

Montclair State University – Ecovillage at Ithaca – Sustainable Tompkins  
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What Is Sustainability?

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This slideshow can be accessed online at:

<https://msuweb.montclair.edu/~franker/SustainableTompkins/Frankewhatissustainability2015.pdf>

A brief trifold brochure version of the definition of sustainability  
can be accessed at:

<https://msuweb.montclair.edu/~franker/SustainableTompkins/TeachYourselfSustainability/WhatIsSustainabilityBrochure.pdf>



# Topics for this Presentation

1. The Common Definition of Sustainability
  - 1.1 Background to the Brundtland Commission
2. The Language of Sustainability - Major Terms and Concepts
3. History of Sustainability - Selected Developments
  - 3.1 Rachel Carson and *Silent Spring*
  - 3.2 The Limits-to-Growth Study
  - 3.3 Aftermath of the Brundtland Report
  - 3.4 Herman Daly's Rules for Sustainability
4. Measuring Sustainability
  - 4.1 The Ecological Footprint
  - 4.2 The Millennium Assessment Report

## Related Topics in Separate Slideshows --

5. Collapse: What Happens Instead of Sustainability?
6. Sustainability and Social Justice
7. Making the Earth Sustainable: What Must We Do?
8. Global Warming Basics

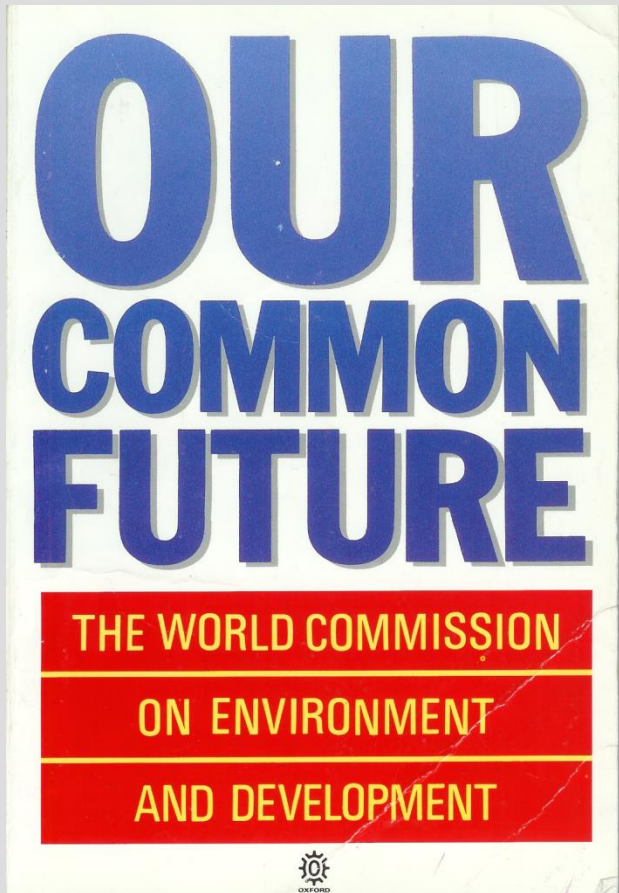
# Topic 1

# The Common Definition of Sustainability

# Topic 1.1

## The Brundtland Commission

(The World Commission on Environment and Development)



The most widely used definition of sustainability derives from the Brundtland Report, named after its author Gro Harlem Brundtland.



She is a Norwegian  
M.D. and former  
Labor Party prime  
minister (1986 - 1989  
and 1990 - 1996)



She was educated in Norway and at the Harvard Public Health School.

From 1998 to 2003 she was Director General of the World Health Organization (WHO) of the United Nations.

At WHO she is credited with taking rapid and effective measures to prevent the 2002-2003 SARS (Severe Acute Respiratory Syndrome) outbreak from becoming a worldwide epidemic.

She was Norway's Minister for Environmental Affairs from 1974 to 1979.

In 1983 Brundtland was asked by the Swiss-based *World Commission on Environment and Development* to help draft a report on environmental problems and the potential for overcoming them.

This was partly a follow up to the 1972 *Conference on the Human Environment* held in Stockholm, Sweden, perhaps the first international meeting to highlight environmental problems in a significant way...



...which was itself in part a consequence of the first "Earth Day," held on April 22, 1970 in which 20 million people celebrated the earth and expressed concern about the state of the planet.

In December of 1970  
President Nixon  
created the  
Environmental  
Protection Agency  
(EPA) partly in  
response to popular  
movements of concern  
about the environment  
- including Earth Day.

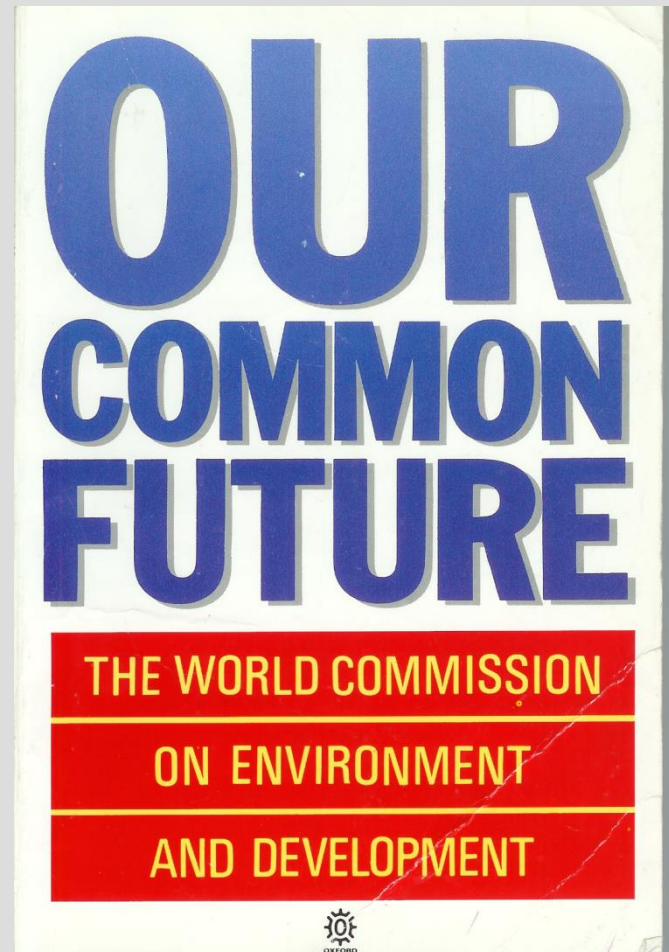


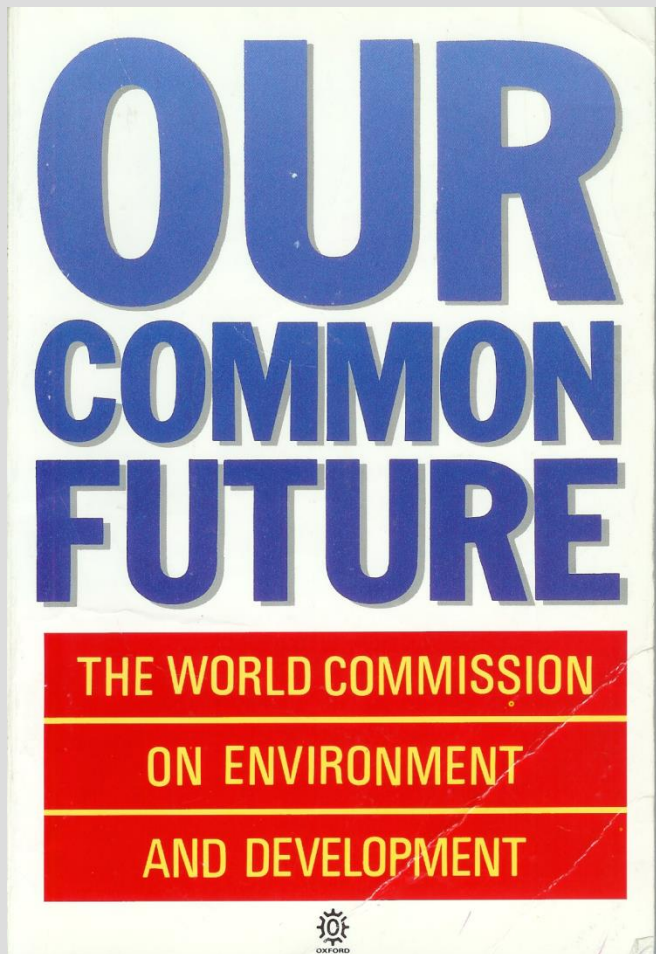
Earth Day itself was partly an outcome of the radical movements of the 1960s in which diverse Americans - including many college students - fought for civil rights for African Americans, opposed the Vietnam War, and agitated for greater rights for women.

During this time the modern gay and lesbian equality movement also began.



The Brundtland Commission began its work in 1983, with 23 official members and panels of experts on energy, industry and food security. Public hearings were held in Indonesia, Canada, Brazil, Zimbabwe, Kenya, Japan and several other locations.



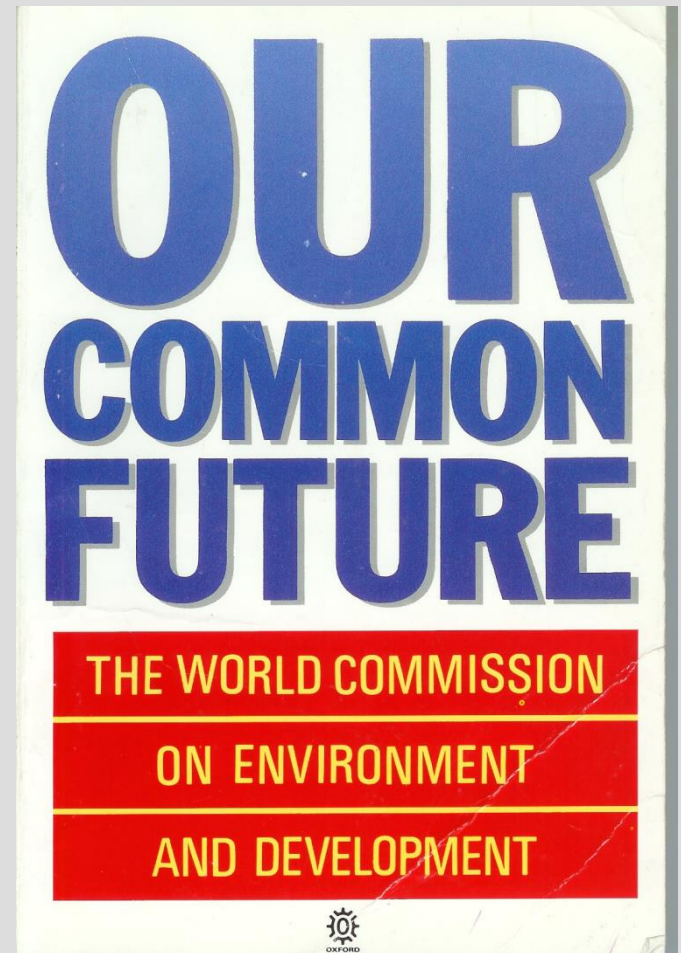


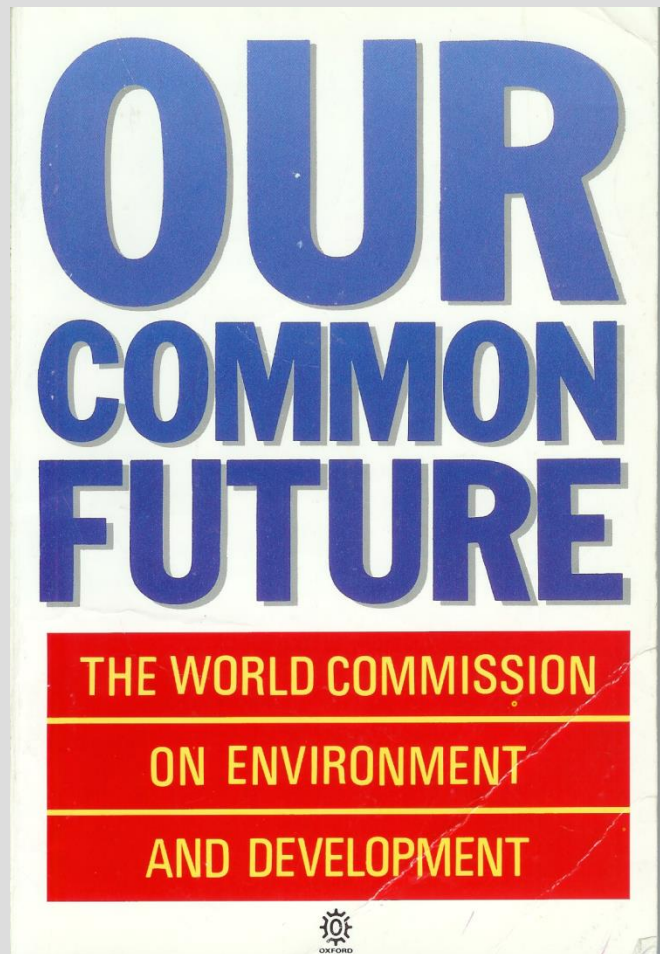
Academics were commissioned to prepare more than 75 studies. The report contains 21 pages of acknowledgements of governments, institutes and individuals who made contributions to its content.

The Brundtland Report came up with the first formal definition of sustainability.

It was directed at the development community but is now widely considered to be appropriate for all nations and peoples.

It was published by Oxford University Press under the title *Our Common Future*.





The main text of *Our Common Future* runs for 347 pages and includes a remarkable amount of detail about the nature of sustainability, the threats to it and the kinds of policies and programs needed to make it viable. Although United Nations reports have earned a reputation for dullness and superficiality owing to the need for approval by member nations, *Our Common Future* remains a relevant document even today, 28 years after its appearance.

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

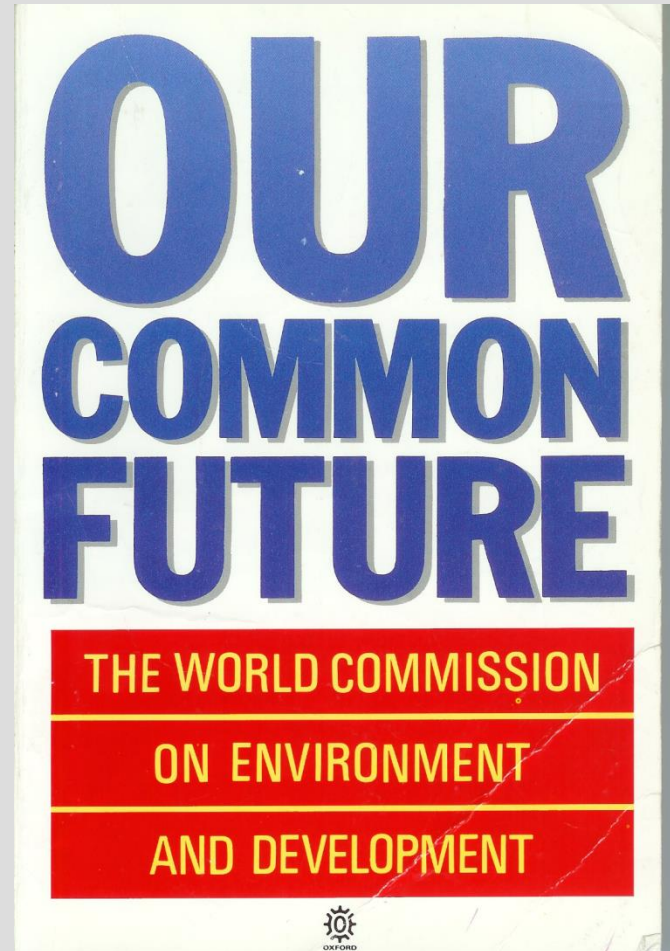


*Our Common Future* (World Commission on Environment and Development 1987: pages 8 and 43)

An additional part of the definition appears later in the Report that is sometimes not cited:

**“At a minimum, sustainable development must not endanger the natural systems that support life on earth: the atmosphere, the waters, the soils and the living beings.”**

*Our Common Future* (World Commission on Environment and Development 1987:44-45)



You can access the entire Brundtland Report free in English at:

<https://www.sustainabledevelopment2015.org/AdvocacyToolkit/index.php/earth-summit-history/historical-documents/92-our-common-future>

# Topic 2

## The Language of Sustainability - Major Terms and Concepts



# Topic 2

On the next three slides, click on any term or concept to access a 600 to 1,000 word description that includes links to additional sources

**Some Commonly Used Terms in  
the Sustainability Movement**  
Click on a Concept Name to Access a Brief Overview

[Systems Thinking 01 – The  
Historical Background](#)

[The Greenhouse Effect](#)

[Systems Thinking 02 –  
Systems Thinking Basics](#)

[Global Warming and  
Climate Change](#)

[Feedback](#)

[The Keeling Curve](#)

[Tipping Points](#)

[Photosynthesis](#)

**Some Commonly Used Terms in  
The Sustainability Movement**  
Click on a Concept Name to Access a Brief Overview

**Environmental Racism 01**

**The Sixth Extinction**

**Environmental Racism 02**

**Strong vs. Weak  
Sustainability**

**Environmental Racism 03**

**The “Triple Bottom Line”**

**The Green New Deal**

**The Precautionary  
Principle**

**Some Commonly Used Terms in  
The Sustainability Movement**  
Click on a Concept Name to Access a Brief Overview

**Planetary Boundaries**

**Easter Island Lessons**

**Smart Farming in Africa**

**Lessons from the Maya  
Collapse**

**Discovering the  
Greenhouse Effect**

**Lessons from the Roman  
Empire Collapse**

**Quantifying the  
Greenhouse Effect**

**Overshoot**

# Topic 3

## The History of Sustainability - Selected Developments

# History of the Sustainability Concept

Parallel to international conferences and the various people's movements, sustainability developed as a result of the accumulation of scientific knowledge.

# History of the Sustainability Concept

This history goes back to the knowledge of the indigenous peoples such as those of North America, to 19th century thinkers such as Henry David Thoreau, Ralph Emerson, John Wesley Powell...20th century scientists such as Aldo Leopold...and many others.

**Some Ancestors of  
the Modern Sustainability Movement**  
Click on a Name to Access a Brief Biography

[Haudenosaunee \(Iroquois\)](#)  
[Three Sisters Farming](#)

[Aldo Leopold](#)

[David Henry Thoreau and](#)  
[Ralph Waldo Emerson](#)

[Rachel Carson](#)

[John Muir](#)

[The Limits to Growth](#)  
[Study](#)

[Limits to Growth More Detailed Info.](#)

[John Wesley Powell](#)

[Charles Keeling](#)



# History of the Sustainability Concept

In this presentation, we shall focus on three contributions that we believe were the most significant in generating or applying the sustainability concept in the scientific community:

# History of the Modern Sustainability Concept:

- 3.1 Scientist Rachel Carson;
- 3.2 *The Limits to Growth* Study;
- 3.3 Economist Herman Daly's Rules for  
Sustainability

# 3.1 Rachel Carson and *Silent Spring*

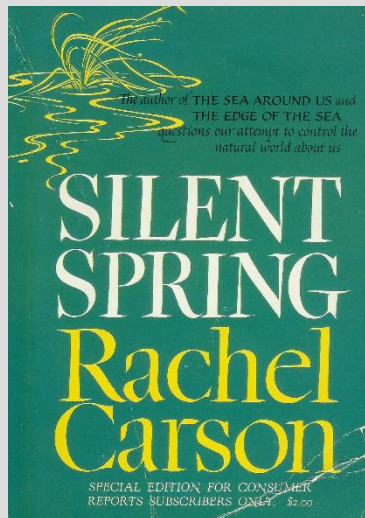
# Rachel Carson

(1907-1964) was a zoologist and marine biologist who worked for many years for the U.S. Fish and Wildlife Service. She is considered one of the finest science writers ever, producing a series of books and articles including *Under the Sea Wind* (1941), *The Sea Around Us* (1951), and *The Edge of the Sea* (1955) as well as several technical reports for the Fish and Wildlife Service.



# Rachel Carson

Rachel Carson's masterpiece, *Silent Spring* (1962), is widely recognized as one of the most influential books of the twentieth century. Thousands of citations to the book have appeared in scientific journal articles and popular publications over the decades. The book



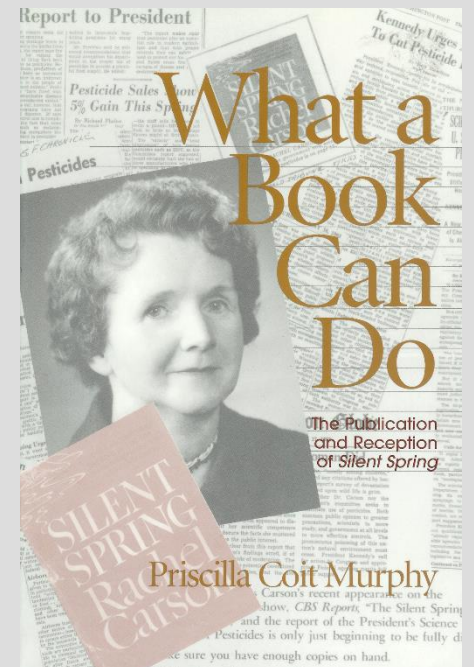
has been published in France, Germany, Italy, Denmark, Sweden, Norway, Finland, Holland, Spain, Brazil, Japan, Iceland, Portugal and Israel and has influenced environmental legislation in all those countries.

## Rachel Carson

In 1963 *Silent Spring* led in part, to the appointment by President Kennedy of a President's Science Advisory Commission. This was followed by congressional hearings that most observers believe vindicated Carson's warnings that some pesticides and spraying campaigns were threatening to cause environmental and health disasters.

# Rachel Carson

*Silent Spring* was the impetus for the founding in 1967 of the Environmental Defense Fund which later led the battle to ban DDT - a ban that took effect in the U.S. in 1972. Today Rachel Carson continues to inspire people around the world who want to know what chemicals are being added to our environment, whether they have been properly tested and whether they fit into the web of life she defended in *Silent Spring*.



## Rachel Carson

Rachel Carson might never have used the word "sustainability." But *Silent Spring* rang a warning bell that uncontrolled and careless over spraying of chemical pesticides could damage the web of life. Indeed, the very title of her book refers to the first chapter in which she describes a fictitious town in which a spring arrived but no birds sang.



## Rachel Carson

*Silent Spring* is one of the first popularized scientific statements of the idea that we humans are part of nature, not its conquerors and that we should use science and technology to maintain or strengthen rather than to weaken or break the strands of the web of life:

## Rachel Carson

explained that any alternatives to pesticides should be “based on understanding of the living organisms they seek to control, and of the whole fabric of life to which these organisms belong.”

Source: *Silent Spring*, page 278

# Rachel Carson

Today we might say that Carson understood the need to maintain biodiversity. But it was not just species biodiversity: it was biodiversity of the elements and the networks and systems of the web of life that she recognized as crucial to the existence and quality of human life. Organic farmers today make use of many of the ideas Carson advocated.

## Rachel Carson

Her emphasis on connections among the elements of the web of life makes Carson one of the first science writers to present to the public a systems view of nature and of our place in it.

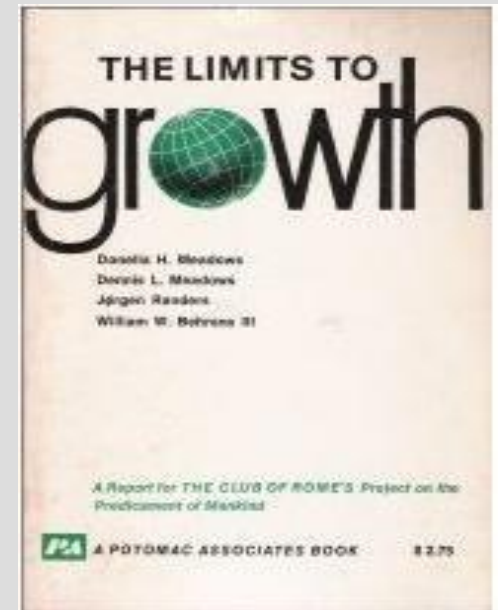
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To read a 5-page overview of Rachel Carson's contributions to sustainability thinking, click [here](#).

## 3.2 The Limits to Growth

In 1972 - just two years after the first Earth Day - a group of Massachusetts Institute of Technology computer geeks - among the earliest of the genre - published a slim volume called *The Limits to Growth*. Working since 1968, they had developed a computer program called "World3," which allowed them to run projections of world economic growth and resource use with changing sets of assumptions.

This work was one of the earliest attempts to use computers to work with "big data."  
It would have taken years to accomplish by hand calculations.



The authors employed their computer program World3 to explore past and future relations among five economic sectors: (1) population, (2) capital, (3) agriculture, (4) nonrenewable resources and (5) pollution. One hundred total variables and 80 fixed parameters allowed the program to be set or reset to test for all kinds of possible interrelations among the variables over time.



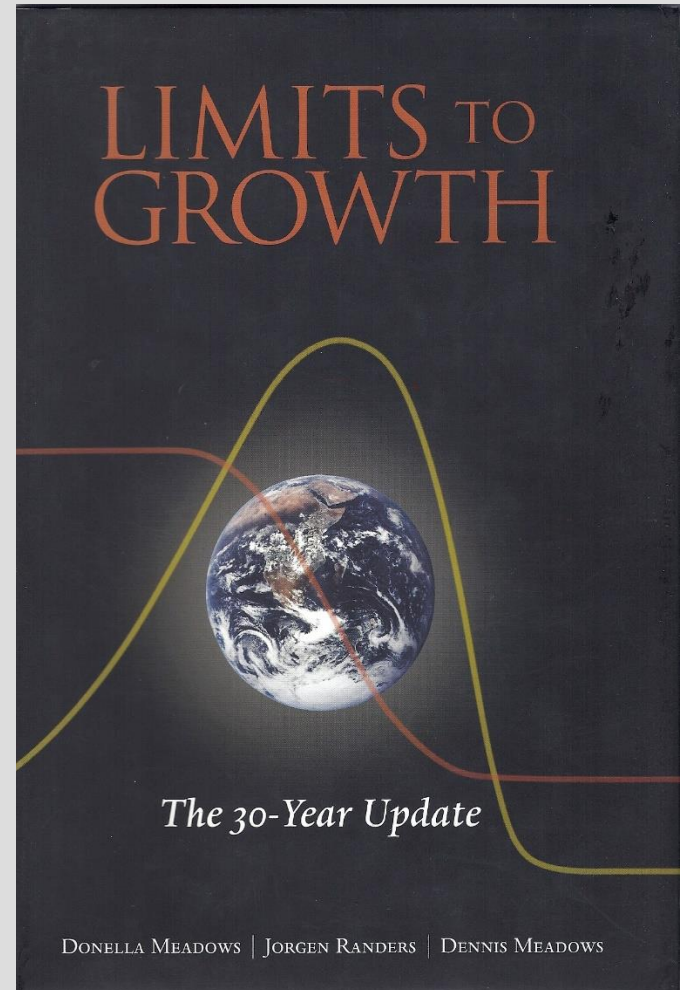
They compiled  
their massive  
data runs into  
ten “scenarios.”

They were  
shocked by  
their  
findings.

The computer output seemed to show that if (then) present trends in population, industrial and consumption growth continued – that is, “Business as Usual” – or, if any one of eight alternative scenarios emerged, it was likely that “a rather sudden and uncontrollable decline in both population and industrial capacity” would occur “sometime within the next one hundred years.”

Translation: a collapse  
of civilization and  
massive human  
suffering.

In 2004 the authors published a “30-year update” in which they combined their original computer runs with the 1990s developed Ecological Footprint (EF).

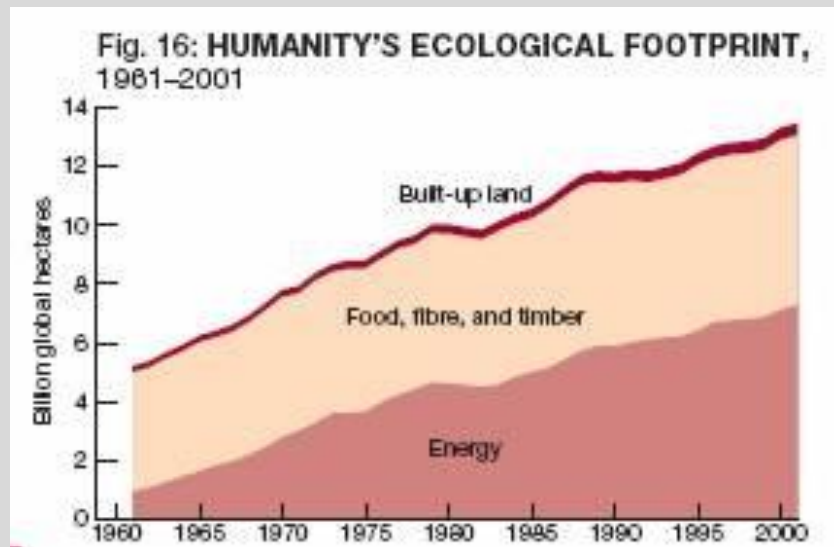
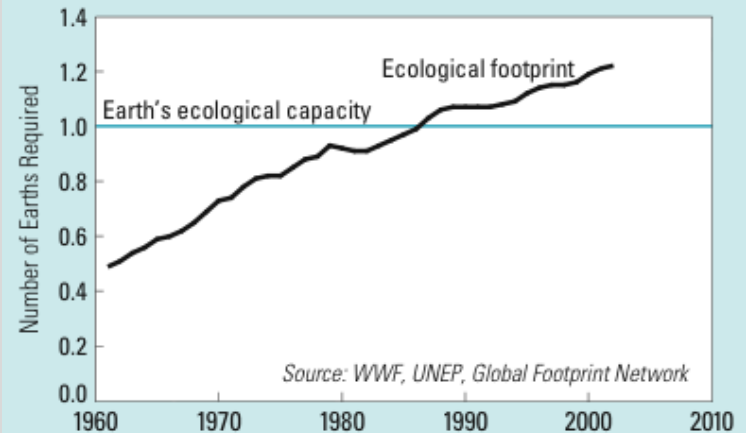


## Sustainability Indicators: The Ecological Footprint

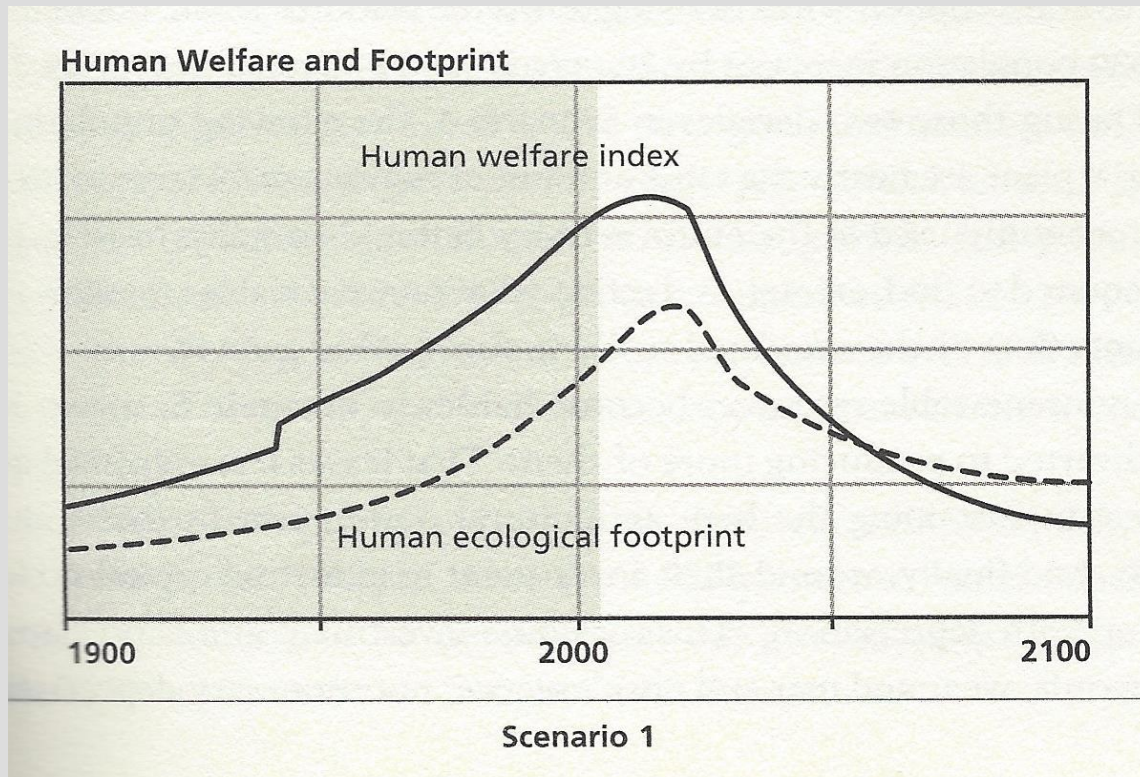
The Ecological Footprint is defined as "the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located."

Source:  
<https://www.sustainablescale.org/conceptualframework/understandingscale/measuringscale/ecologicalfootprint.aspx>

Figure 1. World Ecological Footprint, 1961–2002



Do you see the collapse?



Scenario 01 shows a strong positive relationship between human welfare and the human ecological footprint.

Source: Meadows, Donella, Jørgen Randers and Dennis Meadows. 2004. *Limits to Growth: The 30-Year Update*. White River Junction, Vermont: Chelsea Green Publishing Company. Page 169.

Sound familiar?



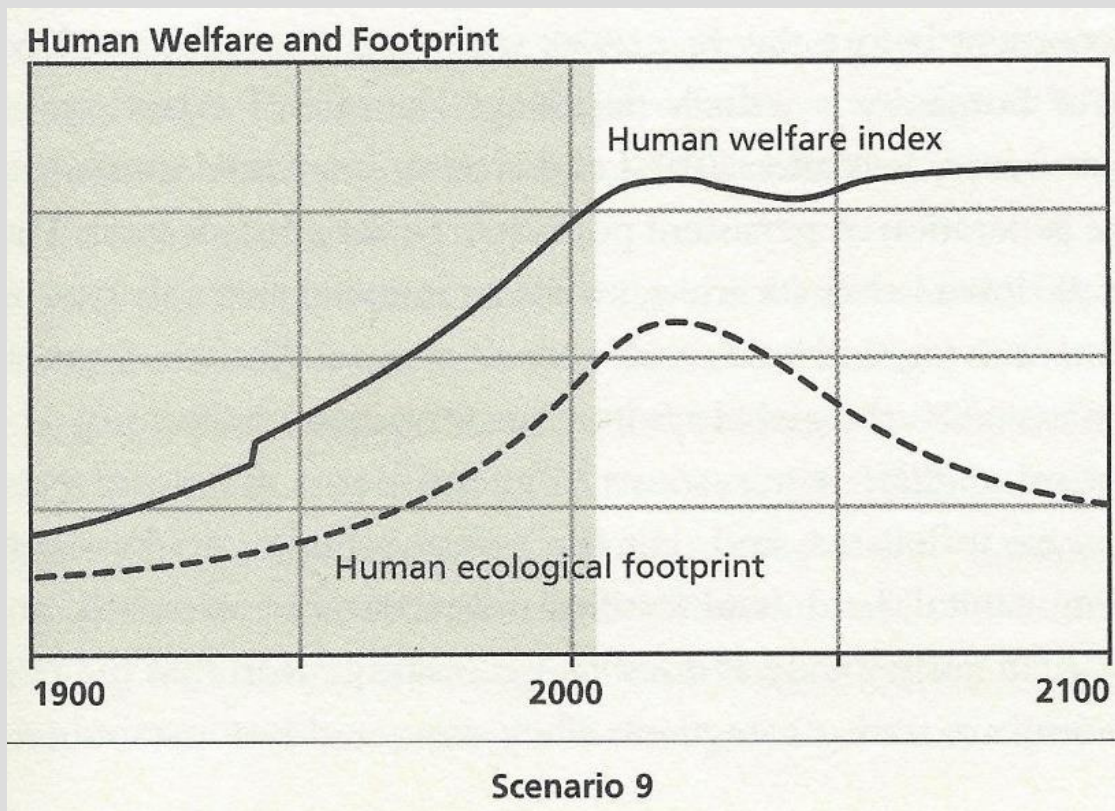
Scenario 09 - the only sustainable outcome emerging from their projections - required massive restructuring of world and national economies along with big changes in human attitudes and lifestyles.

Do you see the point of divergence?

Do you notice anything unusual in the graph?

What "massive restructuring" would be necessary?

Scenario 09 shows a diverging relationship between human welfare and the human ecological footprint.



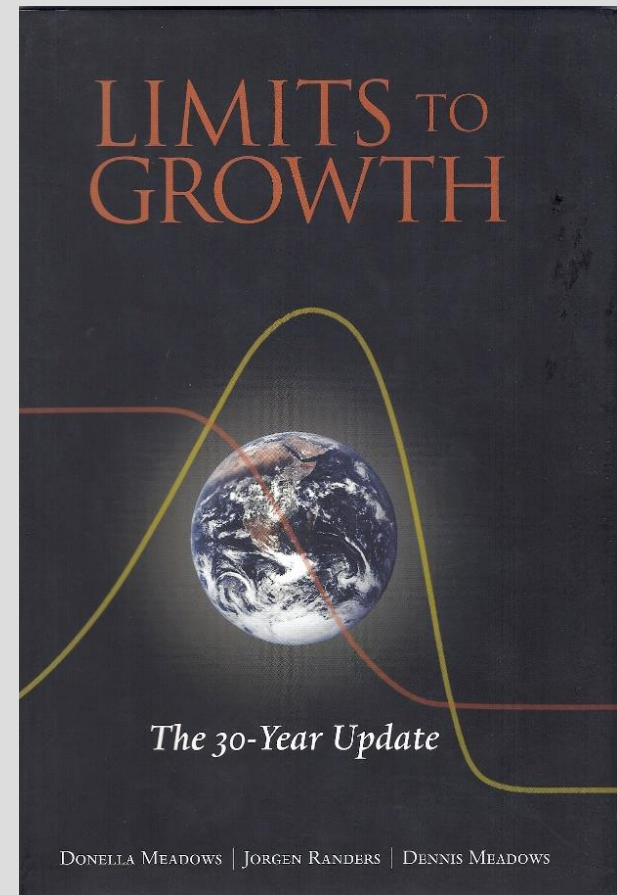
Source: Meadows, Donella, Jørgen Randers and Dennis Meadows. 2004. *Limits to Growth: The 30-Year Update*. White River Junction, Vermont: Chelsea Green Publishing Company. Page 245.

Among establishment economists, *The Limits to Growth* was harshly criticized and widely ridiculed.

# Sound familiar?

**Can you guess what some of their objections were?**

Gradually over the decades, however, more and more scientists have come to the conclusion that *The Limits to Growth* is fundamentally correct.



As physical chemist Ugo Bardi noted in a 2011 summary of the debates, "the world's resources are limited, a consequence of the way the universe is built,"

To read a 2-page summary of *The Limits to Growth* and its consequences for the sustainability movement, click on:

<https://sustainabletompkins.org/signs-of-sustainability/steps-to-sustainability-part-15-of-a-series-the-limits-to-growth-study/>

To read a 9-page, more detailed account with references, click on:

<https://msuweb.montclair.edu/~franker/TeachYourselfSustainability/LimitstoGrowthDetailed.pdf>

## 3.3 Aftermath of the Brundtland Report



The Brundtland Report laid the basis  
for the 1992

United Nations Conference on  
Environment and Development

also known as the Rio Conference  
also known as the “earth summit”

The Rio Conference of 178 nations adopted a document called “Agenda 21”

21 for 21<sup>st</sup> Century

It included a statement of 27 principles to achieve sustainable development...

You can access the brief statement of the 27 principles at:

[https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A\\_CONF.151\\_26\\_Vol.I\\_Declaration.pdf](https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf)

...and the 2012 follow up conference at

<https://sustainabledevelopment.un.org/rio20>

Another outcome of the 1992 Rio Conference was the creation of the United Nations Commission on Sustainable Development

<https://sustainabledevelopment.un.org/csd.html>

The Commission was to carry on activities for sustainable development between conferences every 5 years:

- 1997 – Kyoto Protocol on Climate Change (US and Australia refused to ratify – Australia ratified at the end of 2007 after the Labor Party won the parliamentary elections there) – Kyoto expired in 2012
- 2002 – Johannesburg World Summit on Sustainable Development – WSSD (also known as Rio +10)  
(The US boycotted the Johannesburg Conference)

## 2007 – The Bali, Indonesia UN Climate Change Conference: 3–14 December 2007

Official conference site:

[https://unfccc.int/meetings/cop\\_13/items/4049.php](https://unfccc.int/meetings/cop_13/items/4049.php)

BBC site with accomplishments and criticisms:

<https://news.bbc.co.uk/1/hi/sci/tech/7136486.stm>

Greenpeace report with detailed alternatives:

[https://www.greenpeace.org/international/campaigns/climate-change/our\\_work/negotiations/un-climate-change-bali-meeting](https://www.greenpeace.org/international/campaigns/climate-change/our_work/negotiations/un-climate-change-bali-meeting)



During all these conferences and related events scholars have discussed and debated the sustainability concept.



In general the original Brundtland definition has held up well as a central unifying concept:

**“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”**

But many feel the definition is too general and so...

additional definitions have been proposed to focus on particular components of sustainability

One of the most important comes from economist Herman Daly...

## 3.4 Herman Daly's Rules for Sustainability

“The market does not distinguish... between ethically just and unjust distributions of income. Sustainability, like justice, is a value not achievable by purely individualistic market processes”

Steady-state economist Herman Daly 1986:320 in the Journal *Land Economics* 62(3).

# Technical Conditions for Sustainability: System Integrity

Economist Herman Daly argues that all environmental systems display a characteristic he calls “throughput.” It includes the input and output of a system

- Throughput occurs with energy
- Throughput occurs with matter

Daly claims there are three fundamental rules of throughput that must be met to achieve sustainability. One rule each for:

- Renewable resources
- Non renewable resources
- Pollutants

## Rule I. Renewable resources (soil, water, forest, fish)

- the rate of use must be no greater than the rate of (usually natural) regeneration.

## Rule 2. For non-renewable resources (oil, minerals, fossil groundwater)

- The rate of use must be no greater than the rate at which a renewable resource can be substituted for it



### 3. For pollutants –

- the rate of emission must be no greater than the rate at which the pollutant can be
  - Recycled
  - Absorbed, or
  - Rendered harmless in a “sink”

If any one of these three rules is broken, the overall sustainability of a system becomes disturbed and is endangered.

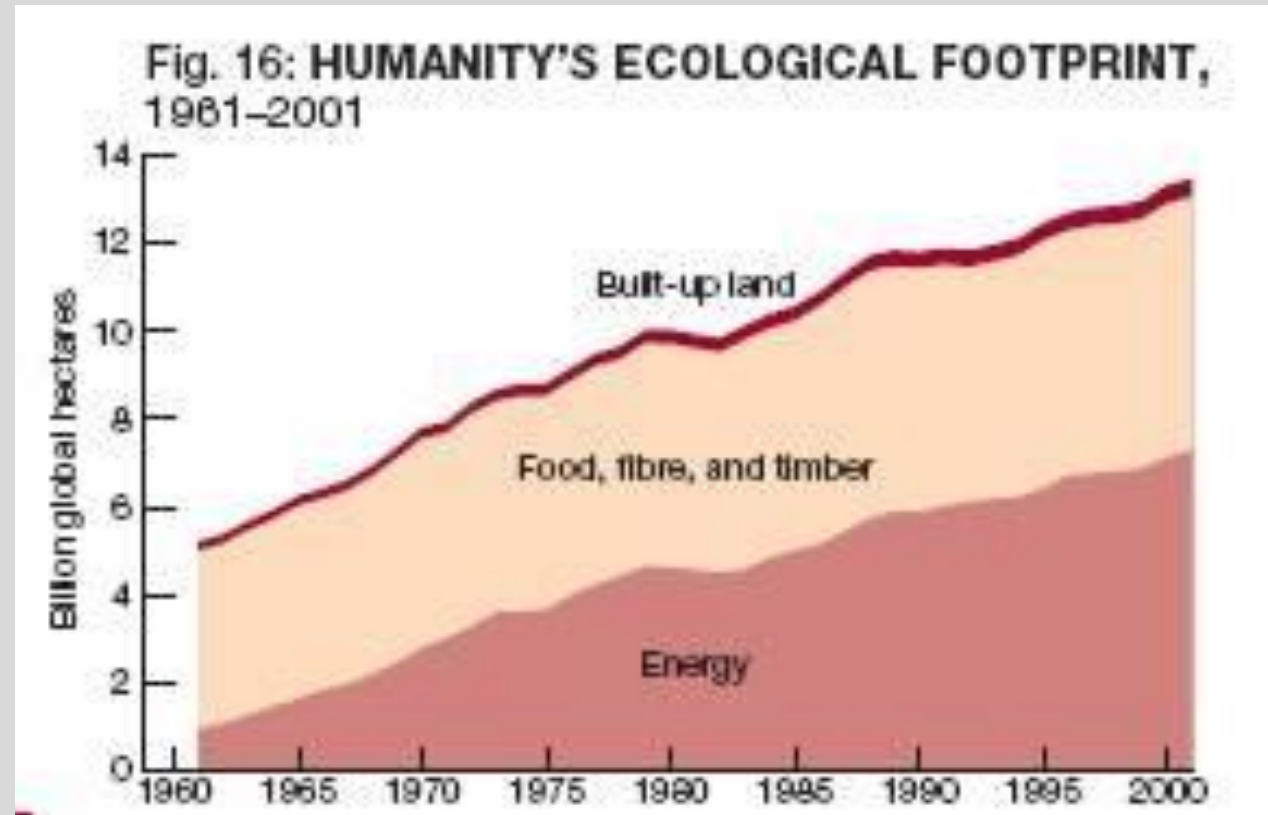
# 4. Measuring Sustainability: The Ecological Footprint and the Millennium Assessment Project

Humans are Now  
Using Earth's  
Resources Faster  
than Earth Can  
Renew Them

The Ecological Footprint is defined as "the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located."

Source:  
<http://www.sustainablescale.org/conceptualframework/understandingscale/measuring/ecologicalfootprint.aspx>

## Sustainability Indicators: The Ecological Footprint

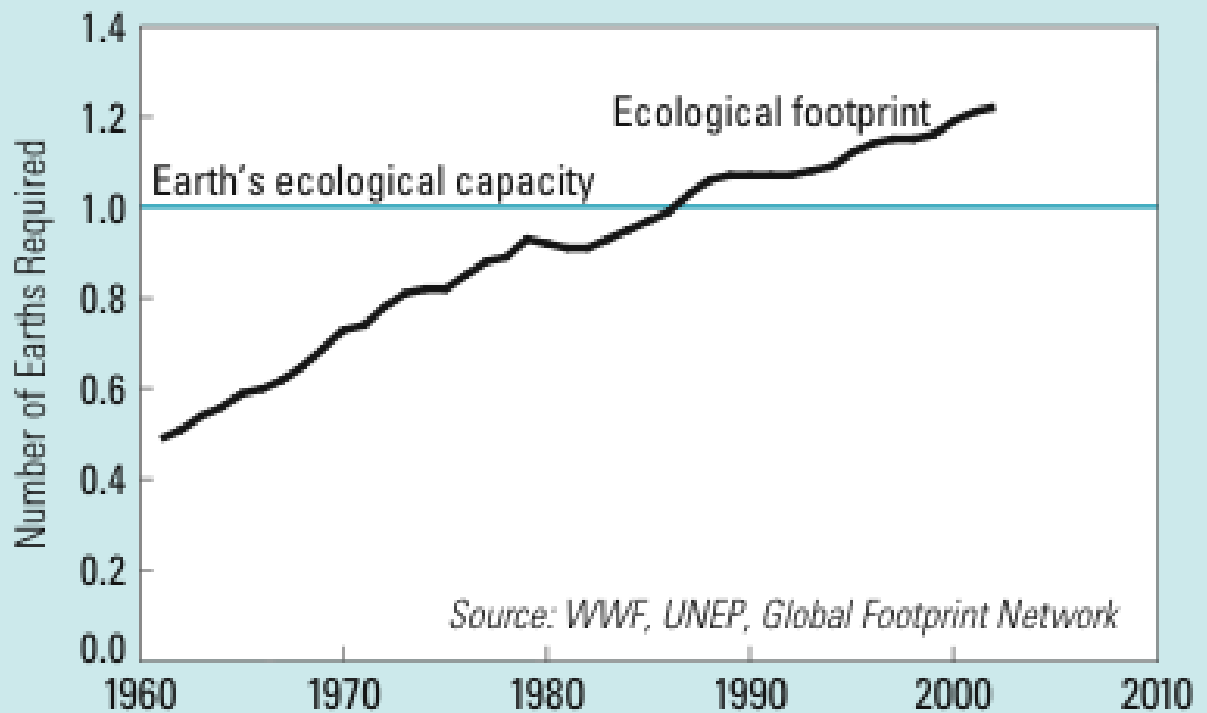


## Sustainability Indicators: The Ecological Footprint

“Overshoot” begins just before 1990 and continues upward even after hitting 1.0, the theoretical maximum...

Source: [Wackernagel, Mathis, et al. 2002. Tracking the ecological overshoot of the human economy. Proceedings of the National Academy of Sciences 99\(14\):9266–71.](#)

**Figure 1. World Ecological Footprint, 1961–2002**



## Ecological Footprint and Overshoot

World Biocapacity Per Person in 2010 Was 1.8 hectares	EVI Overshoot
<p>World Average EF 2010</p> <ul style="list-style-type: none"><li>= 2.7 ha</li><li>= 2.7-1.8</li><li>= 0.9/1.8</li><li>= 50% Overshoot</li></ul>	<p>Overshoot threatens to draw down the life support reserves of the earth...</p>
<p>US overshoot is 439%</p> <ul style="list-style-type: none"><li>= 9.7-1.8</li><li>= 7.9 ha.</li><li>= 7.9/1.8</li><li>= 439% Overshoot</li></ul>	<p>EVI overshoot is 136%</p> <ul style="list-style-type: none"><li>= 4.25-1.8</li><li>= 2.45 ha</li><li>= 2.45/1.8</li><li>= 136% Overshoot</li></ul>

Source for World Average: [http://www.footprintnetwork.org/en/index.php/GFN/page/ecological\\_footprint\\_atlas\\_2008/](http://www.footprintnetwork.org/en/index.php/GFN/page/ecological_footprint_atlas_2008/)

# Overall Environmental Assessment

## 2005 Millennium Ecosystem Assessment By international panel of scientists



# What is the Millennium Ecosystem Assessment?



- Largest assessment ever undertaken of the health of ecosystems
  - *Prepared by 1360 experts from 95 countries; extensive peer review*
  - *Consensus of the world's scientists*
- Designed to meet needs of decision-makers among government, business, civil society
  - *Information requested through 4 international conventions*

## Core Questions

What is the rate and scale of ecosystem change?

What are the consequences of ecosystem change for the services provided by ecosystems and for human-well being?

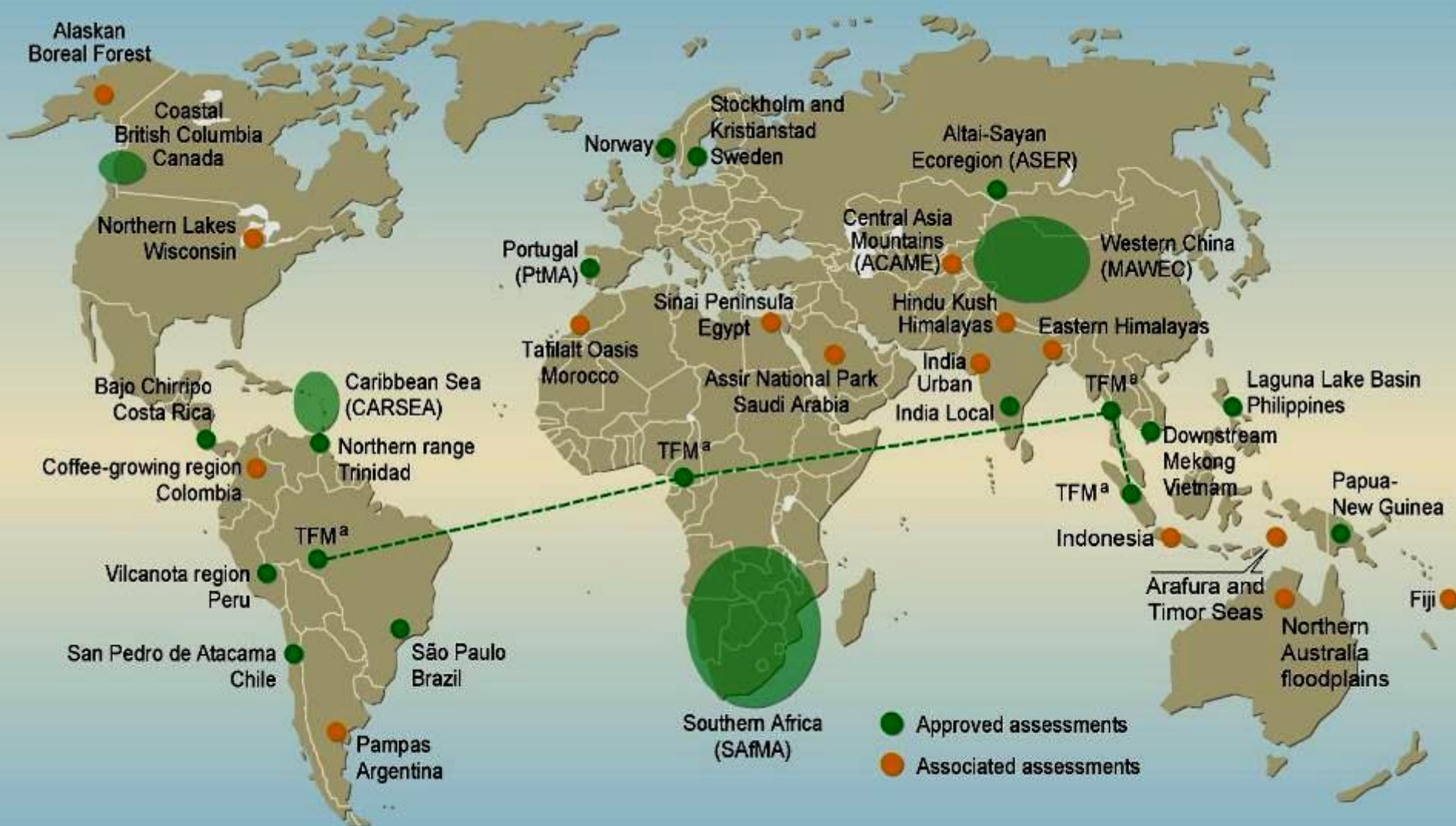
How might ecosystems and their services change over the next 50 years?

What options exist to conserve ecosystems and enhance their contributions to human well-being?

# What was unique?

## Multi-Scale

## Assessment



<sup>a</sup> Tropical Forest Margins

Trade, poverty, and environment: sites in Chile, China, India, Madagascar, Mexico, South Africa, and Viet Nam

# The Balance Sheet

Enhanced	Degraded	Mixed
Crops	Capture fisheries	Timber
Livestock	Wild foods	Fiber
Aquaculture	Wood fuel	Water regulation
Carbon sequestration	Genetic resources	Disease regulation
	Biochemicals	Recreation & ecotourism
	Fresh Water	
	Air quality regulation	
	Regional & local climate regulation	
	Erosion regulation	
	Water purification	
	Pest regulation	
	Pollination	
	Natural Hazard regulation	
	Spiritual & religious	
	Aesthetic values	

**Bottom Line: 60% of Ecosystem Services are Degraded**

# 2005 Millennium Ecosystem Assessment

## More details on next few slides

# The Balance Sheet

**MA Synthesis SDM (p. 6):** “Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment (including 70% of regulating and cultural services) are being degraded or used unsustainably.

Ecosystem services that have been degraded over the past 50 years include capture fisheries, water supply, waste treatment and detoxification, water purification, natural hazard protection, regulation of air quality, regulation of regional and local climate, regulation of erosion, spiritual fulfillment, and aesthetic enjoyment.

The use of two ecosystem services—capture fisheries and fresh water—is now well beyond levels that can be sustained even at current demands, much less future ones.

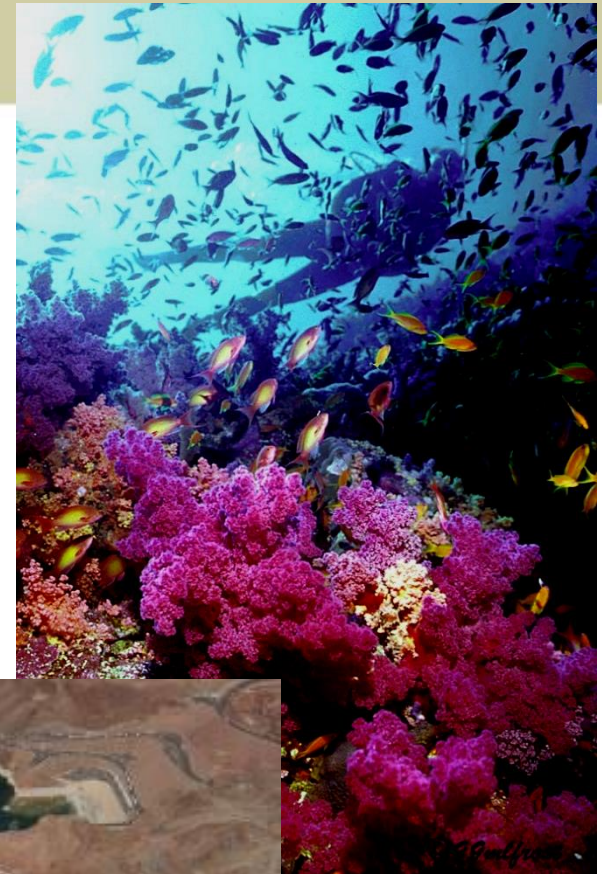
# The Balance Sheet

At least one quarter of important commercial fish stocks are overharvested (*high certainty*). (See Figures 5, 6, and 7.) From 5% to possibly 25% of global freshwater use exceeds long-term accessible supplies and is now met either through engineered water transfers or overdraft of groundwater supplies (*low to medium certainty*). Some 15–35% of irrigation withdrawals exceed supply rates and are therefore unsustainable (*low to medium certainty*).

While 15 services have been degraded, only 4 have been enhanced in the past 50 years, three of which involve food production: crops, livestock, and aquaculture. Terrestrial ecosystems were on average a net source of CO<sub>2</sub> emissions during the nineteenth and early twentieth centuries, but became a net sink around the middle of the last century, and thus in the last 50 years the role of ecosystems in regulating global climate through carbon sequestration has also been enhanced.”

# Scale of Change

- 20% of the world's coral reefs were lost and more than 20% degraded
- 35% of mangrove area has been lost in the last several decades
- Amount of water in reservoirs quadrupled since 1960





# MA Findings - Outline

## 1. Ecosystem Changes in Last 50 Years

## 2. Gains and Losses from Ecosystem Change

*Three major problems may decrease long-term benefits*

- Degradation of Ecosystem Services
- Increased Likelihood of Nonlinear Changes – sometimes called “ecological surprises”
- Exacerbation of Poverty for Some People

# Impact on Poor and Marginalized People

Poor people are most dependent on ecosystem services and most vulnerable to degradation of the services



# Level of poverty remains high and inequities are growing

## **Economics and Human Development**

- 1.1 billion people surviving on less than \$1 per day of income. 70% in rural areas where they are highly dependent on ecosystem services
- Inequality has increased over the past decade. During the 1990s, 21 countries experienced declines in their rankings in the Human Development Index

## **Access to Ecosystem Services**

- An estimated 852 million people were undernourished in 2000–02, up 37 million from the period 1997–99
- Per capita food production has declined in sub-Saharan Africa
- Some 1.1 billion people still lack access to improved water supply, and more than 2.6 billion lack access to improved sanitation
- Water scarcity affects roughly 1–2 billion people worldwide

# Ecosystem services and poverty reduction

## **Degradation of ecosystem services harms poor people**

- Half the urban population in Africa, Asia, Latin America, and the Caribbean suffers from one or more diseases associated with inadequate water and sanitation
- The declining state of capture fisheries is reducing an inexpensive source of protein in developing countries. It also makes it harder for local fisherpeople to make a living. Per capita fish consumption in developing countries, excluding China, declined between 1985 and 1997
- Desertification affects the livelihoods of millions of people, including a large portion of the poor in drylands

**Pattern of winners and losers has not been taken into account in management decisions**

# Overall Environmental Assessment

## Services provided by ecosystems...

- Provisioning
- Regulating
- Cultural

# Provisioning Services

## Goods produced or provided by ecosystems

### Food

- Crops
- Livestock
- Capture Fisheries
- Aquaculture
- Wild Foods



### Fiber

- Timber
- Cotton, hemp, silk
- Wood Fuel



### Genetic resources

### Biochemicals

### Freshwater



# Regulating Services

## Benefits obtained from regulation of ecosystem processes

**Air Quality Regulation**

**Climate Regulation**

- Global (CO<sub>2</sub> sequestration)
- Regional and local

**Erosion regulation**

**Water purification**

**Disease regulation**

**Pest regulation**

**Pollination**

**Natural Hazard regulation**



# Cultural Services

**Non-material benefits obtained from ecosystems**

**Spiritual and Religious Values**

**Knowledge Systems**

**Educational values**

**Inspiration**

**Aesthetic Values**

**Social Relations**

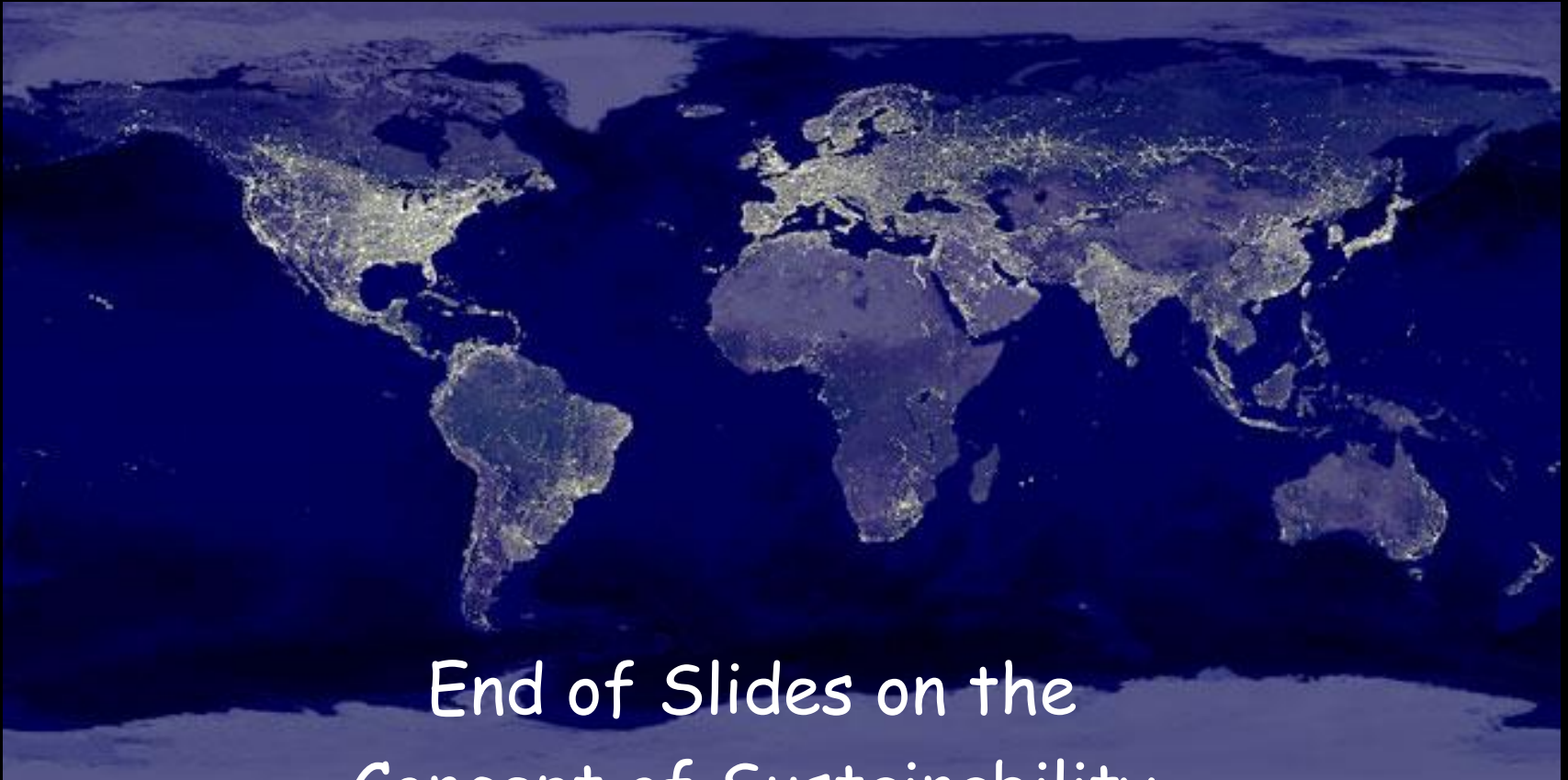
**Sense of Place**

**Recreation and Ecotourism**





Montclair State University – Ecovillage at Ithaca – Sustainable Tompkins – Sustainability Center  
Professors Emeritus Richard W. Franke and Barbara H. Chasin

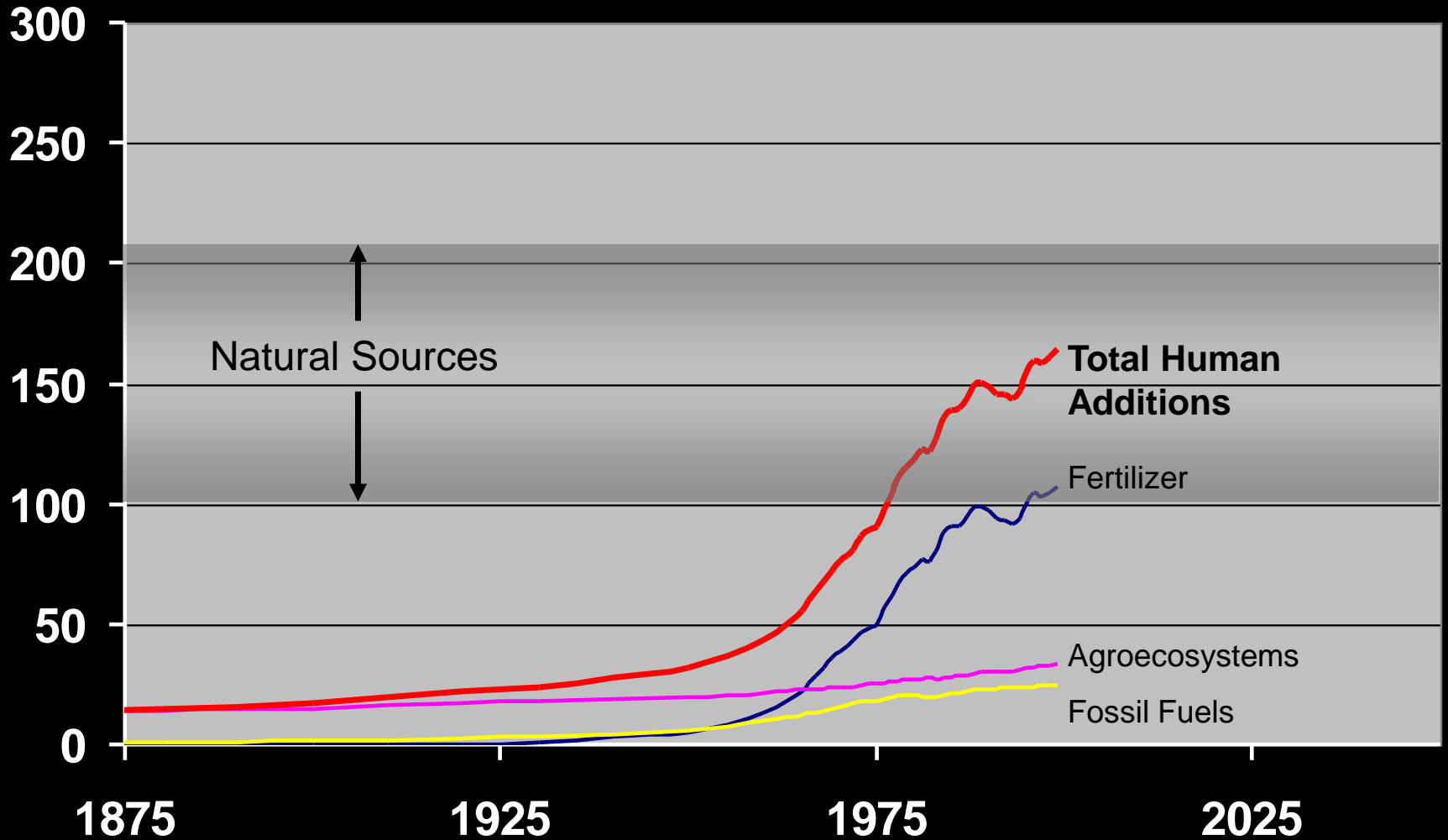


End of Slides on the  
Concept of Sustainability

# 2005 Millennium Ecosystem Assessment

## Example: Spread of Reactive Nitrogen

# Teragrams of Nitrogen per Year



Source: Millennium Ecosystem Assessment

# The Three Sisters

**Here are the notes from the previous slide:**

From: **MA Synthesis Figure 14. Global Trends in the Creation of Reactive Nitrogen on Earth by Human Activity, with Projection to 2050 (R9 Fig 9.1)**

Most of the reactive nitrogen produced by humans comes from manufacturing nitrogen for synthetic fertilizer and industrial use.

Reactive nitrogen is also created as a by-product of fossil fuel combustion and by some (nitrogen-fixing) crops and trees in agroecosystems. The range of the natural rate of bacterial nitrogen fixation in natural terrestrial ecosystems (excluding fixation in agroecosystems) is shown for comparison.

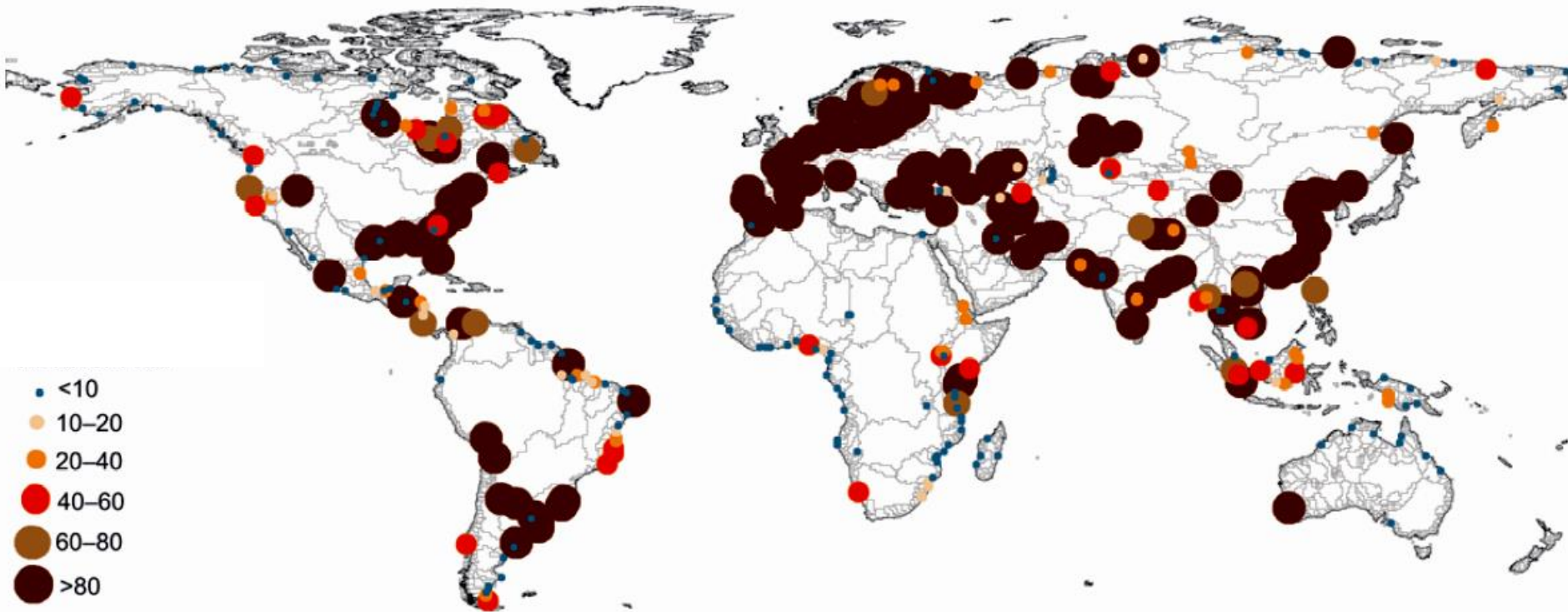
## The Three Sisters

### Notes continued...

Human activity now produces approximately as much reactive nitrogen as natural processes do on the continents. (Note: The 2050 projection is included in the original study and is not based on MA Scenarios.)

MA Synthesis SDM: “Since 1960, flows of reactive (biologically available) nitrogen in terrestrial ecosystems have doubled, and flows of phosphorus have tripled. More than half of all the synthetic nitrogen fertilizer, which was first manufactured in 1913, ever used on the planet has been used since 1985.”

# Percent Increase in Nitrogen Flows in Rivers



Source: Millennium Ecosystem Assessment

Some results of excessive reactive nitrogen: eutrophication



# Impacts of Excessive Nitrogen Flows

## Environmental effects:

- eutrophication of freshwater and coastal ecosystems
- contribution to acid rain
- loss of biodiversity

### *Contribution to:*

- creation of ground-level ozone
- destruction of ozone in the stratosphere
- contribution to global warming

## Resulting health effects:

- consequences of ozone pollution on asthma and respiratory function
- increased allergies and asthma due to increased pollen production
- risk of blue-baby syndrome
- increased risk of cancer and other chronic diseases from nitrate in drinking water,
- increased risk of a variety of pulmonary and cardiac diseases from production of fine particles in the atmosphere



# Gulf of Mexico Dead Zone

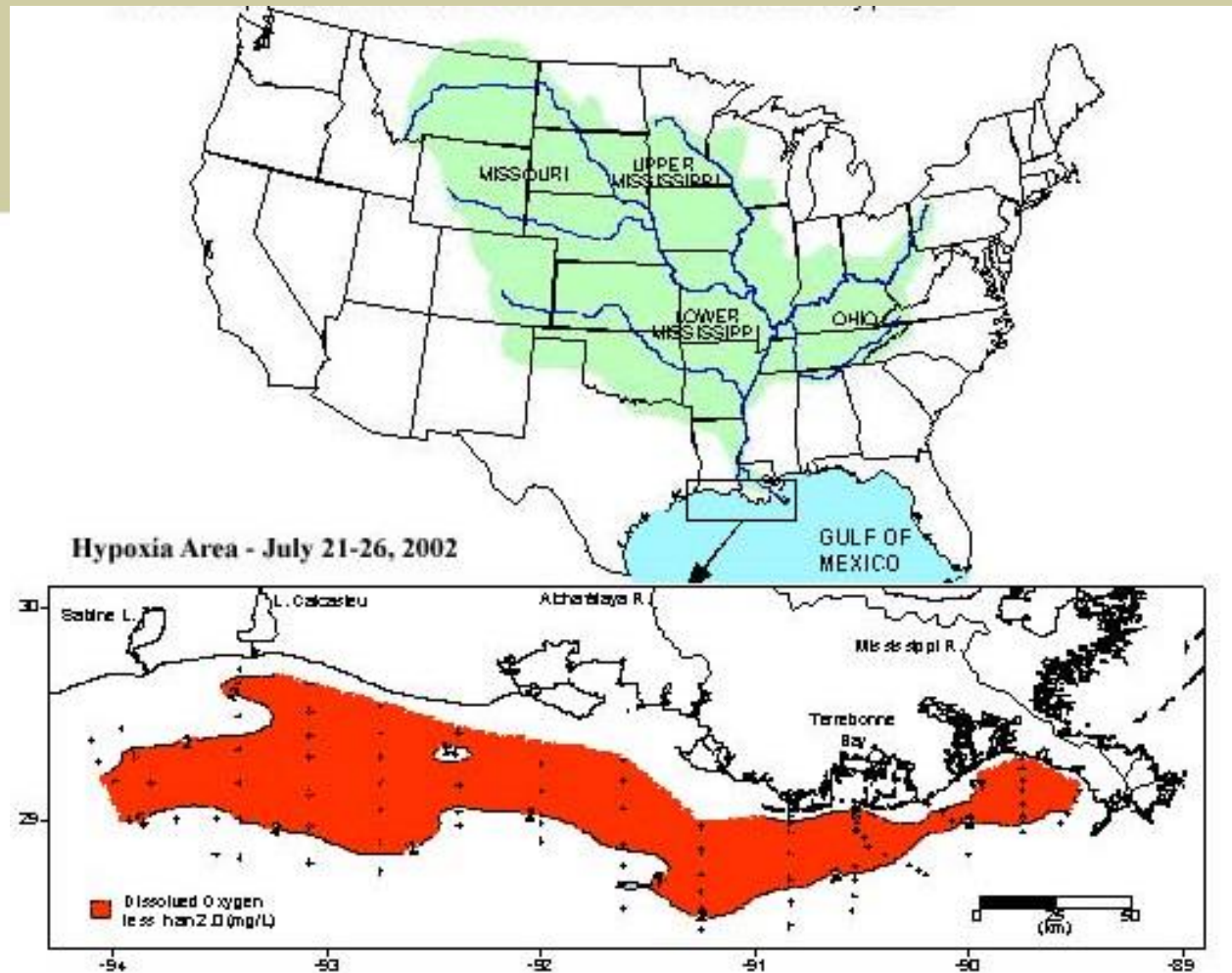
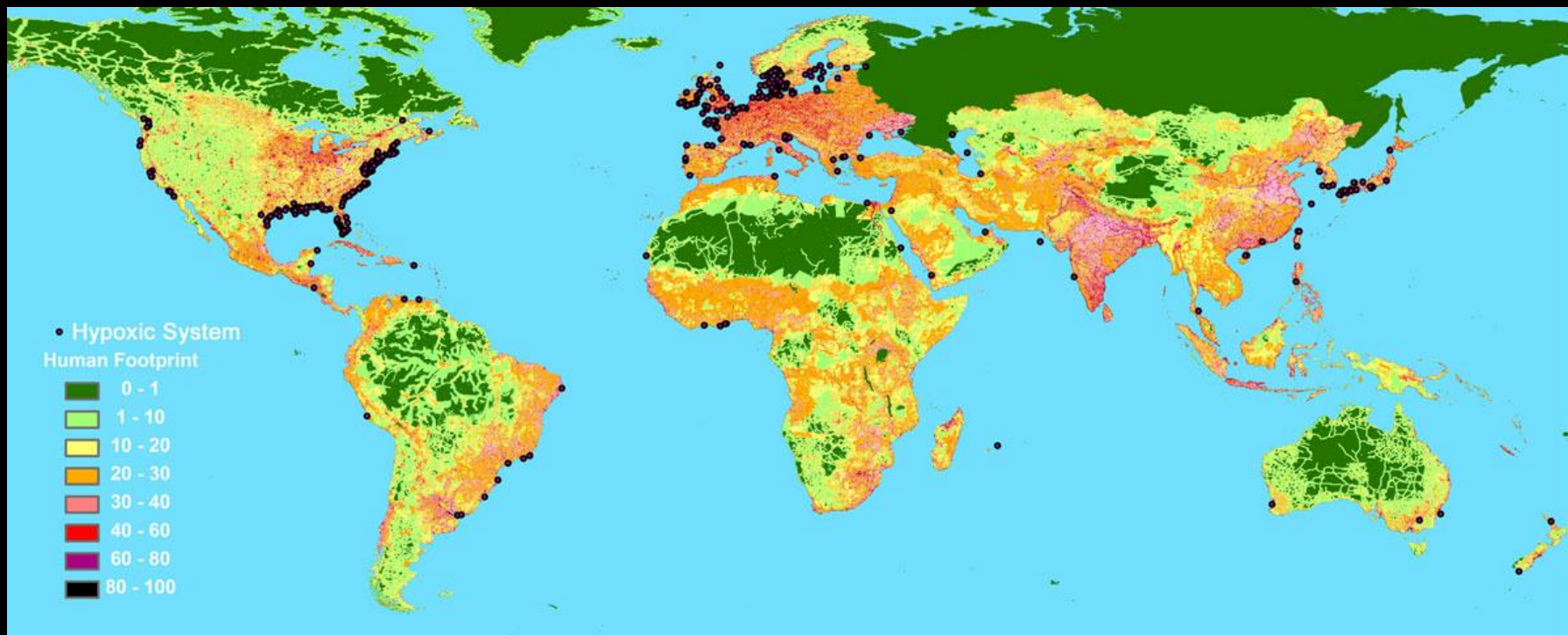


Figure is not in MA. Source: NOAA.  
<https://www.noaanews.noaa.gov/stories/s2004.htm>



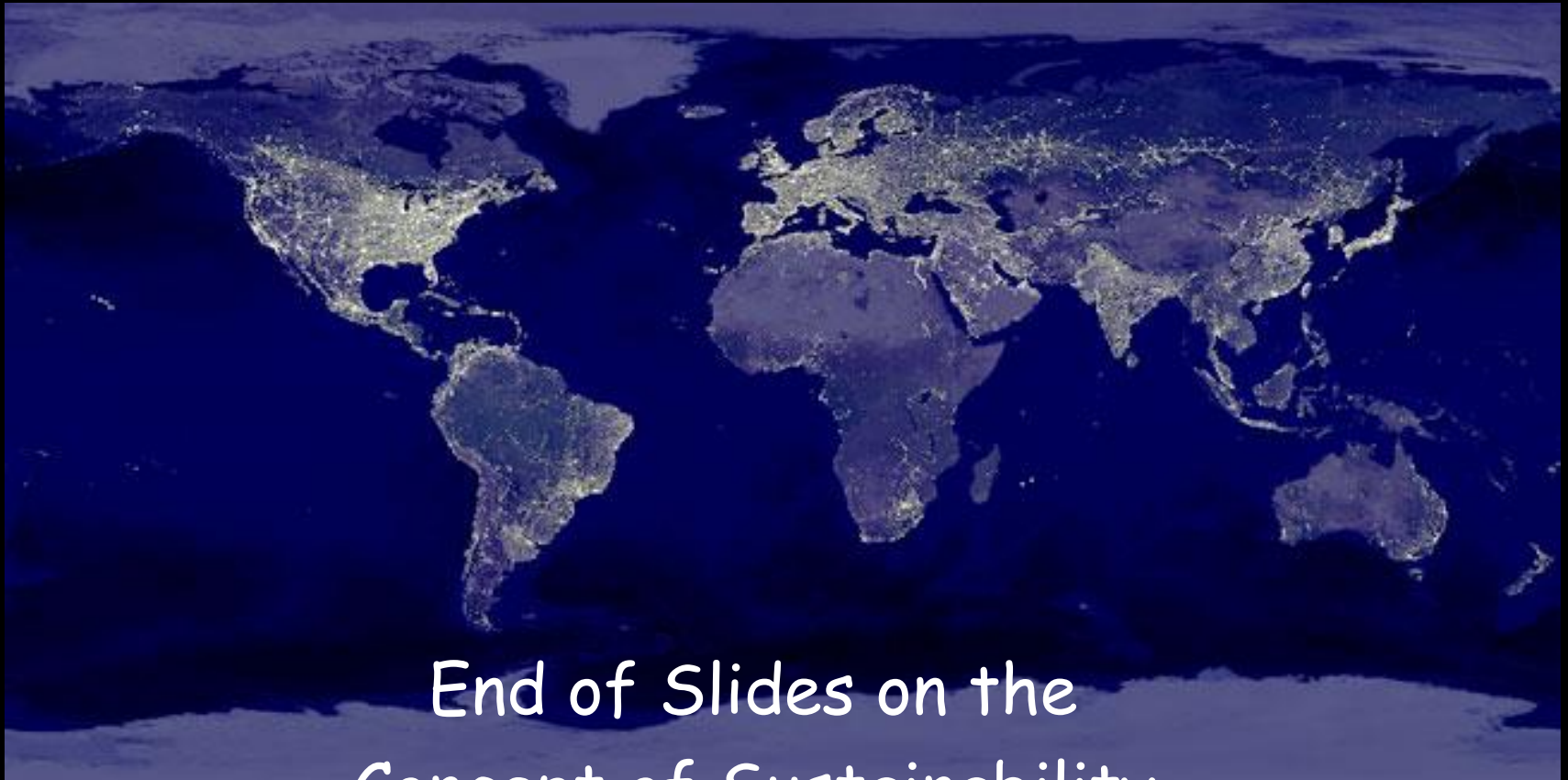
## The World's 405 Dead Zones as of 2008; up from 49 in the 1960s

Source: Biello, David. 2008. <http://www.scientificamerican.com/article.cfm?id=oceanic-dead-zones-spread>

This is no small economic matter. A single low-oxygen event (known scientifically as hypoxia) off the coasts of New York State and New Jersey in 1976 covering a mere 385 square miles (1,000 square kilometers) of seabed ended up costing commercial and recreational fisheries in the region more than \$500 million. As it stands, roughly 83,000 tons (75,000 metric tons) of fish and other ocean life are lost to the Chesapeake Bay dead zone each year—enough to feed half the commercial crab catch for a year.

Source: Biello, David. 2008. <http://www.scientificamerican.com/article.cfm?id=oceanic-dead-zones-spread>

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