

Sustainability



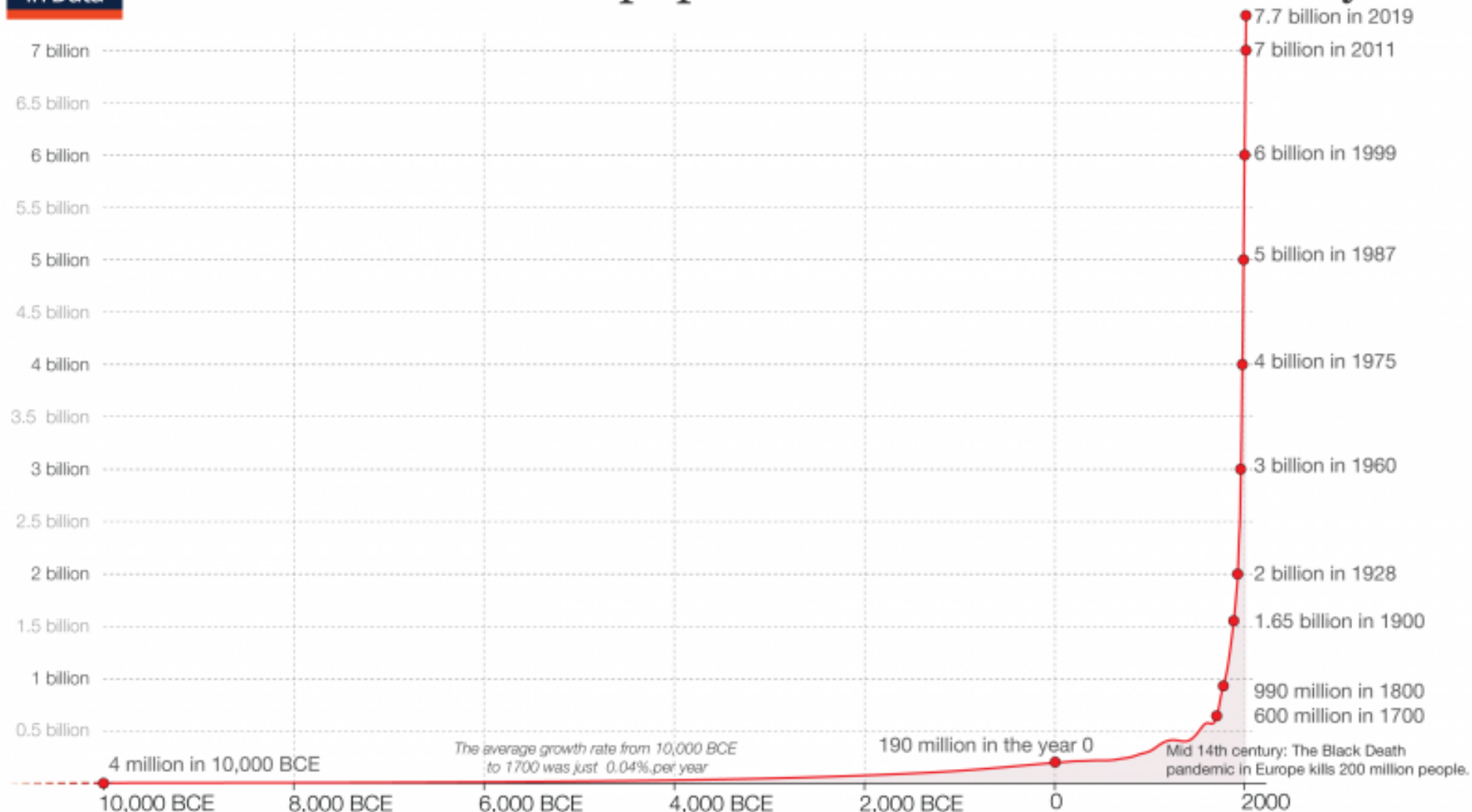
Population Growth

- 25,000 to 10,000 years B.P.
 - Global population below 5 million



Population Growth

Our World in Data The size of the world population over the last 12,000 years



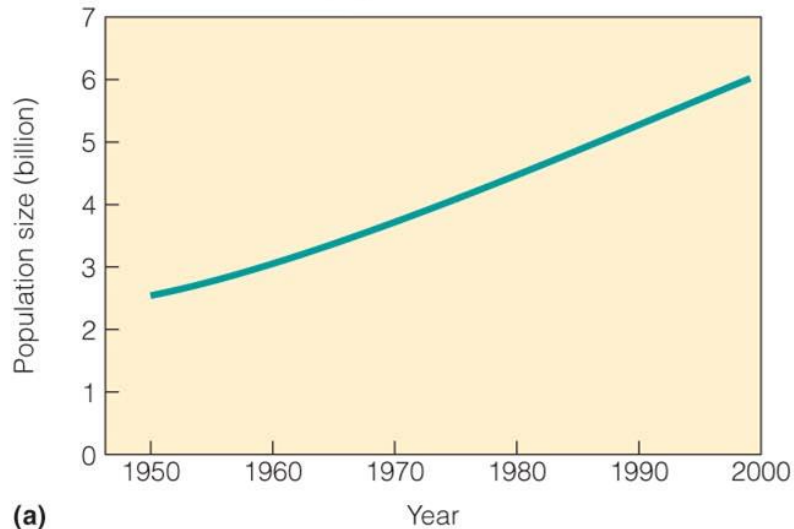
Based on estimates by the History Database of the Global Environment (HYDE) and the United Nations. On [OurWorldinData.org](https://ourworldindata.org) you can download the annual data.

This is a visualization from [OurWorldinData.org](https://ourworldindata.org), where you find data and research on how the world is changing.

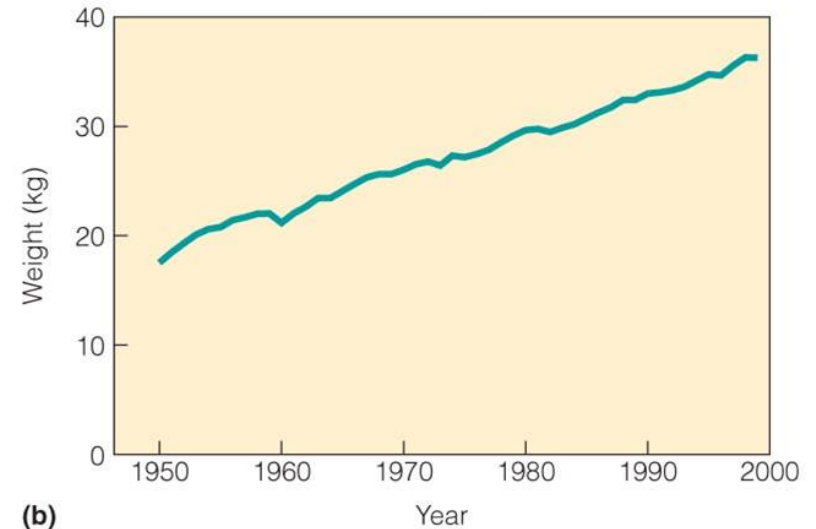
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Resource Use

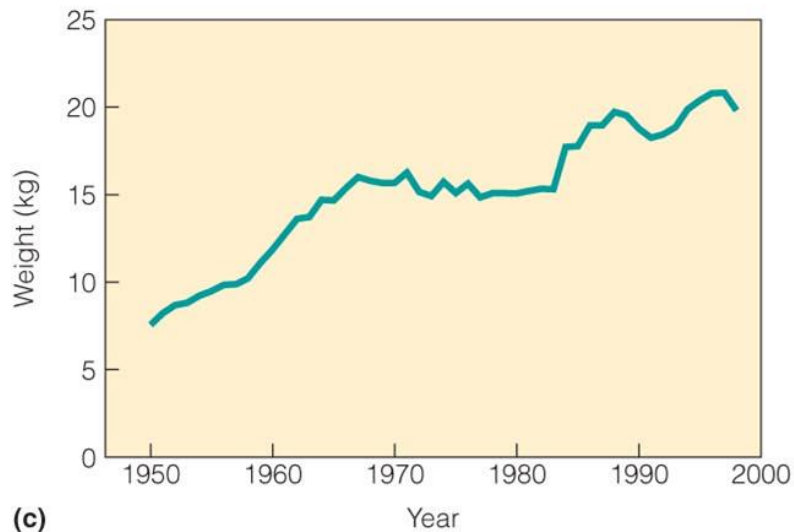
World population 1950–1999



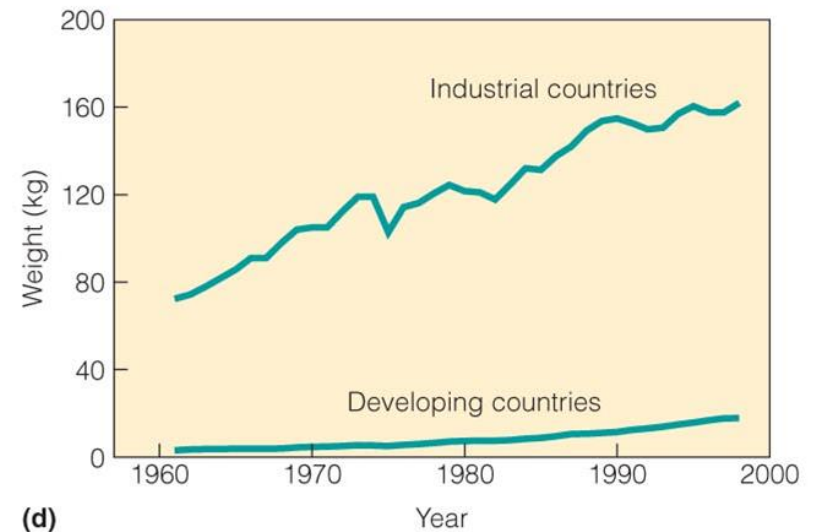
World meat production per person 1950–1999

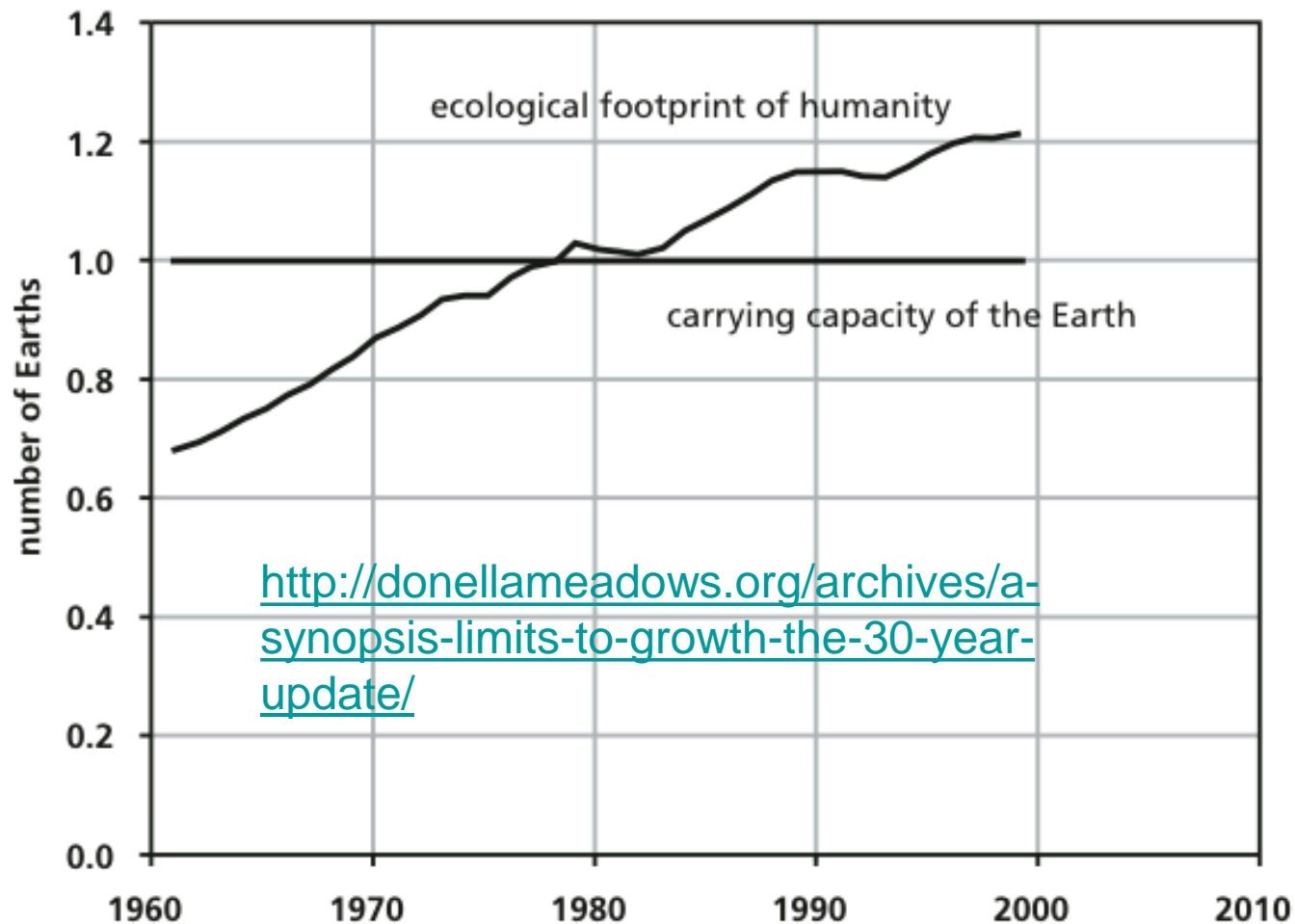


World fish harvest per person 1950–1998



Consumption of paper and paperboard per person, industrial and developing countries, 1961–1998





Ecological Footprint versus Carrying Capacity

This graph shows the number of Earths required to provide the resources used by humanity and to absorb their emissions for each year since 1960. This human demand is compared with the available supply: our one planet Earth. Human demand exceeds nature's supply from the 1980s onward, over-shooting it by some 20 percent in 1999. (Source: M. Wackernagel et al.)

Sustainability

- What is Sustainability?
 - Wikipedia: In ecology, sustainability is the capacity to endure (to sustain)
 - UN World Commission on Environment and Development:
“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”



chemical-materials.elsevier.com

Sustainability

What is sustainability?

- <https://www.youtube.com/watch?v=B5NiTN0chj0>



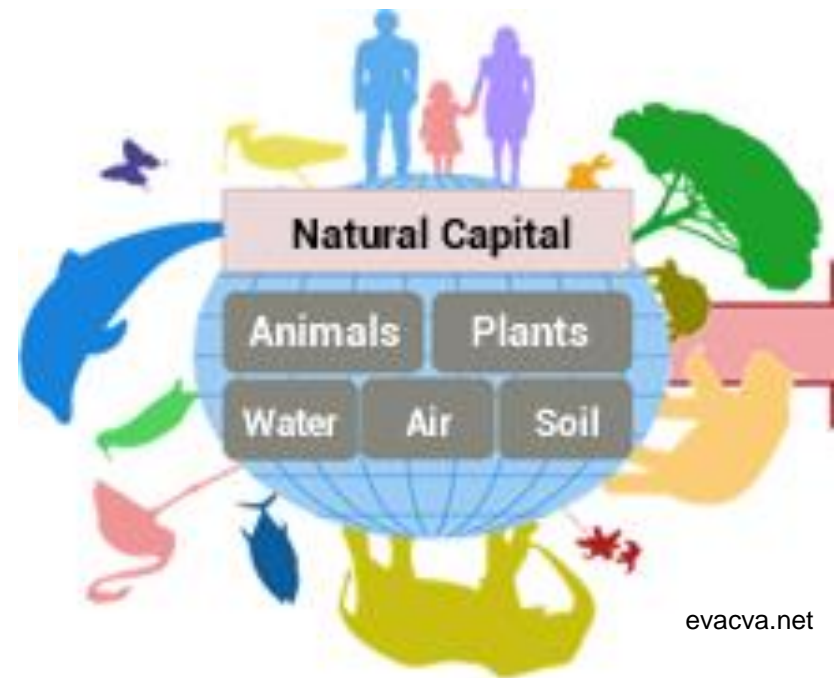
Sustainability

Environmental sustainability

- Ability to sustain the use of natural capital to meet (growing?) human needs
 - Agriculture
 - Forestry
 - Fisheries

Natural capital

- Wealth stored in natural resources

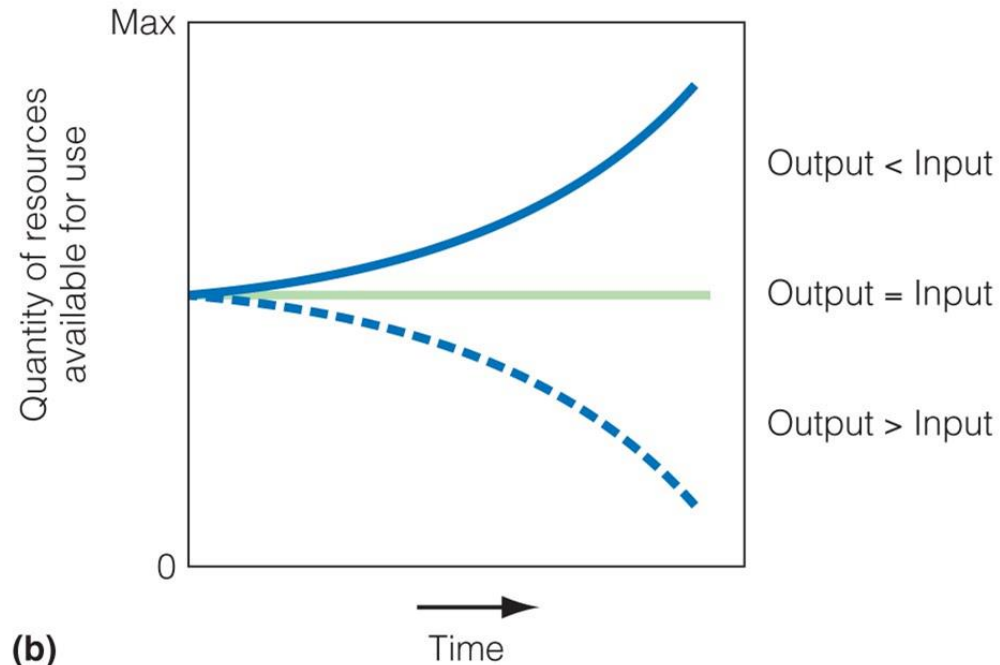
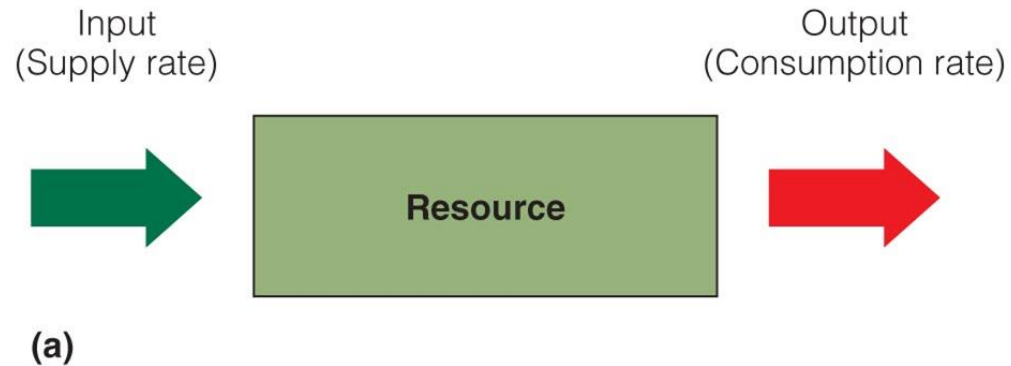


evacva.net

28.1 Sustainable Resource Use

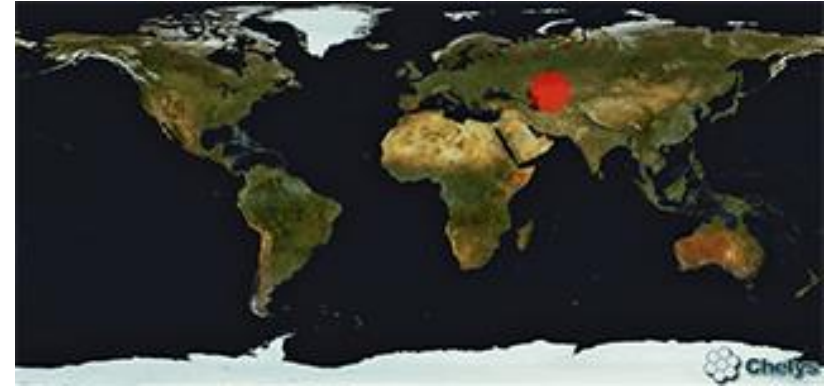
- Sustainable Resource Use Is a Balance between Supply and Demand

- Rate at which resources is being supplied (replaced, regenerated)
- Rate at which the resource is being used (consumed, harvested)

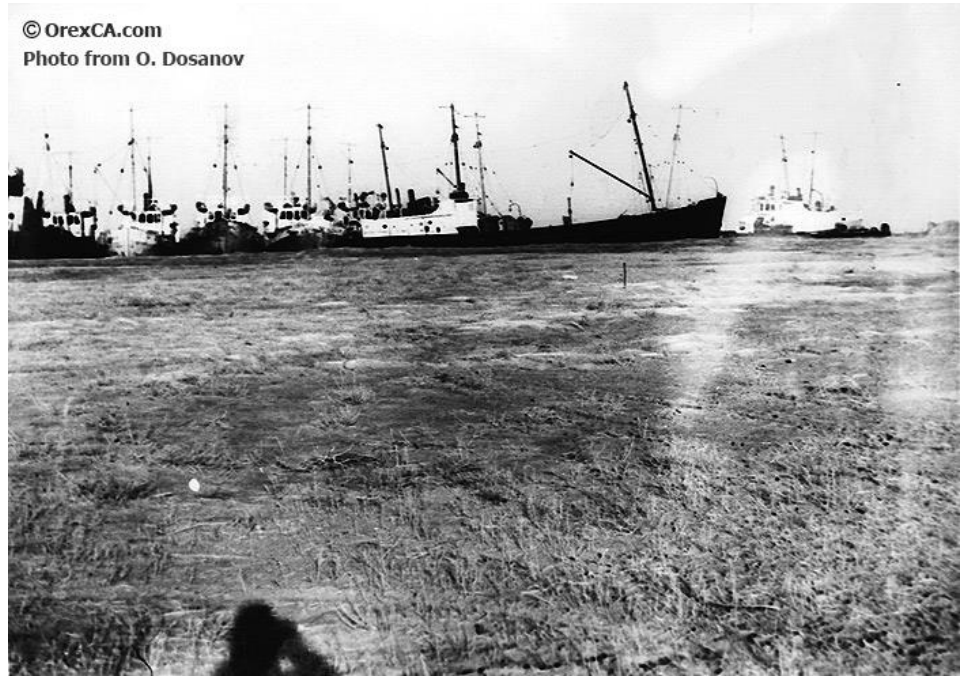


Unsustainable Resource Use

- Case Study: Water resources in the Aral Sea (central Asia)
 - Formerly one of the four largest lakes in the world with an area of 68,000 km² (26,300 sq mi)

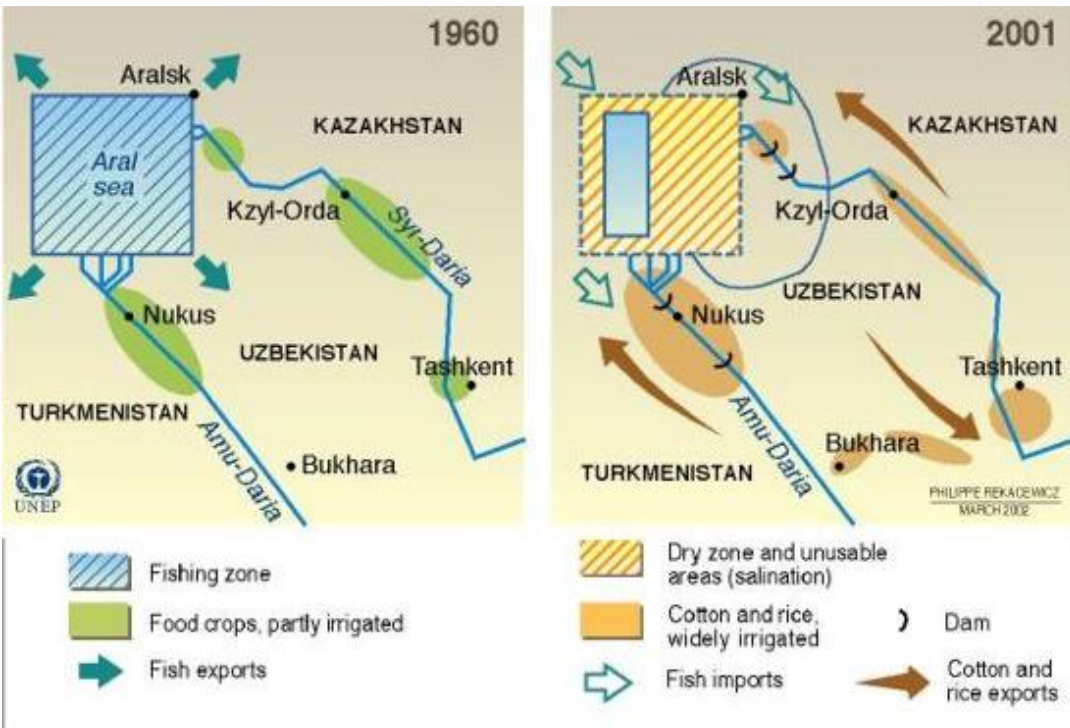


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Photo from O. Dosanov



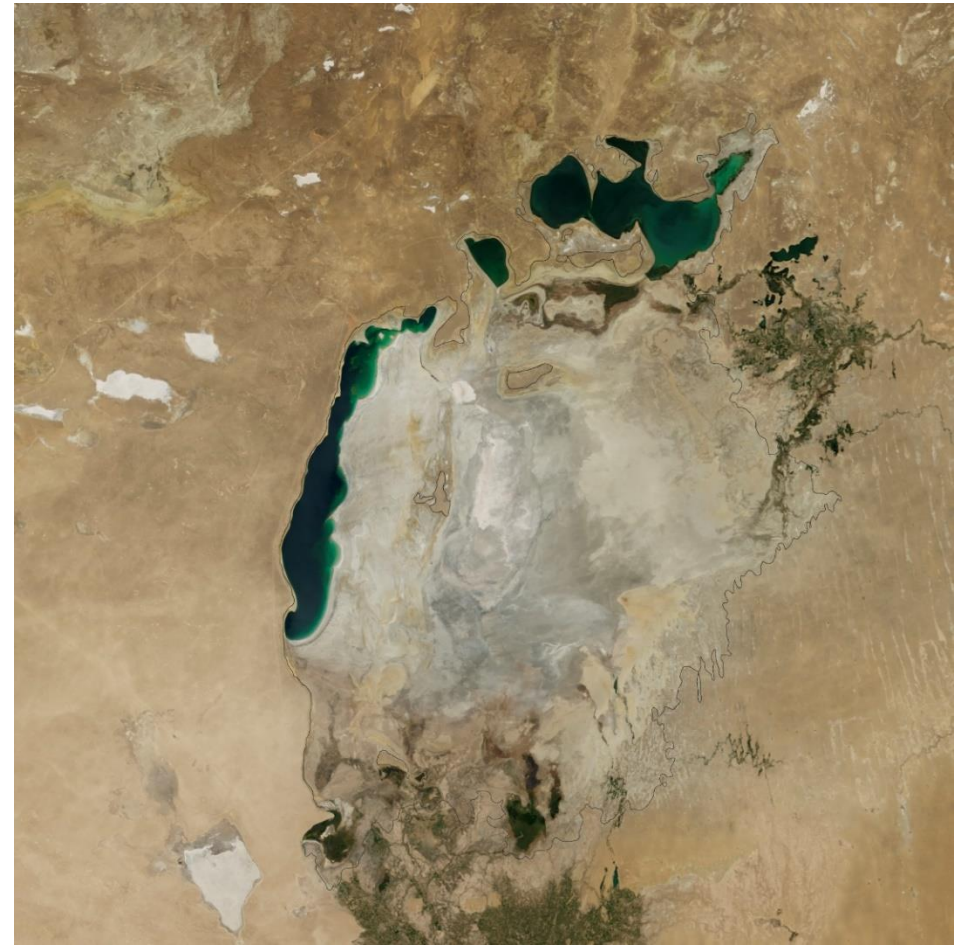
Unsustainable Resource Use

- Aral Sea (central Asia)
 - At the current rate of decline, the Aral Sea could disappear by 2020



Unsustainable Resource Use

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August, 2014

Unsustainable Resource Use



August, 2014



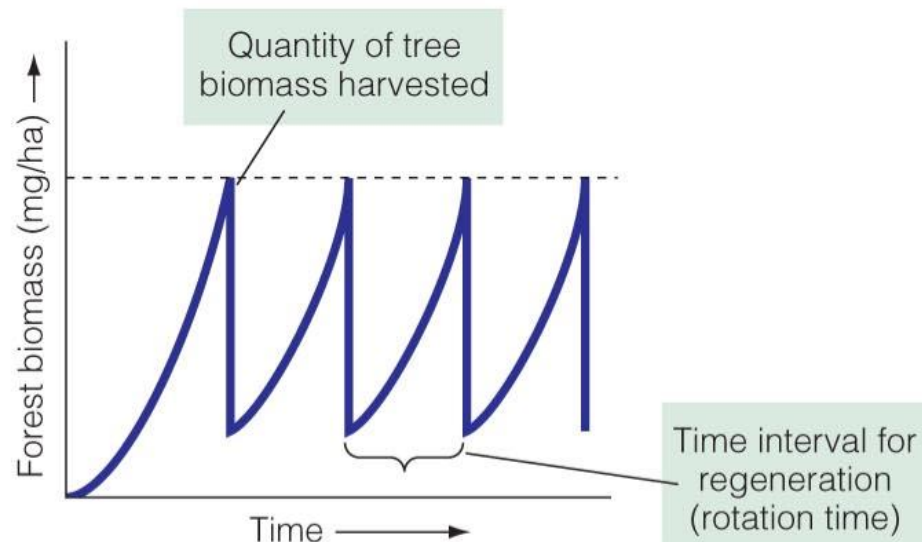
August 2017

- There is hope...

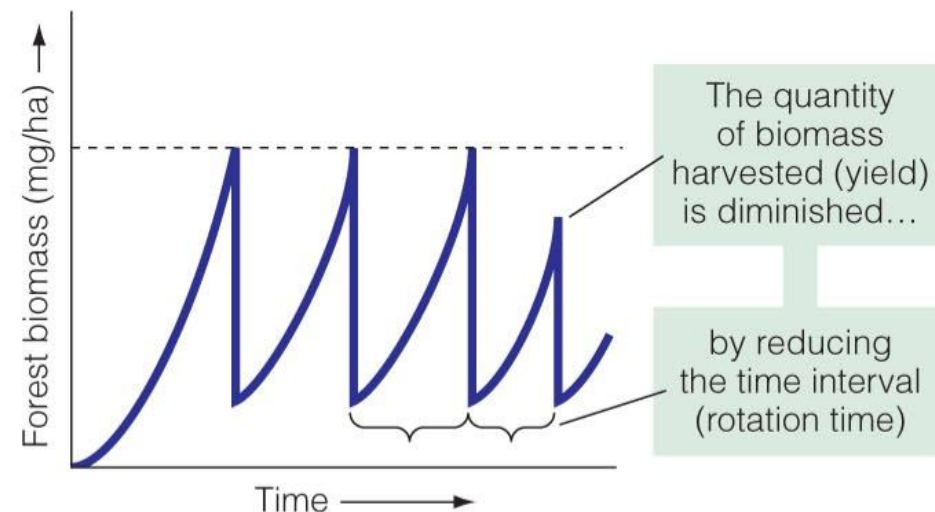
Sustainable Resource Use Is a Balance between Supply and Demand

- Resources harvested need to allow for regeneration
 - Yield:** Amount of resource harvested per time
 - Rotation period or harvest interval:** time for resource to return to levels before the harvest

→ **sustained yield**



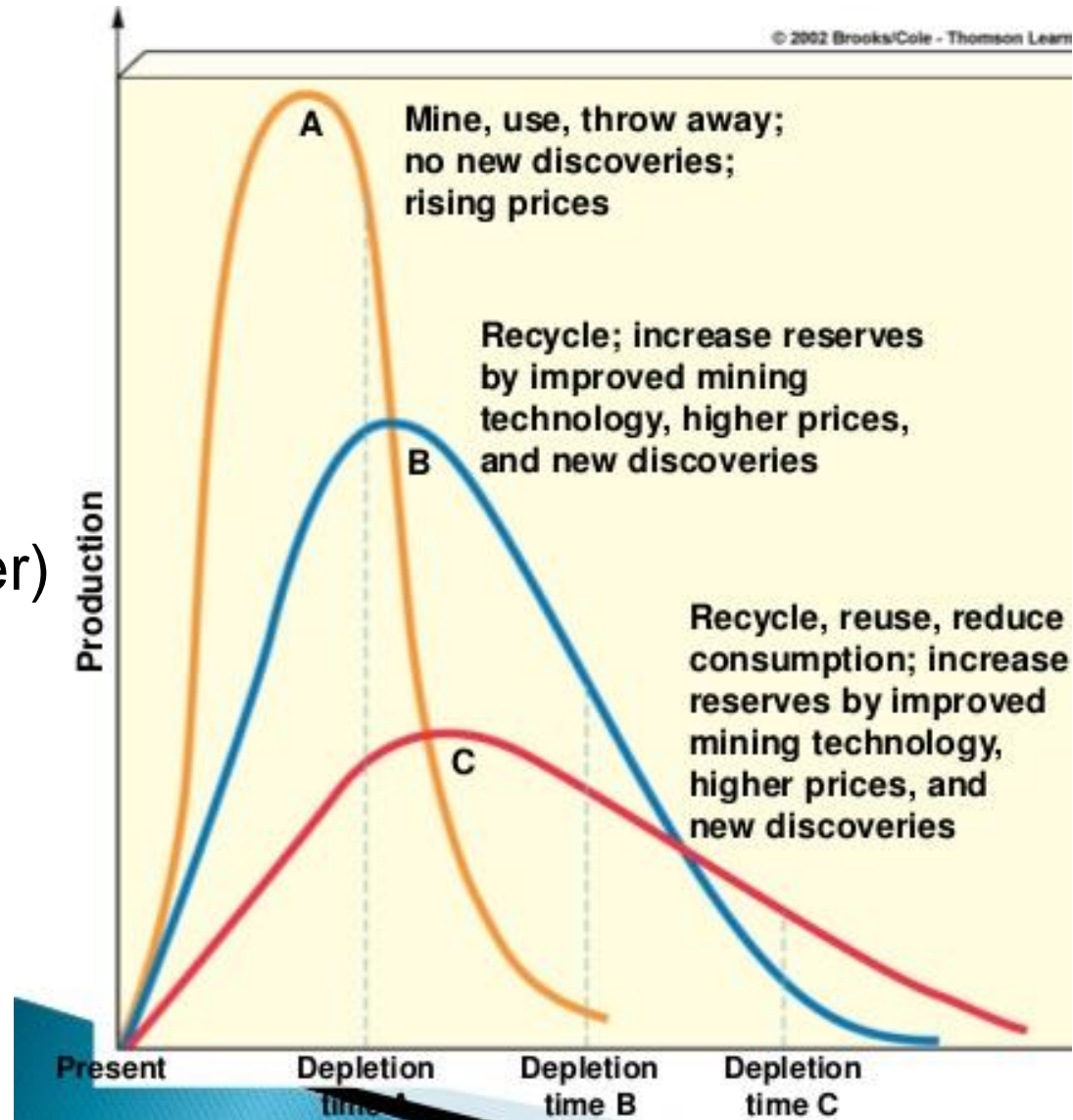
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(b)

Sustainable Resource Use

- Nonrenewable resource
 - Use is **not** sustainable
 - Reuse and recycling may extend resource lifetime
 - Mineral resources (e.g., aluminum, copper)
 - Coal, oil, and natural gas — nonrenewable because recharge takes millions of years



Sustainability Is a Concept Learned from Natural Ecosystems

Sustainable resource use

- Mimics natural ecosystems: naturally sustainable
 - Link between primary productivity and decomposition
 - Flexible rate of resource use with supply variation
 - E.g. drought: Reduced NPP – reduced use



Sustainable Agriculture

- Most human food derived from agriculture

- 15 plant, 8 animal species:
90% of food supply
- 80% fish/shellfish exploited
from natural resources
- ~14% of ice-free land area
under cultivation
- ~another 26% used
for grazing livestock

- **Monoculture:**
Single crop species

- **Polyculture:**
Mixture of crops



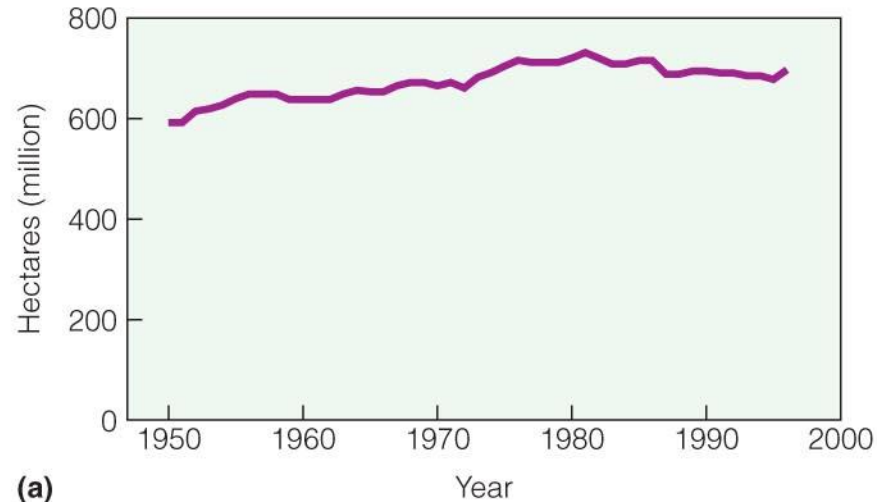
Sustainable Agriculture

Table 28.3 Comparison of Energy Inputs and Energy Yields for Corn Harvested Using Traditional Agricultural in Mexico and Industrial Agricultural Production in the United States

Item	Mexico(kcal/ha)	USA(kcal/ha)
<i>Inputs</i>		
Labor	589,160	5,250
Axe and hoe	16,570	
Machinery		1,018,000
Gasoline		400,000
Diesel		855,000
Irrigation		2,250,000
Electricity		100,000
Nitrogen		3,192,000
Phosphorus		730,000
Potassium		240,000
Lime		134,000
Seeds	36,608	520,000
Insecticides		300,000
Herbicides		800,000
Drying		660,000
Transportation		89,000
Total	642,338	11,036,650
<i>Outputs</i>		
Total corn yield	1,944 kg	7,000 kg
	8,748,000 kcal	31,500,000 kcal
kcal output/kcal input	13.62	2.85

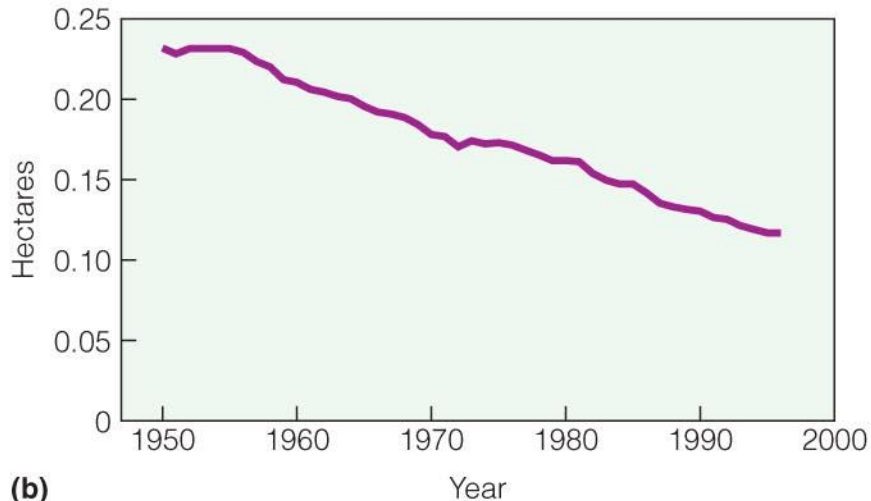
Sustainable Agriculture

World grain area harvested 1950–1996



(a)

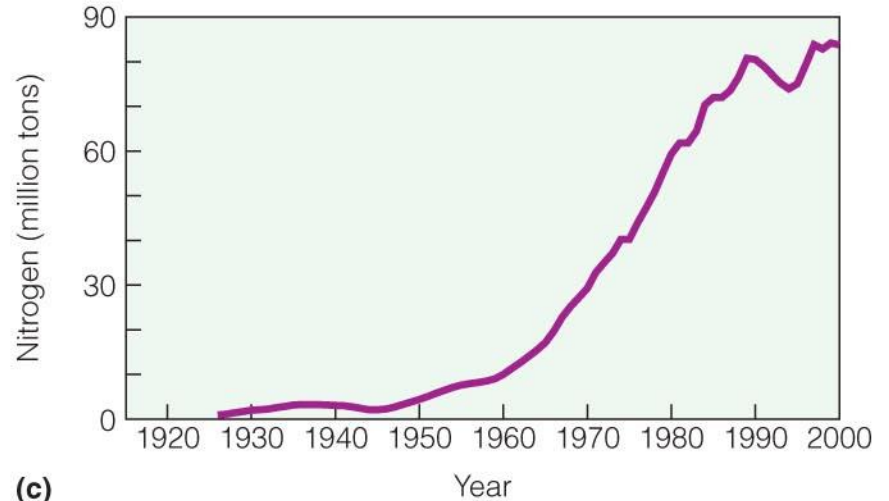
World grain area harvested per capita 1950–1996



(b)

But rapid increase in population!

Nitrogen fertilizer use



(c)

Sustainable Agriculture

Problems of Industrialized agriculture

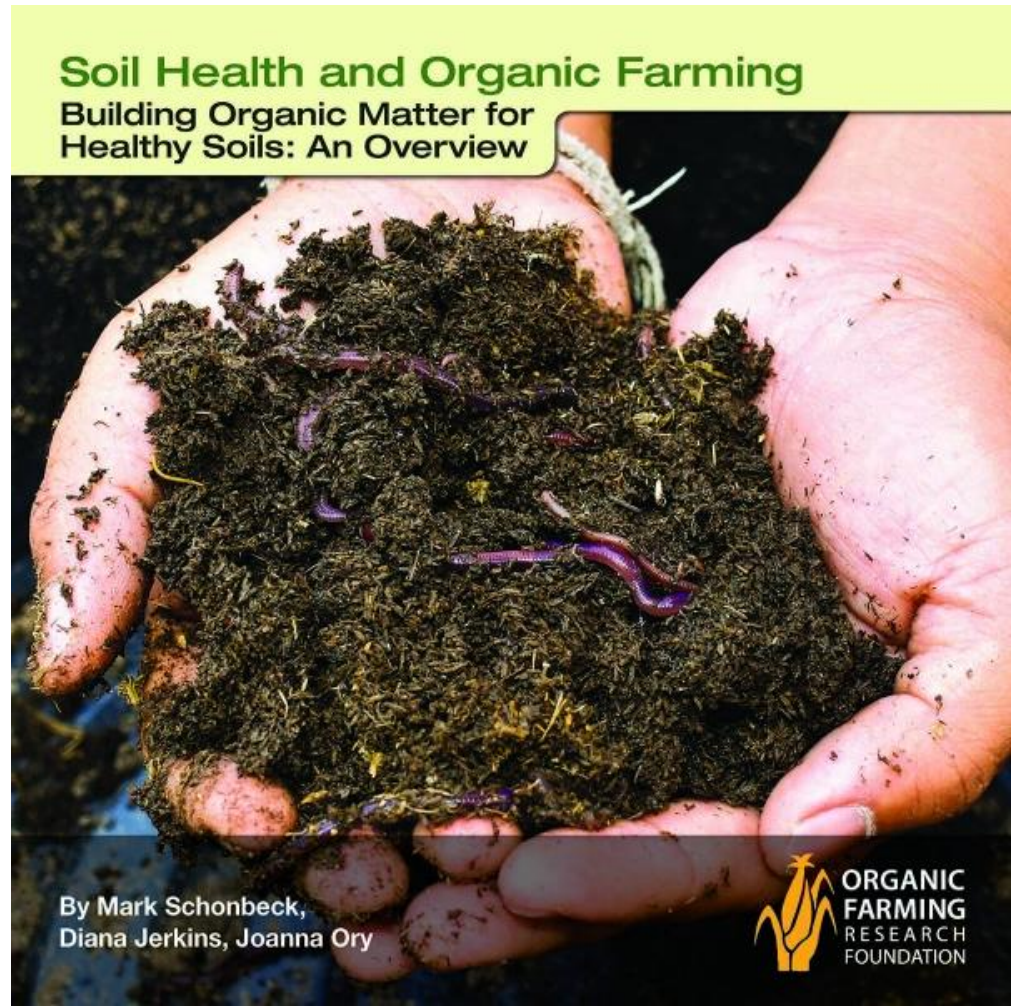
- Needs plenty of money and land
- Monoculture or continuous rotation
- Harvest removes entire plant → Nutrient depletion
- Nutrients added as fertilizer are soluble
 - Leaching
- Monoculture: Pests and plant diseases spread
 - Pesticides, herbicides, fungicides: Environmental and health problems



Sustainable Agriculture

Sustainable agriculture

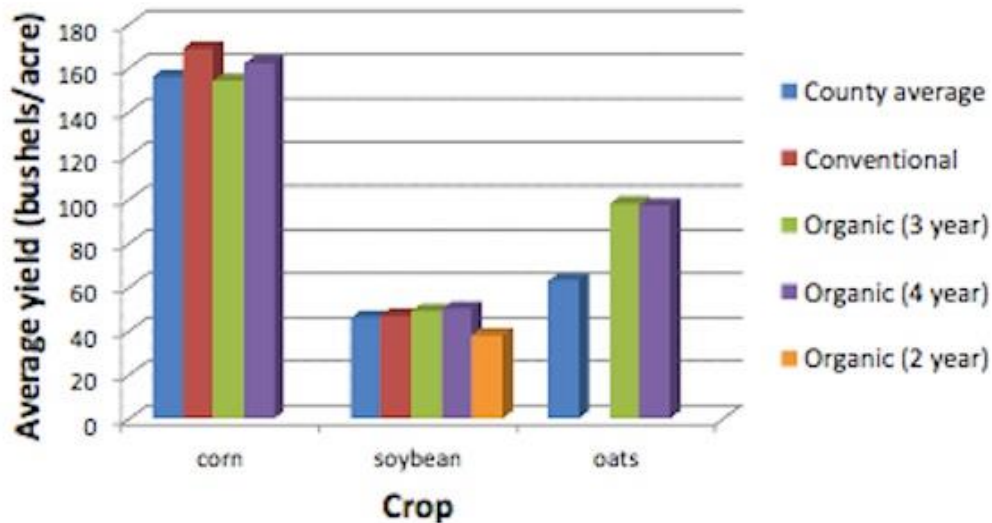
- maintain productivity, preserve resources, minimize impacts
 - Soil conservation methods
 - No /Reduced use of pesticides
 - Alternative sources of soil nutrients
 - Water conservation and protection
 - Permaculture and other innovative methods



Agricultural Methods: Trade-off between Sustainability and Productivity?

- Do we need industrialized agriculture to feed the world's growing population?
 - Organic agriculture may have higher yields

Average yields (1998-2010)

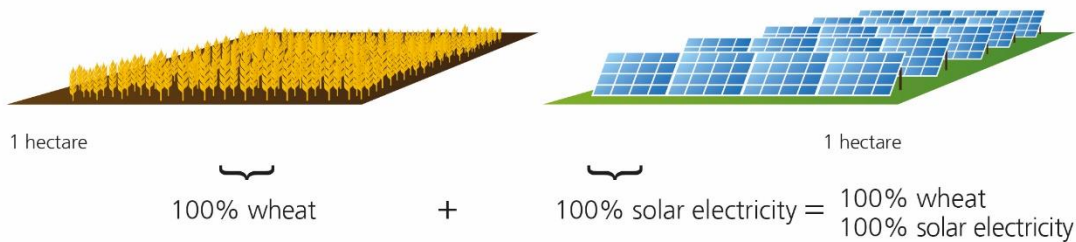


- Conventional corn-soybean (2 year)
- Organic corn-soybean-oat/alfalfa (3 year)
- Organic corn-soybean-oat/alfalfa-alfalfa (4 year)
- Organic soybean-wheat/red clover (2 year)

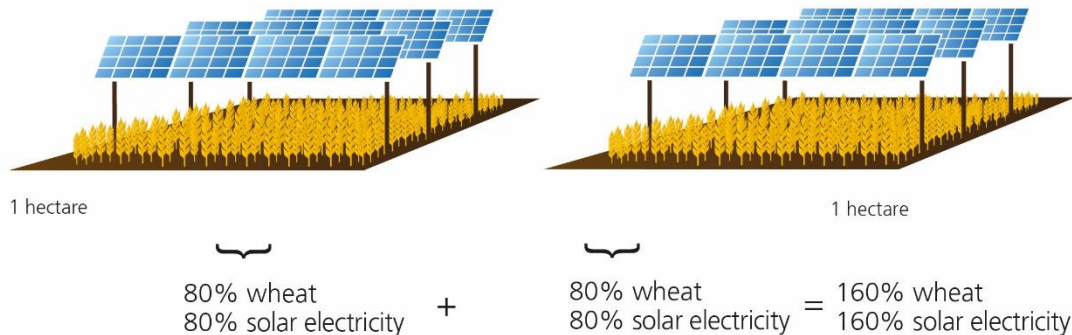
Agricultural Methods: Trade-off between Sustainability and Productivity?

- Do we need industrialized agriculture to feed the world's growing population?

Separate Land Use on 2 Hectare Cropland



Combined Land Use on 2 Hectare Cropland: Efficiency increases over 60%



Agricultural Sustainability

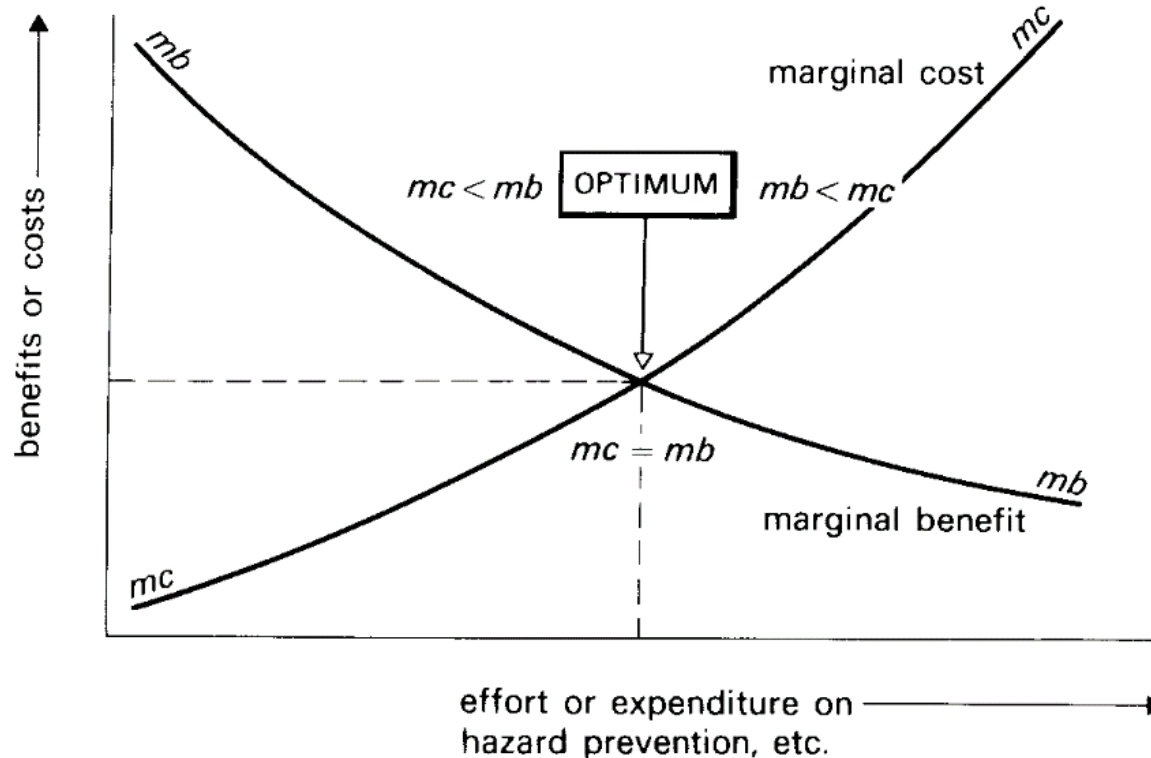
- Do we need industrialized agriculture to feed the world's growing population?



<https://www.youtube.com/watch?v=BIXPf-e1a0U>

Economics in Resource Management

- Economic considerations and natural resource management
 - Benefit–cost analysis



lancaster.ac.uk

Economics in Resource Management

- **Discounting:**

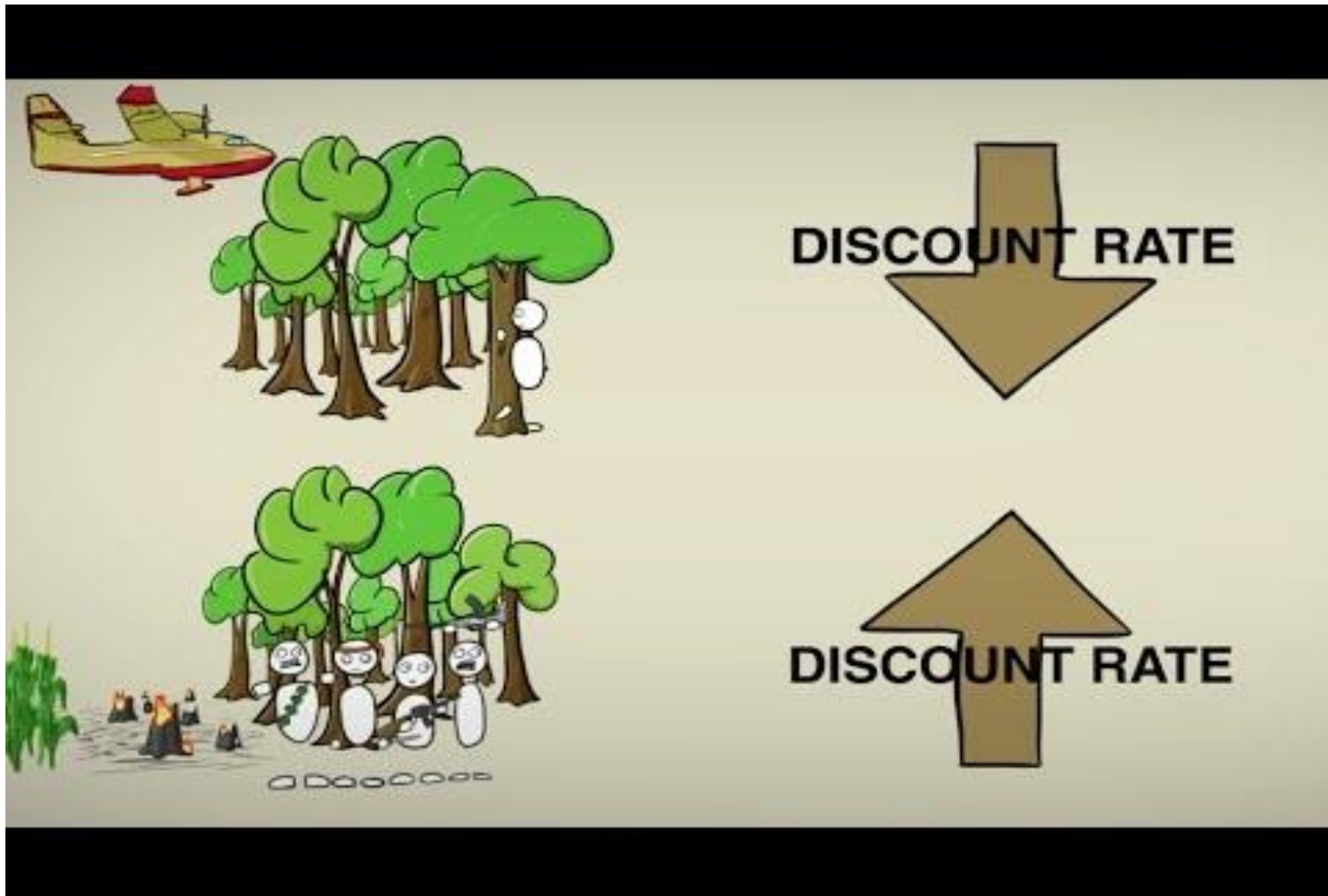
Costs and benefits at different times

- Which practice would yield the whalers the most money:
 1. cease hunting and let the blue whales recover in numbers and then harvest them sustainably
 2. Kill the remaining whales as quickly as possible and invest the profits in the stock market?

(economist Colin W. Clark)

Economics in Resource Management

- Discounting



Economics Are a Key Factor Governing Resource Management

- **Externalities:**

Actions of an industry affect other parts of society

- Costs not reflected in market prices
- Environmental costs are passed to tax payer
- Example: Clear-cuts of forest → erosion, reduced water quality, loss of recreational value, loss of species

Economics Are a Key Factor Governing Resource Management

- **Environmental economics:**
Study of environmental problems with the perspective and analytic tools of economics

Economics Are a Key Factor Governing Resource Management

- Age of Sustainable Development

- Short Video: <https://www.youtube.com/watch?v=x7PTbo4ZSW0>

