THE STATE OF THE PLANET

IN 2000, KOFI ANAN, THEN SECRETARY GENERAL OF THE UNITED Nations, proposed the undertaking of the Millennium Ecosystem Assessment. It was cochaired by Robert T. Watson, Chief Scientist of the World Bank, and A.H. Zakri, Director of the Institute of Advanced Studies of the United Nations University. The four-year study was released in 2005 after the input of 1,360 experts from 95 countries. Its purpose was to assess the changes in ecosystems over the course of past decades and to project changes into the future. It is considered one of the largest studies of the Earth's natural systems ever undertaken.

Declining Ecosystem Services

"Nearly two thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets. In many cases, it is literally a matter of living on borrowed time."

~ Millennium Ecosystem Assessment, 2005

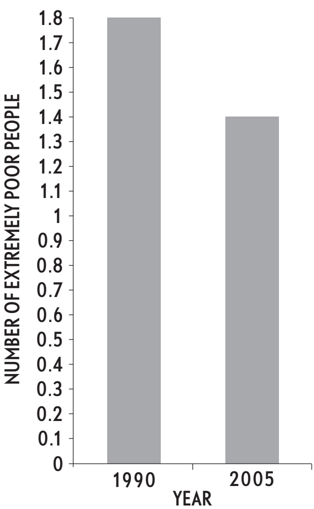
NASA, © Aris Entertainment, 1994

Another source of detailed information of the current state of the world is the annual report of the United Nations entitled the "Millennium Development Goals Indicators."[1, 2]

And finally, once a year, the Worldwatch Institute (worldwatch.org), releases a report that also reviews global environmental success stories and areas of concern for the 24 preceding months. Its latest publication is the *2008 State of the World* report.[3]

Here are some of the findings of these three reports:

On the positive side of the balance sheet, the studies confirm that substantial net gains in human well-being and economic development have been made. In fact, a 2008 update by the World Bank shows that the number of extremely poor people in the world fell from 1.8 billion in 1990 to 1.4 billion in 2005 and that the proportion of people living below the poverty line fell from 42% to 26% over the same period (Figure 2.1). At the current rate of change, the Development Goal of reducing extreme poverty by 50% by 2015 will be met (most of the change is attributable to China, while some sub-Saharan areas are faring worse).[2, 4]



Godo Stoyke

FIGURE 2.1
The number of extremely poor people fell by 22% between 1990 and 2005.[2]

Some other positive changes include the following:

- In all but two regions, primary school enrolment is at 90% or more.
- The Gender Parity Index in primary education is 95% or higher in 6 of the 10 regions.
- Some 1.6 billion people have gained access to safe drinking water since 1990 (Figure 2.2).

- The use of ozone-depleting substances has been almost eliminated, also contributing to efforts to reduce climate change.
- The share of developing countries' export earnings devoted to servicing external debt fell from 12.5% in 2000 to 6.6% in 2006.
- Deaths from measles and AIDS have declined, and malaria prevention is expanding.
- More people in developing countries have access to long-distance communication through the use of mobile phone networks.[1]
- Brazil reports that the rate of Amazon deforestation in 2006 slowed to half the level of 2005, the second lowest since record-keeping began in 1988.
- In 2007, an alliance of major US corporations and NGOs called for strong federal legislation to reduce greenhouse gas emissions.
- The bald eagle was removed from endangered species status in the US in 2007, reaching 9,789 pairs after a low of 417 pairs in 1963.
- Investments in renewable energy reached a record US$100 billion in 2006.

However, the studies point out that environmental degradation and climate change may unravel the positive economic and health trends. These are some of the negative trends and outstanding problems:

- Two billion people living in dry regions of the world are intensely vulnerable to the loss of ecosystem services, including water supply.

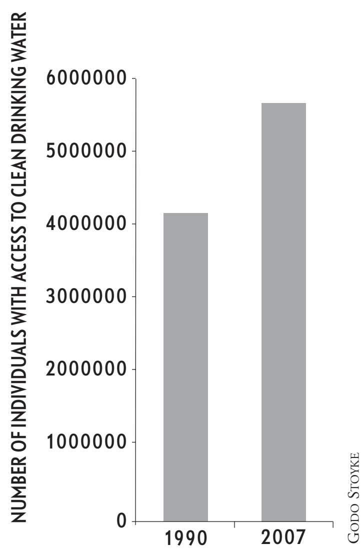


FIGURE 2.2
An additional 1.6 billion people have obtained access to safe drinking water since 1990.[3]

- There is a growing threat to ecosystems from climate change and nutrient pollution.
- 60% of world ecosystem services are being degraded or used in ways that cannot be sustained.
- Of 24 ecosystems evaluated in the study, 15 are being damaged.
- About a quarter of the Earth's land surface is now under cultivation.
- People now use between 40 percent and 50 percent of all available freshwater running off the land.
- Water withdrawals have doubled over the past 40 years.
- Since 1980, about 35 percent of mangroves have been lost (as well as providing various ecosystem services, mangroves play a vital role in protecting coastal areas and help provide a bulwark against storm surges, such as the 2004 Asian tsunami that killed over 225,000 people; Figure 2.3).
- About 20% of corals have been lost in just 20 years.
- Nutrient pollution has led to eutrophication (over-fertilization) of waters and coastal dead zones.
- Species extinction rates are now 100 to 1,000 times above the natural background rate (Figure 2.4).[7, 8]

FIGURE 2.3
The value of Tampa Bay mangroves has been estimated at $15,000 per acre (4,000 m^2) for fisheries production, and an additional $3,190 per acre for storm protection.[6]

- Carbon dioxide emissions have continued to increase, despite an international timetable for addressing the problem.
- International trade is still not favorable for developing nations.
- In one third of developing countries, women account for less than 10% of parliamentarians.
- More than 500,000 prospective mothers in developing countries die annually in childbirth or of complications from pregnancy.
- About 25% of all children in developing countries are considered to be underweight and are at risk of having a future blighted by the long-term effects of undernourishment.[1]
- Between 2004 and 2006 the number of low-oxygen "dead zones" in the world's oceans increased from 149 to 200.
- Unusually low temperatures have led to record ozone loss over Antarctica, resulting in a record "ozone hole" of 11 million square miles (28 million km^2).
- Scientists project that at current fishing rates, all currently fished species could collapse (90% depletion) by 2050 (Figure 2.5).
- The World Bank estimates that in 2006 natural disasters caused record damages of US$159 billion.

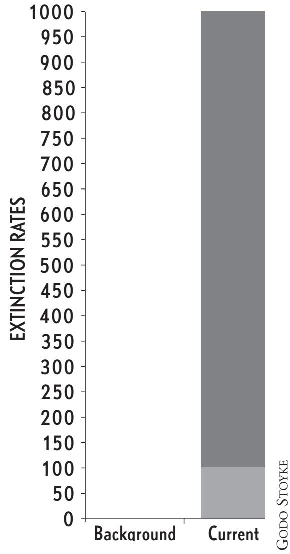


FIGURE 2.4
The extinction rate of plant and animal species due to human influence has increased by a factor of 100 to 1,000 compared to natural background rates.

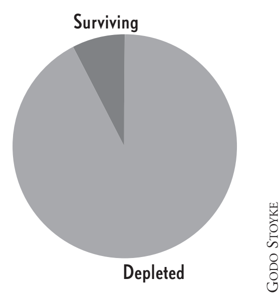


FIGURE 2.5
At today's rates, 90% of global fish stocks currently harvested will be depleted by 2050.

Some of the general recommendations put forth in the Millennium Ecosystem Assessment include the following:

- Remove subsidies to agriculture, fisheries, and energy sources that harm the environment.
- Encourage landowners to manage property in ways that enhance the supply of ecosystem services, such as carbon storage and the generation of fresh water.
- Protect more areas from development, especially in the oceans.[8]

> *"The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA [Millennium Ecosystem Assessment] has considered, but these involve signifcant changes in policies, institutions, and practices that are not currently under way."*
>
> ~ Millennium Ecosystem Assessment, 2005[9]

The Value of Ecosystem Services

Ecosystems provide many valuable products that are traded in the marketplace. These include fish and other marine foodstuffs, timber, fibers, and terrestrial food.

However, ecosystems also provide many services that are not traded in the marketplace. These include filtration of wastes and pollutants, regulation of the earth's climate, protection from extreme weather, floods, land slides, fire, and disease, even from tidal waves (for example, East

Gleam, Yokohama, Japan, GNU free documentation license

FIGURE 2.6
The Biosphere II project demonstrated the difficulty and great cost of artificially providing ecological services for even a handful of people.

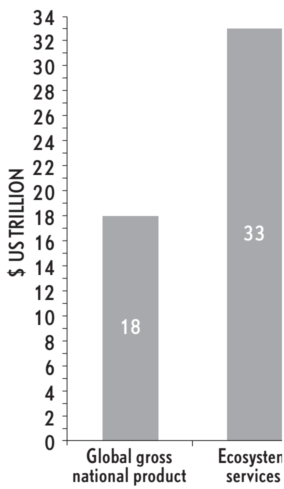

DARIUSZ DARAS, STOCKXCHNG IMAGE

Indian mangrove forests), regeneration of clean air, water, and soil, and inspiration, recreation, spiritual sustenance, and support for a way of life.[7]

According to Amory Lovins, chief scientist of the resource efficiency think-tank Rocky Mountain Institute (rmi.org), "Biosphere 2" was a US$200 million experiment in the Arizona Desert about two decades ago, whose purpose it was to create an artificial environment that could support human life. However, even though a lot of good science went into the project and in spite of its staggering cost, the artificial environment was unable to provide many ecosystem services, such as breathable air for eight people, on a consistent basis (Figure 2.6).

> *"Even today's technology and knowledge can reduce considerably the human impact on ecosystems.*
> *They are unlikely to be deployed fully, however, until ecosystem services cease to be perceived as free and limitless, and their full value is taken into account."*
> ~ Millennium Ecosystem Assessment, 2005[9]

"Biosphere 1" (the Earth), on the other hand, provides this service for more than 6.7 billion people on a daily basis, for free.[10] Even though the service is free, economists have estimated its economic value. In 1997, a number of economists and ecologists examined the economic value of 17 ecosystem services for 16 biomes (large ecosystems that are climatically and geographically defined) and published the results in the respected scientific journal *Nature*. The scientists arrived at a minimum average estimated value for these 17 services and 16 biomes of US$33 trillion (US$33,000 billion) in 1997,



GODO STOYKE

FIGURE 2.7
Value of 17 ecosystem services in 16 biomes vs. global gross national product in 1997 US$.[9]

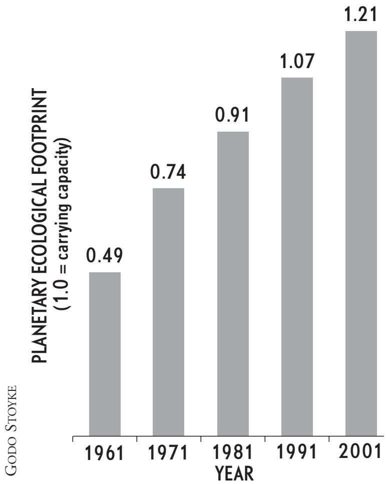


FIGURE 2.8
A comparison of the planetary ecological footprints over time (shorter is better). Around 1990, humans started exceeding the planet's carrying capacity.[12]

compared to a global gross national product of around US$18 trillion for that year (Figure 2.7).[11]

> *The economic value of ecosystem services provided by the planet to humanity—not currently accounted for in our economic system — has been estimated at US$33 trillion per year.[11]*

When humans impose a new role onto an ecosystem or degrade the functioning of that ecosystem, they may be able to extract an economic benefit from this change, but when the loss of non-market ecosystem services is taken into account, this impairment can have a negative net benefit (Figures 2.8, 2.9, 2.10).

QuickLink: CarbonCharter.org/01

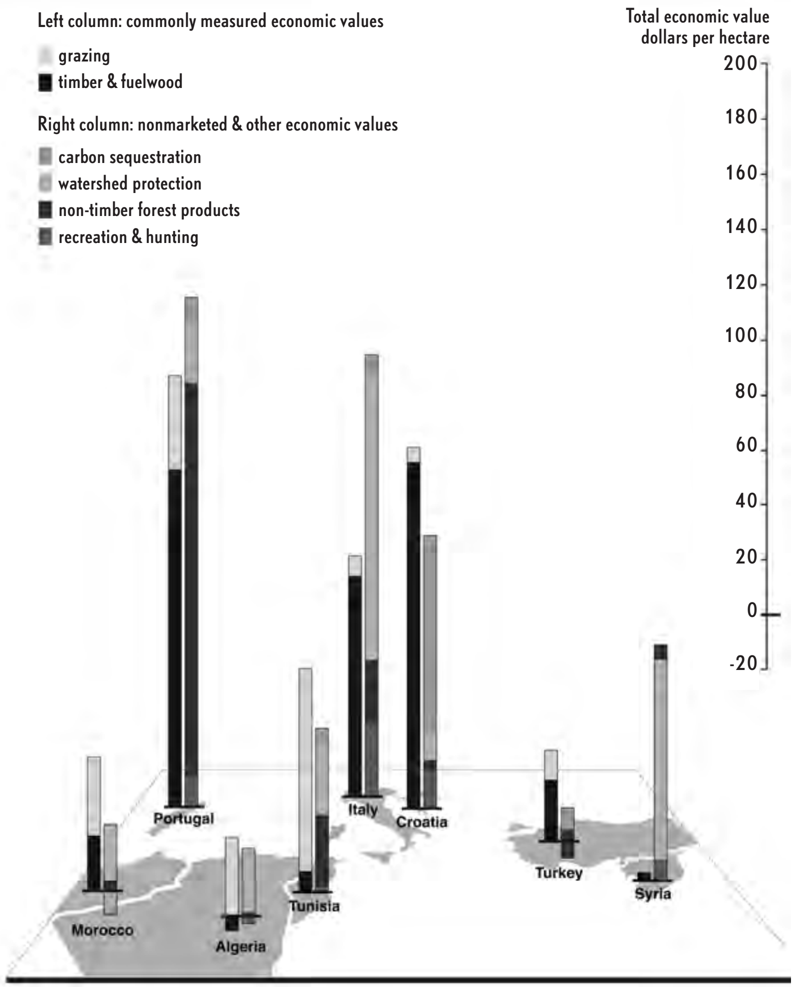
The Loss of Biodiversity

Next to climate change, the loss of global biodiversity through the extinction of species of plants, animals, and microorganisms is probably the other most serious global environmental threat (Figure 2.11).

While the slow loss of existing species and the creation of new species over very long periods of time is a natural process, the human-induced loss of species biodiversity is now estimated to be at 100 to 1,000 times the natural background rate.[8]

The International Union for Conservation of Nature (IUCN) is the world's main authority keeping track of the conservation status of plant and animal species, having representation from over 200 government and 800 non-government organizations and enlisting

ANNUAL FLOW OF BENEFITS FROM FORESTS IN SELECTED COUNTRIES



DENISE DAHL AFTER MILLENNIUM ECOSYSTEM ASSESSMENT

FIGURE 2.9
A comparison of the measured and non-measured economic values of forest ecosystems in selected countries. The measured value (timber and grazing) is often lower than the non-measured value (carbon sequestration, watershed protection, non-timber forest products, recreation, and hunting). (Illustration after Millennium Ecosystem Assessment, 2005.)[9]

ECONOMIC BENEFITS UNDER ALTERNATE MANAGEMENT PRACTISES

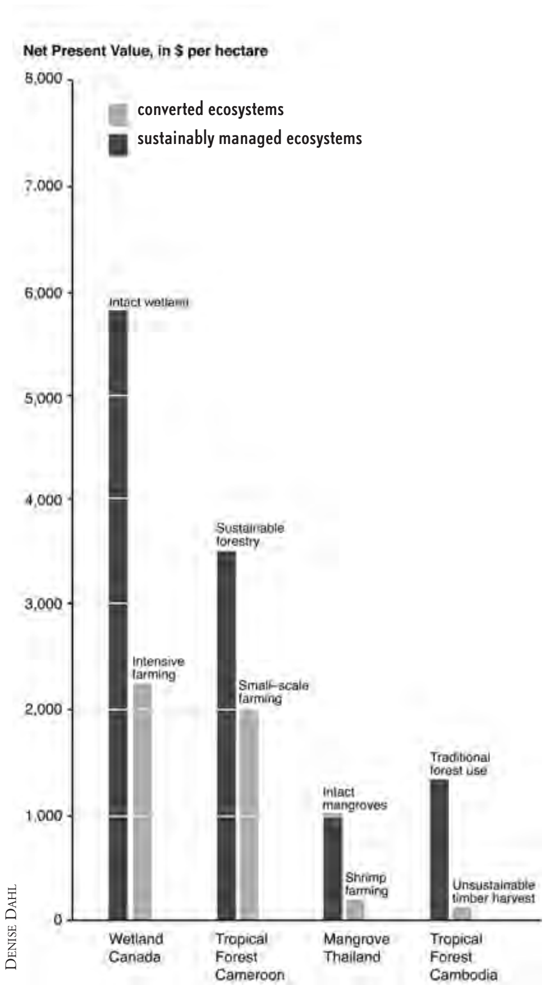


FIGURE 2.10
A comparison of market and non-market economic values of converted and non-converted ecosystems in selected countries. In each case, the non-converted value of the ecosystems exceeds the economic value of converted ecosystems. (Illustration after: Millennium Ecosystem Assessment, 2005.)[9]

over 10,000 volunteer scientists and experts from 140 countries.[13] The IUCN is currently monitoring 41,415 species on its Red List. In 2008, 16,306 of these (just under 40%) were reported to be threatened with extinction, an increase of 188 species in just one year (Figure 2.12). By 2008 a total of 785 species had already become extinct.[14]

It should be noted that the animal Red List, as is reasonable, is biased towards larger and vertebrate species, despite the fact that most of the planet's two million described species are arthropods (mostly insects). Research conducted in the tropics points to the highly endemic nature of many insect populations. It is therefore likely that a very large number of never classified arthropods have already become extinct, before even having become known to science.

Humans are now more populous than any other mammalian species on the planet (the common house mouse, *Mus musculus*, being the second most abundant).[15]

FIGURE 2.11
Next to climate change, loss of global biodiversity through the extinction of plant and animal species is probably the most serious global environmental threat (American Emerald Dragonfly, *Cordulia shurtleffi*).

CLIMATE CHANGE

The greenhouse effect is a natural phenomenon that makes life on earth possible by raising the planet's average temperature above freezing. Water vapor and carbon dioxide are two important naturally occurring greenhouse gases.

Concern about climate change is based on anthropogenic greenhouse gases, i.e., greenhouse gases that are being added to the atmosphere due to human activity. Of these, carbon dioxide is the most important, with 51% of net radiative forcing, followed by methane (17%), halocarbons (11%), and tropospheric ozone (11%). Current air pollution in the form of aerosols (especially sulphate aerosols) appears to have a significant cooling effect on the planet, partially offsetting global warming (Figure 2.13).[16] Nearly every country in the world has ratified the Kyoto

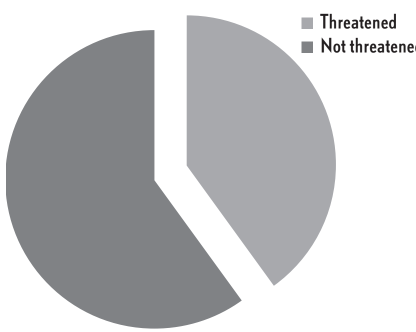
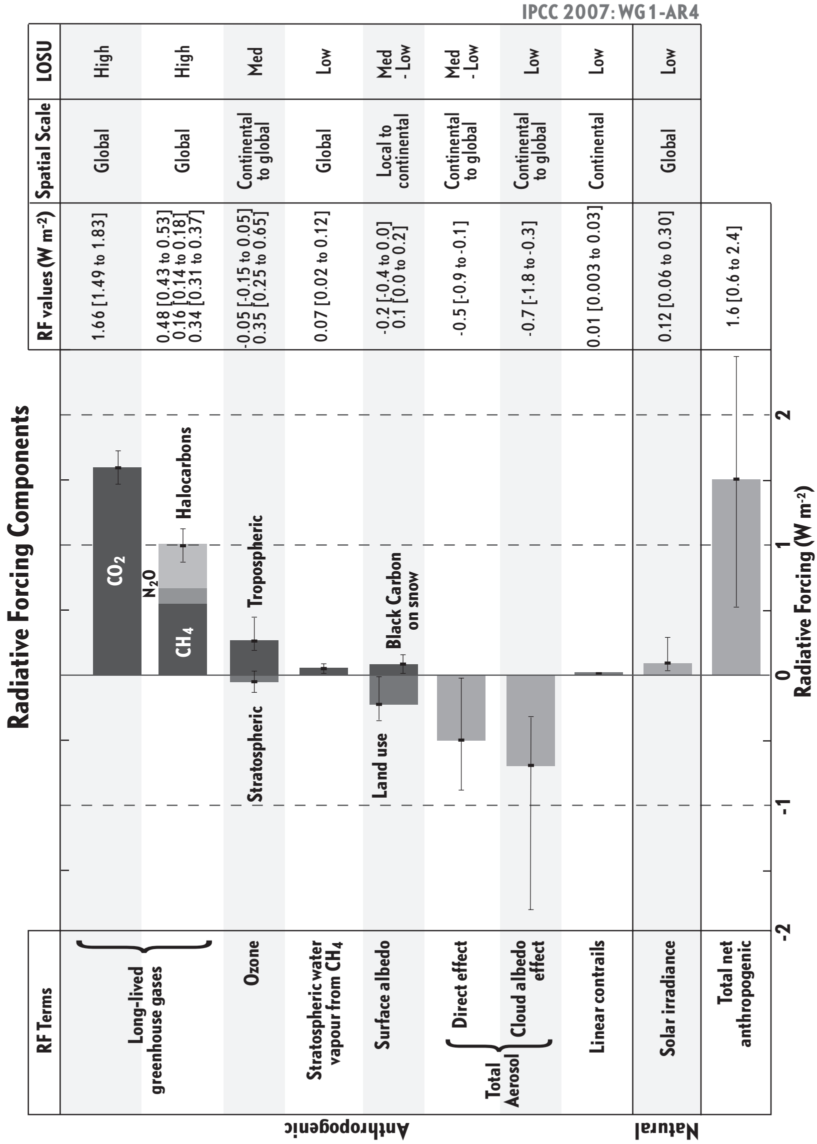


FIGURE 2.12
Of the 41,415 species on the IUCN Red List of monitored species, 16,306 (39.4%) were threatened with extinction in 2007.[14]



DENISE DAHL AFTER IPCC 2007

FIGURE 2.13
Relative importance of changes in anthropogenic and natural radiative forcing components. (Illustration after IPCC 2007: WG1-AR4.)[16]

Protocol, a tiny but significant step towards reducing greenhouse gas emissions.

RESOURCES

The complete Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report from 2007 (also known as AR4) is available in three volumes, free of charge, from the IPCC website:

- Volume I *The Physical Science Basis* at ipcc.ch/ipccreports/ar4-wg1.htm
- Volume II *Impacts, Adaptation and Vulnerability* at ipcc.ch/ipccreports/ar4-wg2.htm
- Volume III *Mitigation of Climate Change* at ipcc.ch/ipccreports/ar4-wg3.htm

These volumes are also available in printed form from Cambridge University Press cambridge.org.

The *Synthesis Report* for policy makers can be found at ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

See also the section "You Want This by *When*?" on p. 27 for updates on rapid climate change.

QuickLink: CarbonCharter.org/02

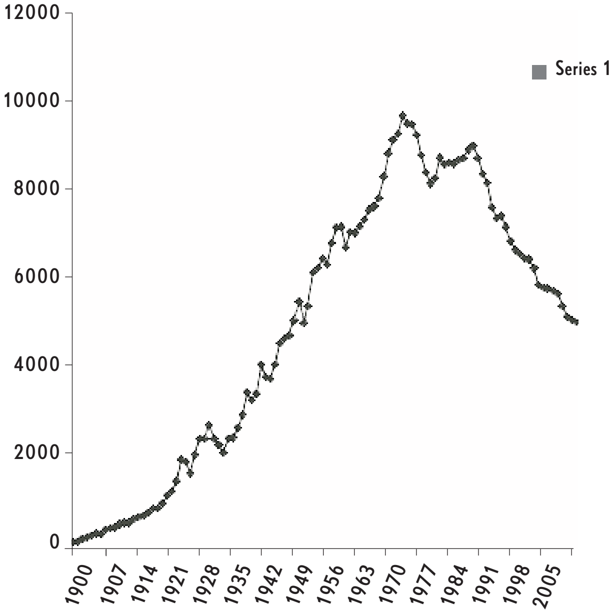
"It's easy to predict the future, it's being right that's difficult."

~ Anonymous

FROM PEAK OIL TO PEAK SUSTAINABILITY

What is Peak Oil?

American geoscientist M. King Hubbert presented a paper at the 1956 meeting of the American Petroleum Institute where he predicted that overall petroleum production would peak in the United States between the late 1960s and the early 1970s. He based his prediction on his finding that regional oil production tended to follow a bell curve, typically declining at about the same rate at



GODO STOYKE

FIGURE 2.14
US crude oil field production in thousands of barrels per day from 1900 to 2007, showing peak production in 1970 at 9,637 thousand barrels per day (2007 production: 5,064 thousand barrels per day).[20]

which production increased, after maximum production peaks. The prediction was widely ignored or even derided, but came true when US oil production peaked in 1970.[18] [19] The National Academy of Sciences accepted Hubbert's calculations on oil depletion and admitted that their own more optimistic estimates had been incorrect (Figure 2.14).[21]

Then, in 1998, Colin J. Campbell and Jean H. Laherrère published an article entitled "The End of Cheap Oil," in which they predicted that production of conventional oil would probably decline within 10 years. Others had already been writing about what later came to be commonly known as "Peak Oil," but since Campbell and Laherrère's article was published in the influential journal *Scientific American*, it received far wider notice.

Campbell and Laherrère pointed out that 80% of the oil produced in 1998 was from fields discovered before 1973 and that in the 1990s the rate of extraction outpaced the rate of new oil discovery by a factor of three to one. The authors stated that when production falls below demand, there may still be plenty of oil left, but that prices would rise significantly. Somewhat presciently, they added, "Barring a global recession, it seems most likely that world production of conventional oil will peak during the first decade of the 21st century."[18]

In this context, it is interesting to examine the "energy return on investment," or EROI, of oil and biofuel production (Figure 2.15). The energy return for oil dropped from a high of 100 barrels of oil equivalent (BOE) returned for every barrel invested in 1945, to 9 barrels for conventional oil and 3 barrels for tar sands (bitumen or oil sands) in 2008. For the tar sands, that represents a decline in EROI by a factor of over 30, indicating that we are beginning to scrape the "bottom of the barrel" with respect to energy returns. The increasing costs of oil exploration and recovery alone are likely to ensure that we will not return to pre-2005 prices for oil for any extended periods of time soon (barring, again, periods of extended global economic slowdown).

In one study, ethanol from corn was calculated to have an EROI of 0.7 to 1.8 — a range from a negative energy balance to a positive one.[22] A

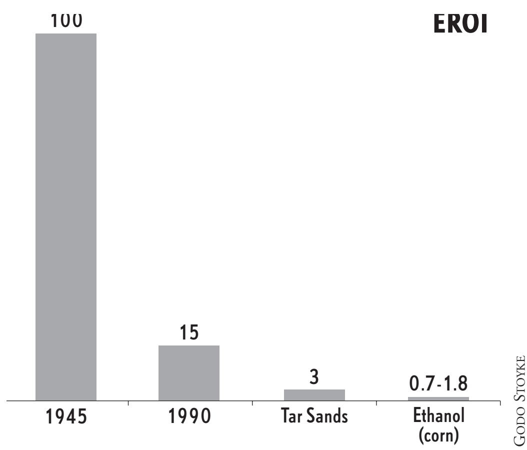


FIGURE 2.15
Energy return on investment (EROI) of oil production from 1945 to 2008, expressed in barrels of oil equivalent (BOE) returned over BOE invested, compared to ethanol from corn.[22, 23, 24]

number of studies indicate, though, that there are many options that would allow us to produce sustainable biofuels with high energy returns without jeopardizing food production. Even switch grass has already been replaced as a potential ethanol champion by the perennial grass *Miscanthus*, which in field trials showed over three times the dry yield per acre and year.[25] David Blume in *Alcohol Can Be a Gas! Fueling an Ethanol Revolution for the 21st Century* describes many sources for sustainable ethanol production, ranging from fodder beets and Jerusalem artichokes to non-agricultural sources such as cattails and marine algae, and even stale donuts (Figure 2.16).[26] A study by Dartmouth College researcher Lee Lynd and colleagues shows how we can move from an unsustainable food vs. fuel position that would require two and a half times the arable land in the US, to resource sufficiency in food *and* fuel with zero additional cropland requirements through integration of agricultural and transportation approaches and cellulosic ethanol production (Figure 2.17).

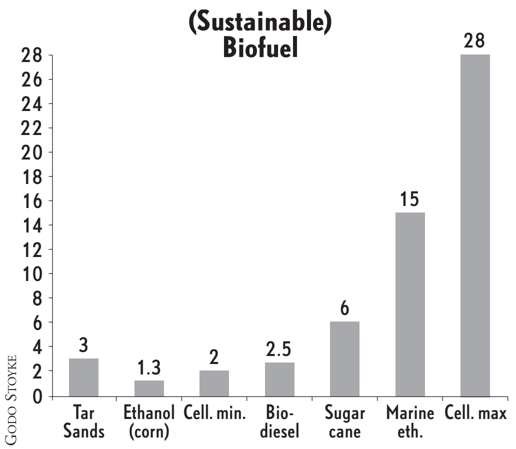


FIGURE 2.16
Energy return on investment (EROI) of biofuels, expressed in barrels of oil equivalent (BOE) returned over BOE invested, compared to oil from Alberta tar sands (bitumen sands) . Cell. = cellulosic ethanol.[23, 24, 25, 26]

The US Government Energy Information Administration (EIA) conducted its own study in 2000 and concluded that the most likely date for Peak Oil was 2037, with a possible range from 2021 to 2112. This position was reaffirmed in 2004 and still appeared to be the official stance in 2008, though the EIA seems to be increasingly isolated in this opinion.[27]

The EIA's own numbers show that global oil

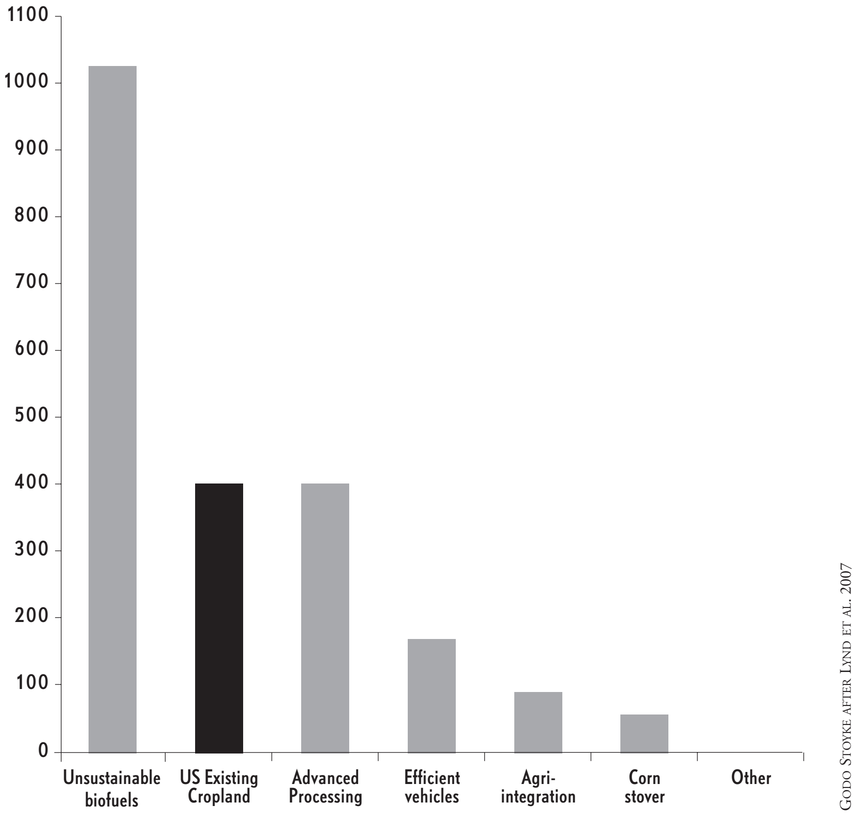


FIGURE 2.17
New land requirements in million acres (1 acre = 4,000 m2) to meet present US light- and heavy-duty vehicle energy demands through biofuels (after Lynd et al. 2007).[25]

production peaked in 2005 and has declined slightly since (Figure 2.18). Is this the beginning of Peak Oil or just a temporary reduction in extraction rates? One of the problems in determining Peak Oil is that it is generally only possible to determine the actual peak in retrospect.

However, the widening gap between increasing consumption and decreasing new discoveries does not bode well for low oil prices in the future (Figure 2.19). It seems clear that countries, municipalities, and economies that are less dependant on erratically

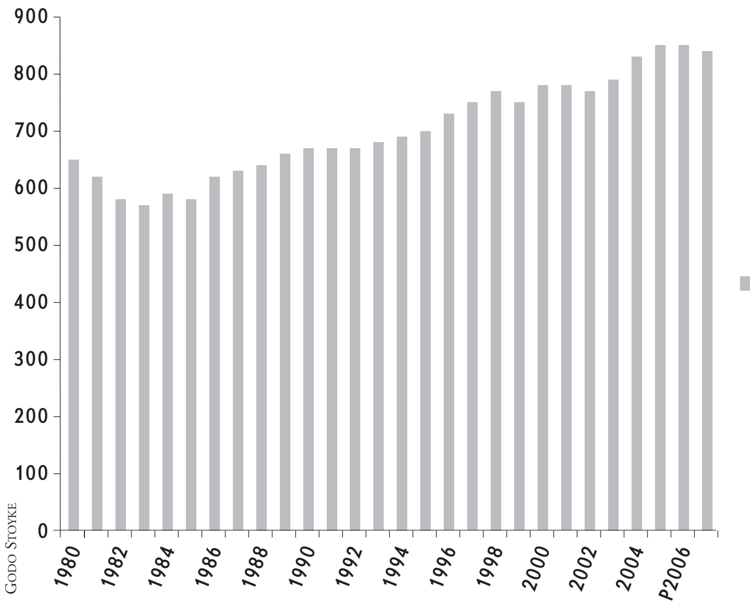


FIGURE 2.18
World production of crude oil in thousand barrels per day.[28]

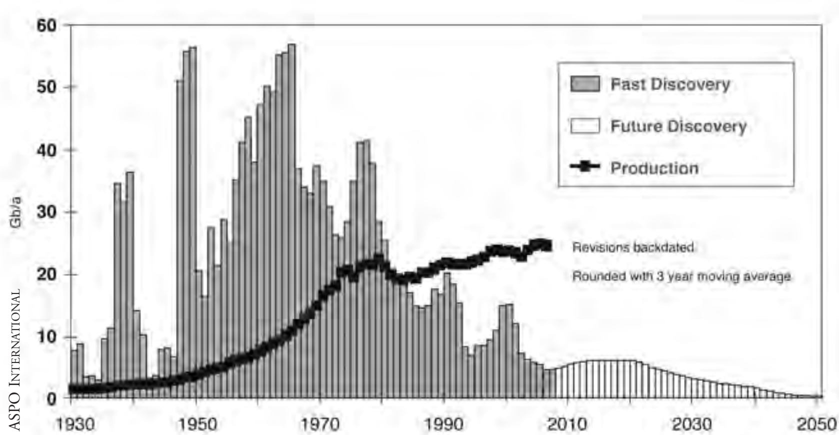


FIGURE 2.19
The growing gap between global oil production and discoveries of new supplies.[29]

priced global energy commodities will be more stable and economically more successful in the intermediate and long term. Numerous cities are establishing Peak Oil Task Forces that assess municipal risks tied to rising fossil fuel prices and determine courses of action on alternatives to be implemented before rising fossil fuel prices threaten affordability of many municipal services — it has been estimated that it takes about 20 years for a municipality to smoothly transition to functioning sustainability models. Waiting for a price signal before taking action would make it very difficult for cities to adapt.

Examples and Case Studies: San Francisco Peak Oil Preparedness Task Force

To deal with the approaching challenges of Peak Oil, the City and County of San Francisco (SF) passed a resolution on May 17, 2007, acknowledging the reality of Peak Oil. The resolution also states that according to a US Department of Energy study, a twenty-year time lead is required for effective mitigation of Peak Oil and that price signals of petroleum scarcity will likely come too late for effective mitigation. [30]

SF began holding a series of town hall meetings in August of 2008 and established the task force's bylaws by October of 2008.

MORE INFO

- Resolution establishing San Francisco Peak Oil Preparedness Task Force: sfenvironment.org/downloads/library/peakoilback grounder.pdf (Amendment May 15, 2007 at sfgov.org/site/uploadedfiles/bdsupvrs/resolutions07/r0268-07.pdf).
- Bylaws of San Francisco Peak Oil Preparedness Task Force passed on October 7, 2008: sfenvironment.org/downloads/library/peak__bylaws100708.doc
- Website of San Francisco Peak Oil Preparedness Task Force: sfgov.org/site/frame.asp?u=http://www.sfenvironment.org

- Slide show of San Francisco Peak Oil Preparedness Task Force: sfgov.org/site/uploadedfiles/lafco/peak_oil_hearing_richard_heinberg.ppt
- globalpublicmedia.com/sites/globalpublicmedia.com/files/SFPeakOilTaskforce-Meeting1.pdf
- Book: Richard Heinberg. 2007. *Peak Everything: Waking Up to the Century of Declines*. New Society Publishers.
- The Association for the Study of Peak Oil and Gas — ASPO International: peakoil.net, ASPO USA: www.aspousa.org
  QuickLink: CarbonCharter.org/03