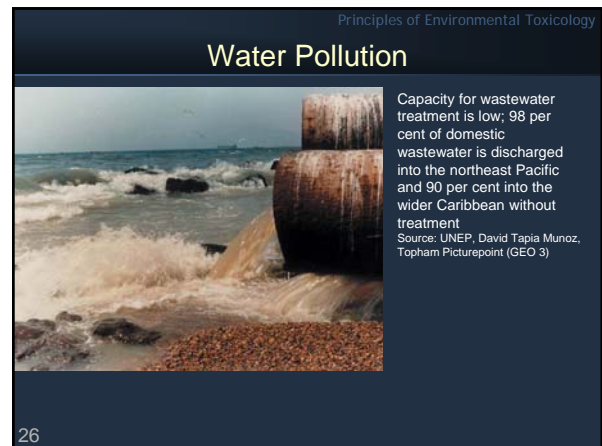
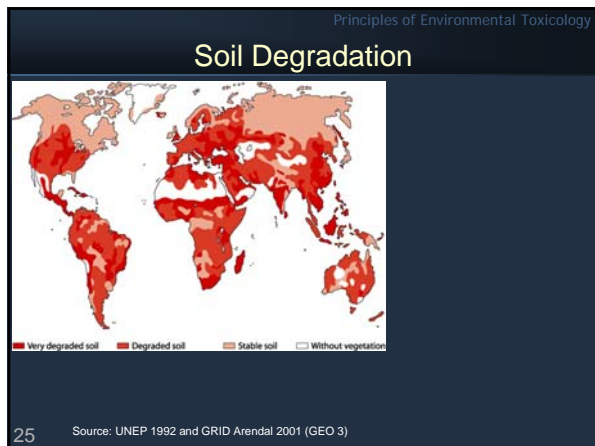
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Chemical Pollution of Land

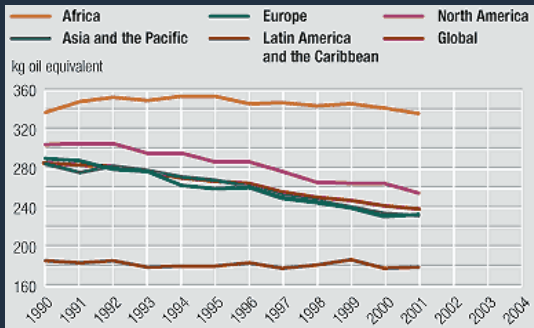


Much good agricultural land is threatened by chemical pollution, particularly — as here in China — by waste products from urban centres. Chemical degradation is responsible for 12 per cent of global soil degradation

Source: UNEP, Zehong Zhong Su, China, Still Pictures (GEO 3)

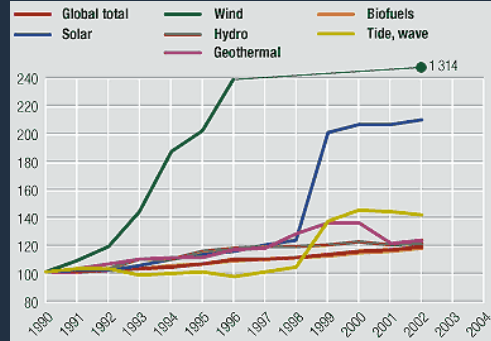


Energy use per unit of Gross Domestic Product (GDP) is gradually decreasing



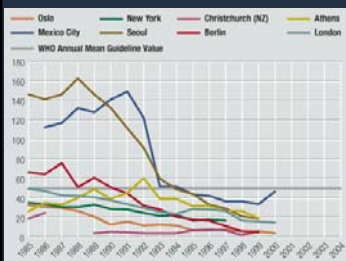
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The total renewable energy supply has risen considerably over the last decade



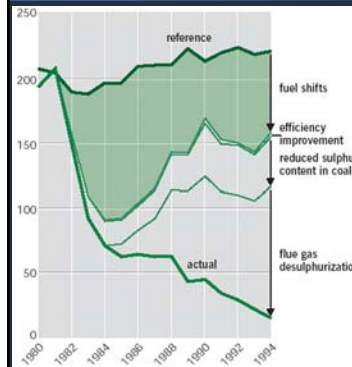
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Concentrations of SO₂ (µg/m³) in air in selected cities, 1985–2000



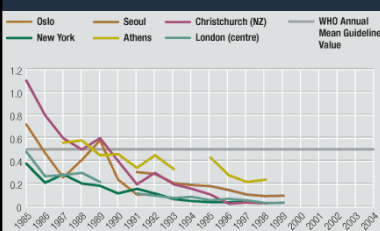
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SO₂ Emissions



Linking policy to emission reductions in the Netherlands
Source: EEA 2000 (GEO 3)

Concentrations of lead (µg/m³) in air in selected cities, 1985–99



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Global Environmental Outlook

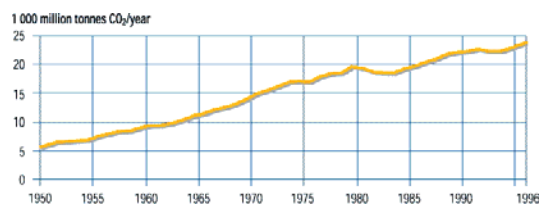
- Global emissions of CO₂ reached nearly 23,900 million tons in 1996 - nearly four times the 1950 total.
- Without the Montreal Protocol, levels of ozone-depleting substances would have been five times higher by 2050 than they are today.
- In 1996, 25% of the world's approximately 4,630 mammal species and 11% of the 9,675 bird species were at significant risk of total extinction.

36 UNEP

Global Outlook

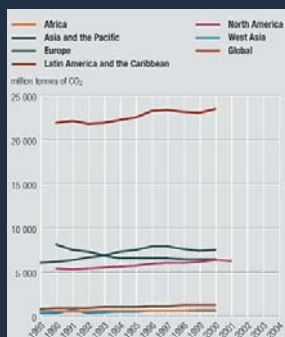
- If present consumption patterns continue, 2 out of every 3 persons will live in water-stressed conditions by 2025. UNEP
- More than ½ the world's coral reefs are threatened.
 - Up to 80% at risk in the most populated areas.
- Exposure to hazardous chemicals has been implicated in numerous adverse effects on humans from birth defects to cancer.
 - Global pesticide use results in 3.5-5 M acute poisonings/yr.
- Some 20% of the world's susceptible drylands are affected by human-induced soil degradation.
 - Livelihoods of more than 1 B people at risk.

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Global CO₂ Emissions

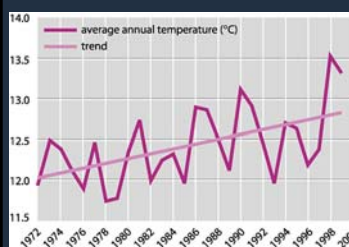
Global carbon dioxide emissions continue to mount. Average annual increase over the past decade has been 1.3 per cent or nearly 300 million tonnes a year.

38 UNEP

Global anthropogenic emissions of CO₂ were slightly higher in the latest reported year (2000)

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Average Temperatures in the United States

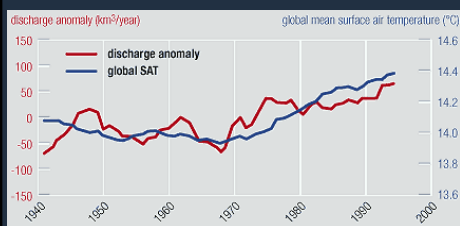


Globally 0.6 °C increase over the past century

Source: DOC, NOAA and NCDC 2000 (GEO 3)

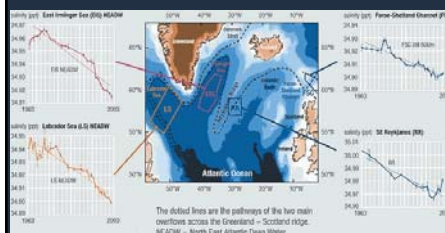
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Eurasian river discharge anomaly, and global surface air temperature (SAT) expressed as 10 year running means for 1936–99



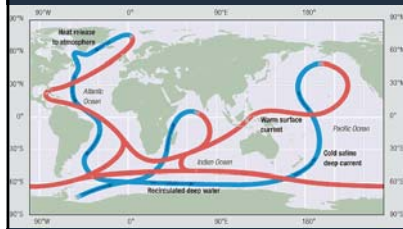
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Declining salinity levels in key areas of the North Atlantic over the last four decades



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Ocean Circulation

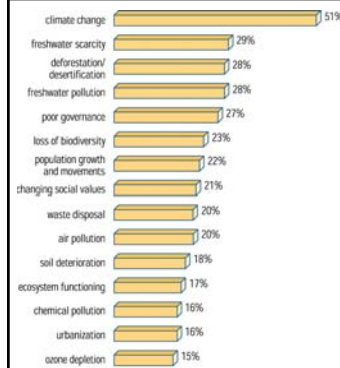


Thermohaline circulation

- Temperature effects
- Deep water CO₂ sequestration

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Major Emerging Issues



Survey of 200 scientists in 50 countries.

Climate change was the most cited issue in the survey although, taken together, water scarcity and pollution ranked higher

UNEP

Full-Scale Emergencies

- World water cycle demand.
- Land degradation has reduced fertility and agricultural potential.
- Tropical forest destruction has gone too far to prevent irreversible damage.
- Many of the planet's species have already been lost or condemned to extinction.
- Many marine fisheries have been grossly over-exploited, and their recovery will be slow.

45 UNEP

Full-Scale Emergencies

- More than half of the world's coral reefs are threatened by human activities.
- Urban air pollution problems are reaching crisis dimensions in many of the megacities of the developing world.
- It is probably too late to prevent global warming as a result of increased greenhouse gas emissions.

46 UNEP

Key Environmental Successes

- The ozone layer is expected to have largely recovered within half a century.
- The first international steps have been taken to tackle the issue of global climate change.
- The public is now much more concerned about environmental issues.
 - Popular movements in many countries are forcing authorities to make changes.

47 UNEP

Key Environmental Successes

- Voluntary action taken by many of the world's major industries is reducing resource use and eliminating waste.
- Governments in developed regions have been markedly successful in reducing air pollution in many major cities.
- Initiatives for sustainable development policies that involve communities and political agencies.

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Number of parties to multilateral environmental agreements, 1971–2004



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Knowledge Gaps

- We still lack a comprehensive view of the interactions and impacts of global and inter-regional processes.
- Information on the current state of the environment is riddled with weakness.
- There are few tools to assess how developments in one region affect others.
 - Are the dreams and aspirations of one region compatible with global sustainability?

50 UNEP

Tackling Root Causes

- Many environmental problems not policy based, e.g. resource consumption.
- Reduce population growth; reorient consumption patterns; increase efficiency of resource use.
- Figure out how to maintain or increase standard of living while decreasing impacts on the environment.

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Taking an Integrated Approach

- Integrate environmental issues into mainstream thinking.
 - Agriculture, trade, investment, research and development, infrastructure and finance.
- Integrate environmental management.
- Better international action to improve the environment.

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Environmental Toxicology Challenges

- Development of scientific methodology and data for understanding the impact of contaminants on environmental systems.
 - Beyond organismal level to the population level.
 - Beyond acute/chronic end effects to an understanding of the processes and consequences of system disruption.
 - Beyond single and towards multi-chemical exposure and dose understanding.

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Environmental Toxicology Challenges

- Better approaches to risk assessment that balance precaution with reality.
- New research with an integrated systems approach to understanding environmental chemistry at the biological interface.
- Education of the world's peoples about personal linkages to environmental quality.

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