Bharathidasan University

Programme: MSc Environmental Science and Sustainable Management

Course Title: ECOSYSTEM SERVICES AND SUSTAINABILITY
Course Code: 21PGEC04-1

Unit- II Ecosystems Services

Prof. R. Mohanraj
Dept. of Environmental Science and Management

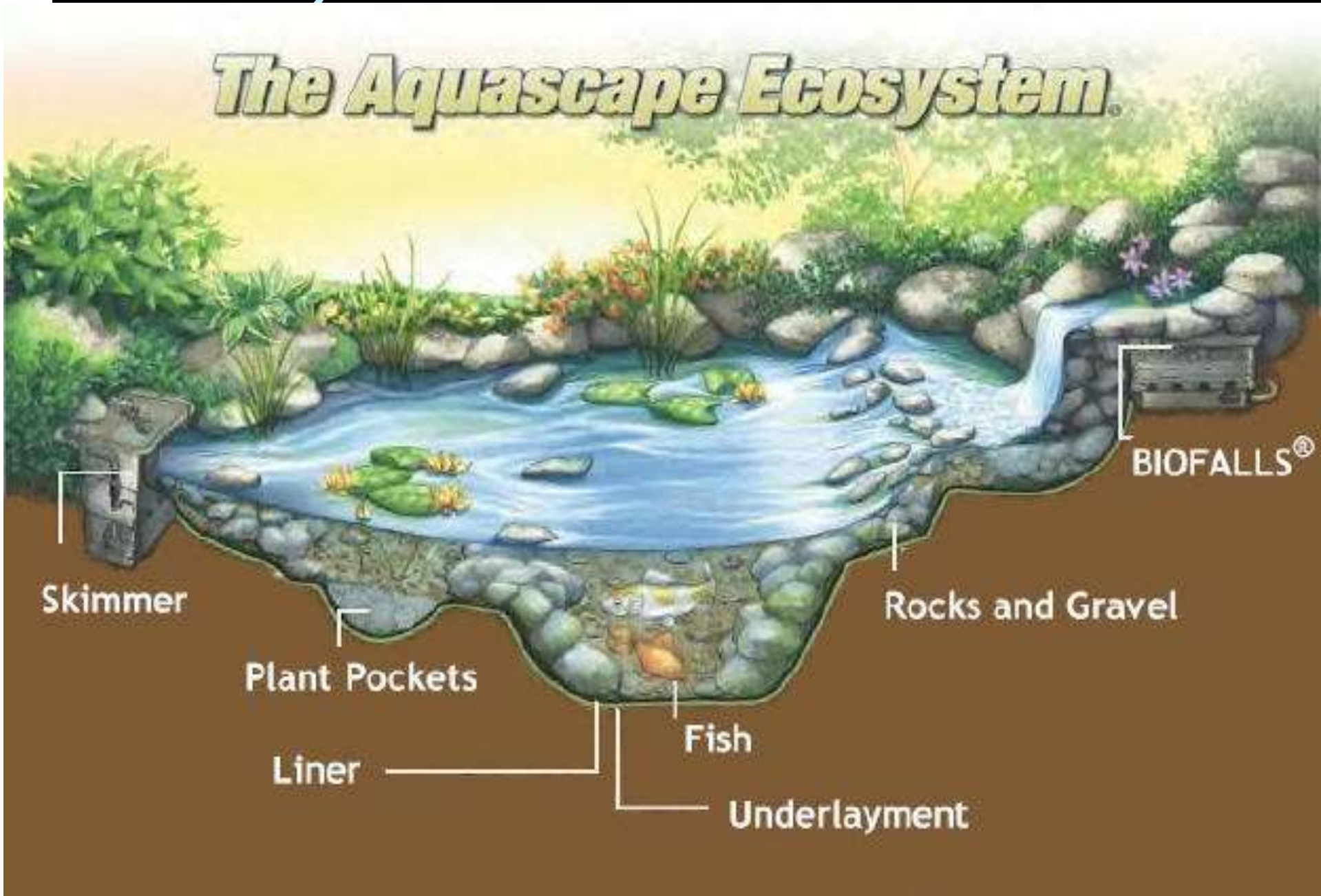
THE HINDU

Tiger envi

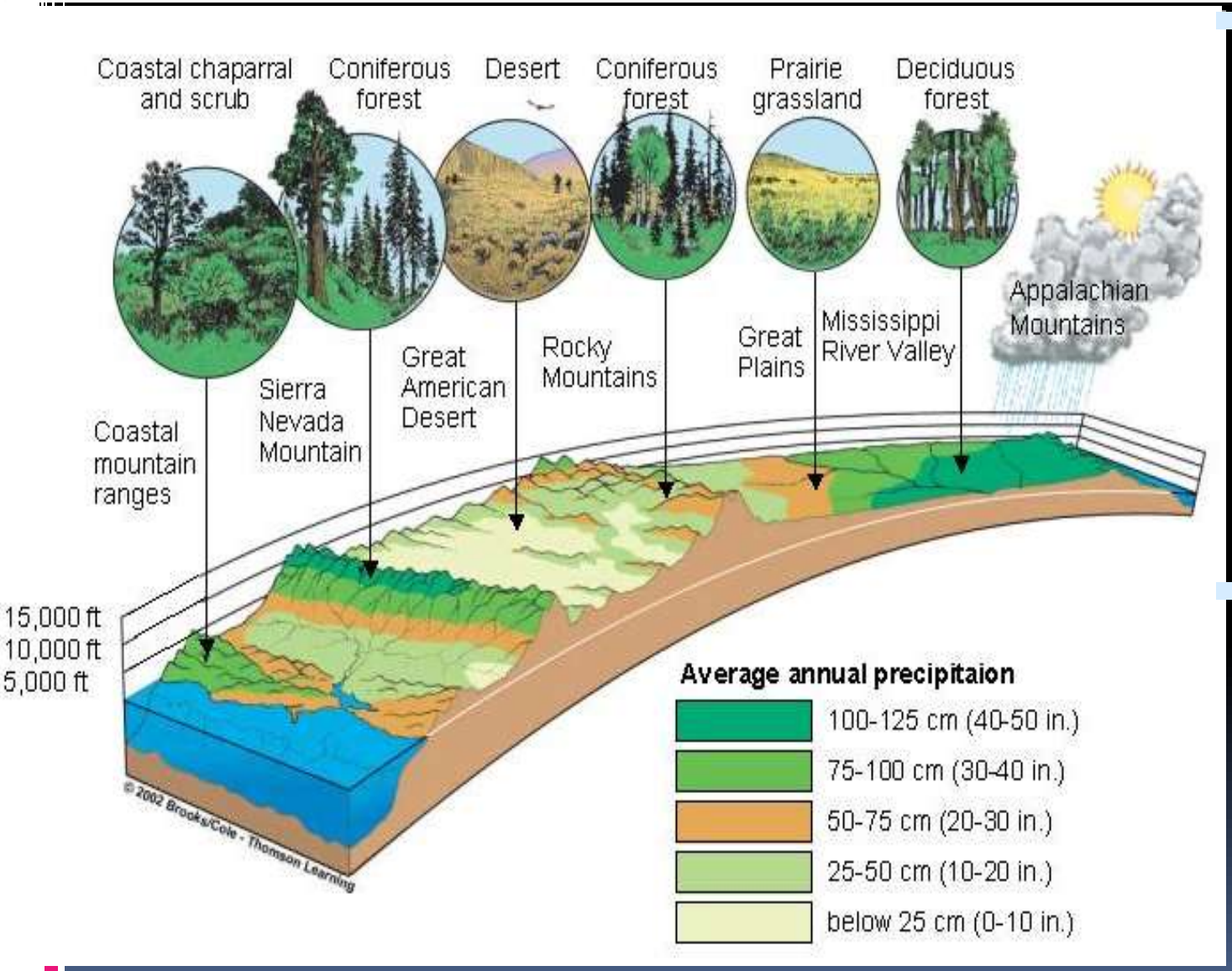
JULY 22, 2017

Saving 2 tigers gives more value than Mangalyaan”’ was intriguing, since it said that saving two tigers yields a capital benefit of ₹520 crores, while Mangalyaan cost us ₹450 crores

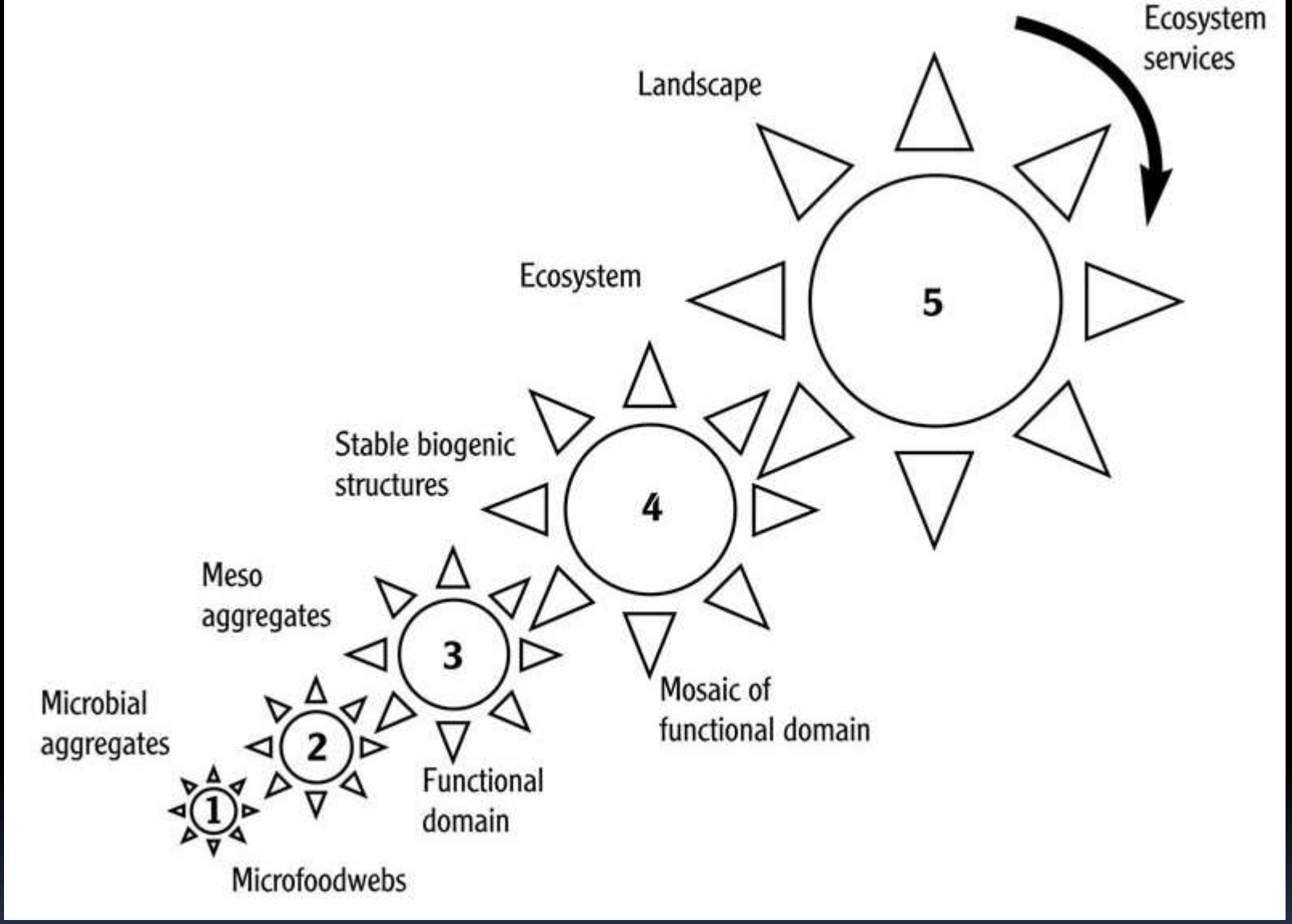
Ecosystem


The Aquascape Ecosystem
BIOFALLS®
Skimmer
Plant Pockets
Liner
Fish
Underlayment
Rocks and Gravel

Ecosystem Contd…



- **Biomes**- areas with a consistent climate and with similar organisms
  - ***Climate***- long-term weather patterns in a given area
- **Aquatic life zones**- marine and freshwater portions of the biosphere

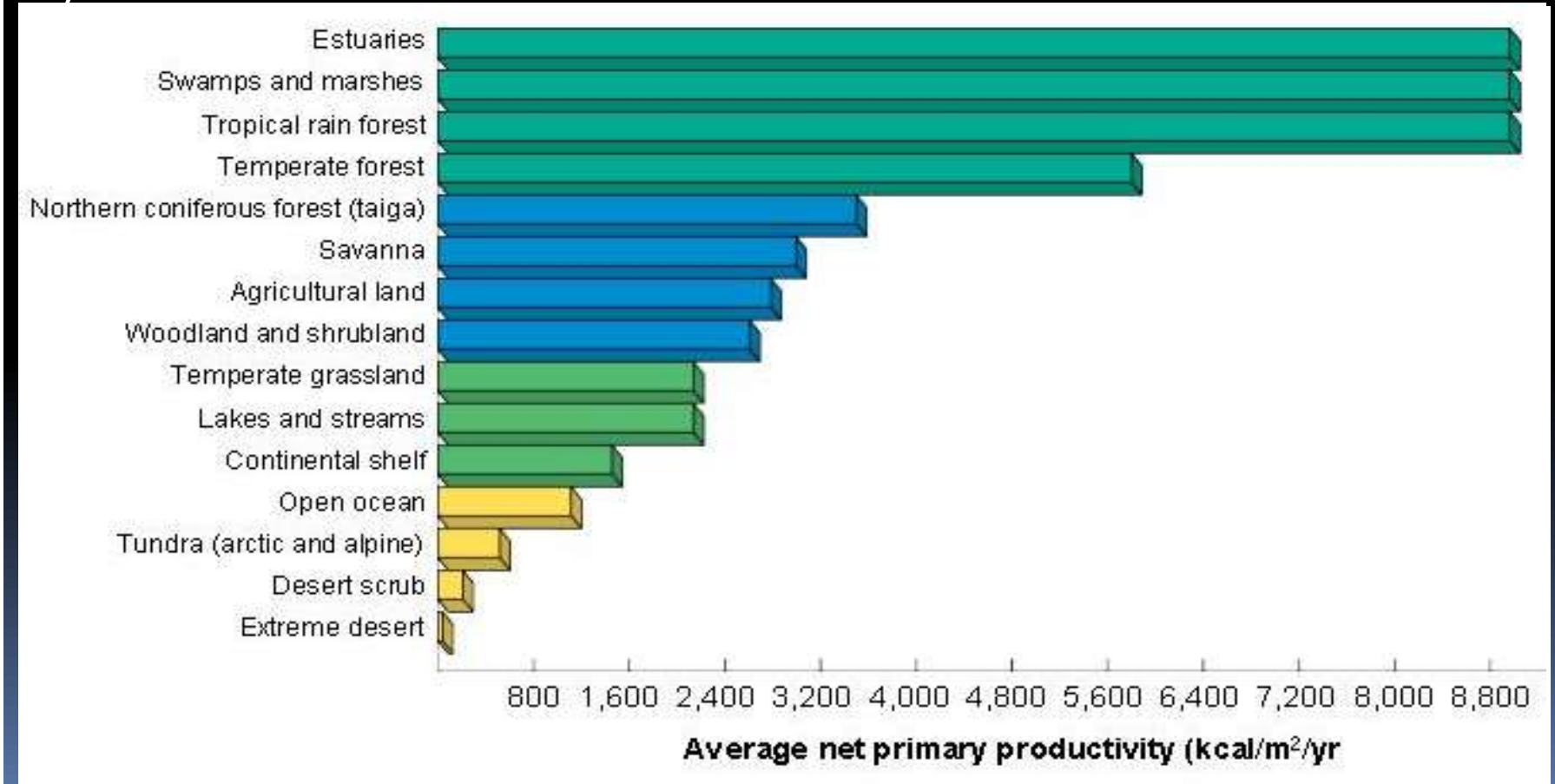


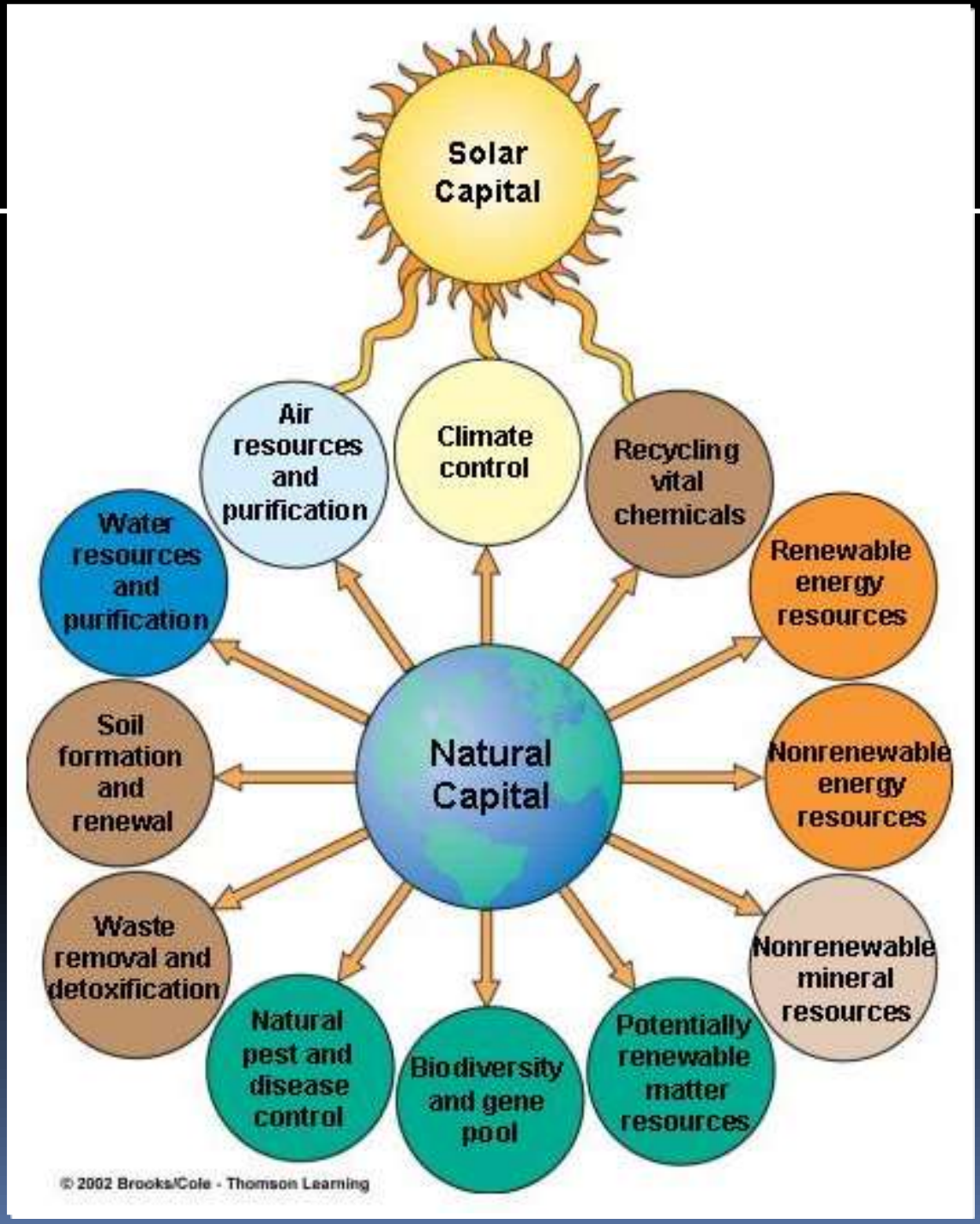
Self-organizing systems at different scales interact (almost like interlocking gears as indicated in the figure) across scales to deliver soil ecosystem services at landscape scale (Lavelle et al. 2004). The delivery of ecosystem services results from the integration across scales of processes that produce and regulate the service. See text for examples – James Aronson (et al 2013)

Light Energy is Converted into Chemical Energy

Primary Productivity of Ecosystems

- **Gross Primary Productivity** (GPP)- the rate at which an ecosystem's producers convert sunlight into biomass
- **Net Primary Productivity** (NPP)- the rate at which energy for use by consumers is stored in new biomass




Solar Capital
Air resources and purification
Climate control
Recycling vital chemicals
Water resources and purification
Renewable energy resources
Soil formation and renewal
Natural Capital
Nonrenewable energy resources
Waste removal and detoxification
Nonrenewable mineral resources
Natural pest and disease control
Biodiversity and gene pool
Potentially renewable matter resources
© 2002 Brooks/Cole - Thomson Learning

We Depend on Ecosystem

- We exchange energy and matter with our environment as we
  - **Eat**
  - **Drink**
  - **Breathe**
- **We use**
  - **Energy for heat and mobility**
  - **Wood for housing and paper**
  - **Food and water for living**

We Depend on Ecosystem

- Nature
  - Absorbs our wastes
  - Provides climate stability
  - Protects us from ultraviolet radiation
- In cities we tend to think of nature as a collection of commodities we obtain from around the world
- But nature is the very source of our lives and well being

World's ecosystem services over past 50 years

	Degraded	Mixed	Enhanced
Provisioning	• Capture fisheries • Wild foods • Biomass fuel • Freshwater • Genetic resources • Biochemicals, natural medicines, and pharmaceuticals	• Timber and other wood fiber • Other fibers (e.g., cotton, hemp, silk)	• Crops • Livestock • Aquaculture
Regulating	• Air quality regulation • Regional and local climate regulation • Erosion regulation • Water purification and waste treatment • Pest regulation • Pollination • Natural hazard regulation	• Water regulation • Disease regulation	• Global climate regulation (carbon sequestration)
Cultural	• Ethical values (spiritual, religious) • Aesthetic values	• Recreation and ecotourism	

Source: Adapted from the Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press.

Ecosystem Services

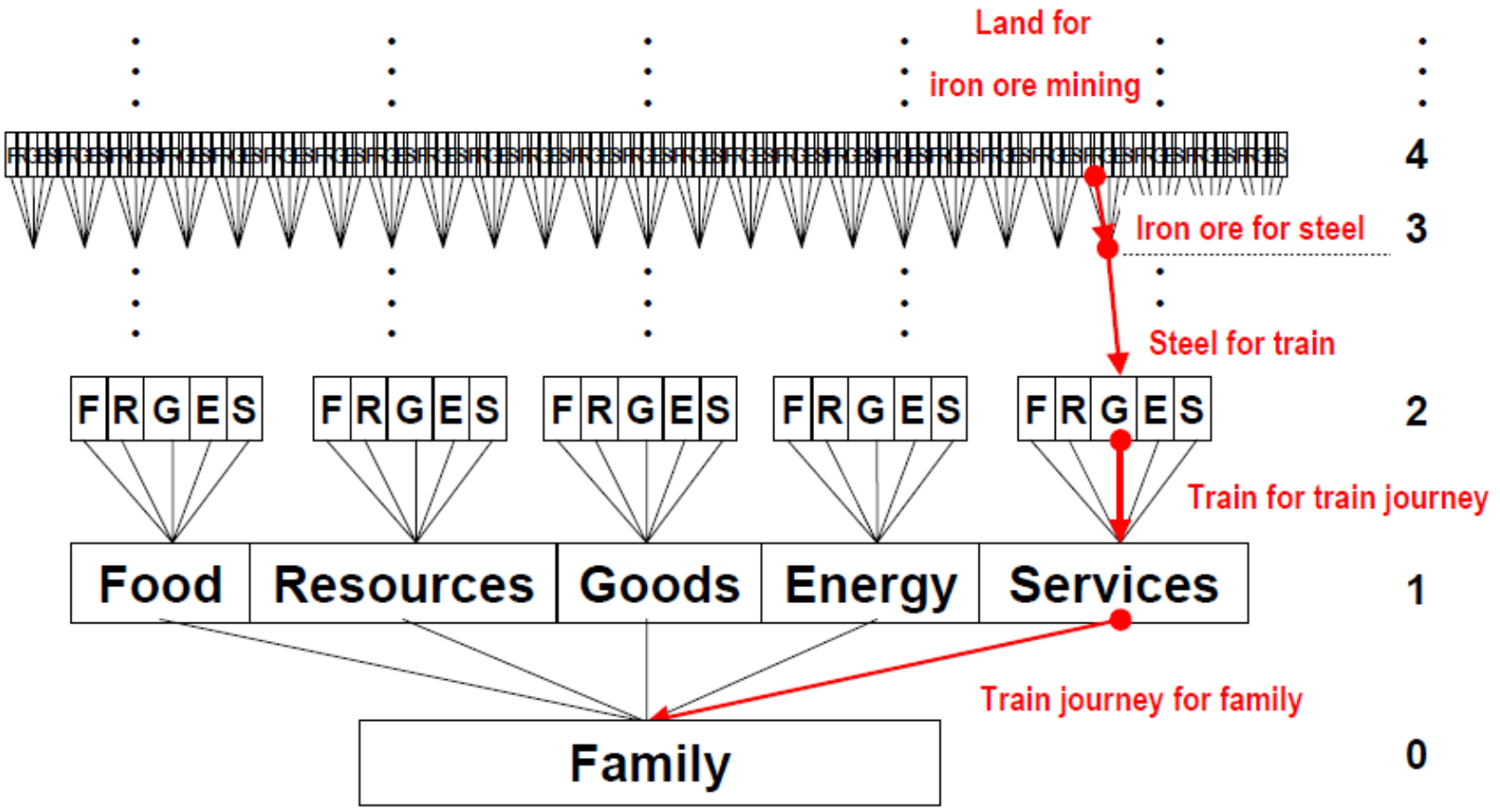


Fig. 2: Production layers and input paths in the ecological footprint of a family.

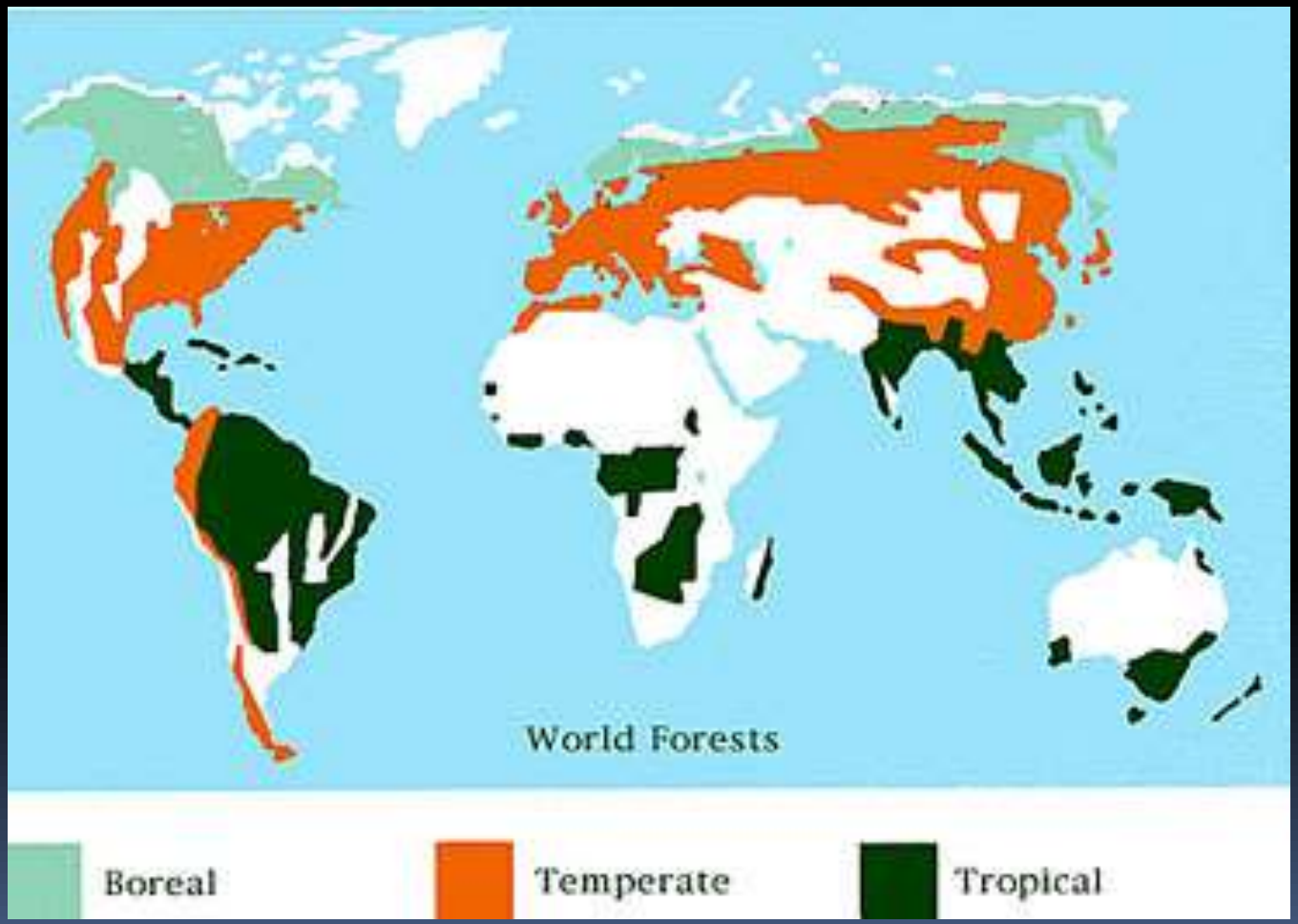
The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#☆, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

* *Center for Environmental and Estuarine Studies, Zoology Department, and † Insitute for Ecological Economics, University of Maryland, Box 38, Solomons, Maryland 20688, USA*
‡ *Economics Department (emeritus), University of Wyoming, Laramie, Wyoming 82070, USA*
§ *Center for Environment and Climate Studies, Wageningen Agricultural University, PO Box 9101, 6700 HB Wageninengen, The Netherlands*
‖ *Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA*
¶ *Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA*
# *Institute of Ecosystem Studies, Millbrook, New York, USA*
** *Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA*
†† *Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*
‡‡ *Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina*
§§ *Jet Propulsion Laboratory, Pasadena, California 91109, USA*
‖‖ *National Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA*
¶¶ *Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA*

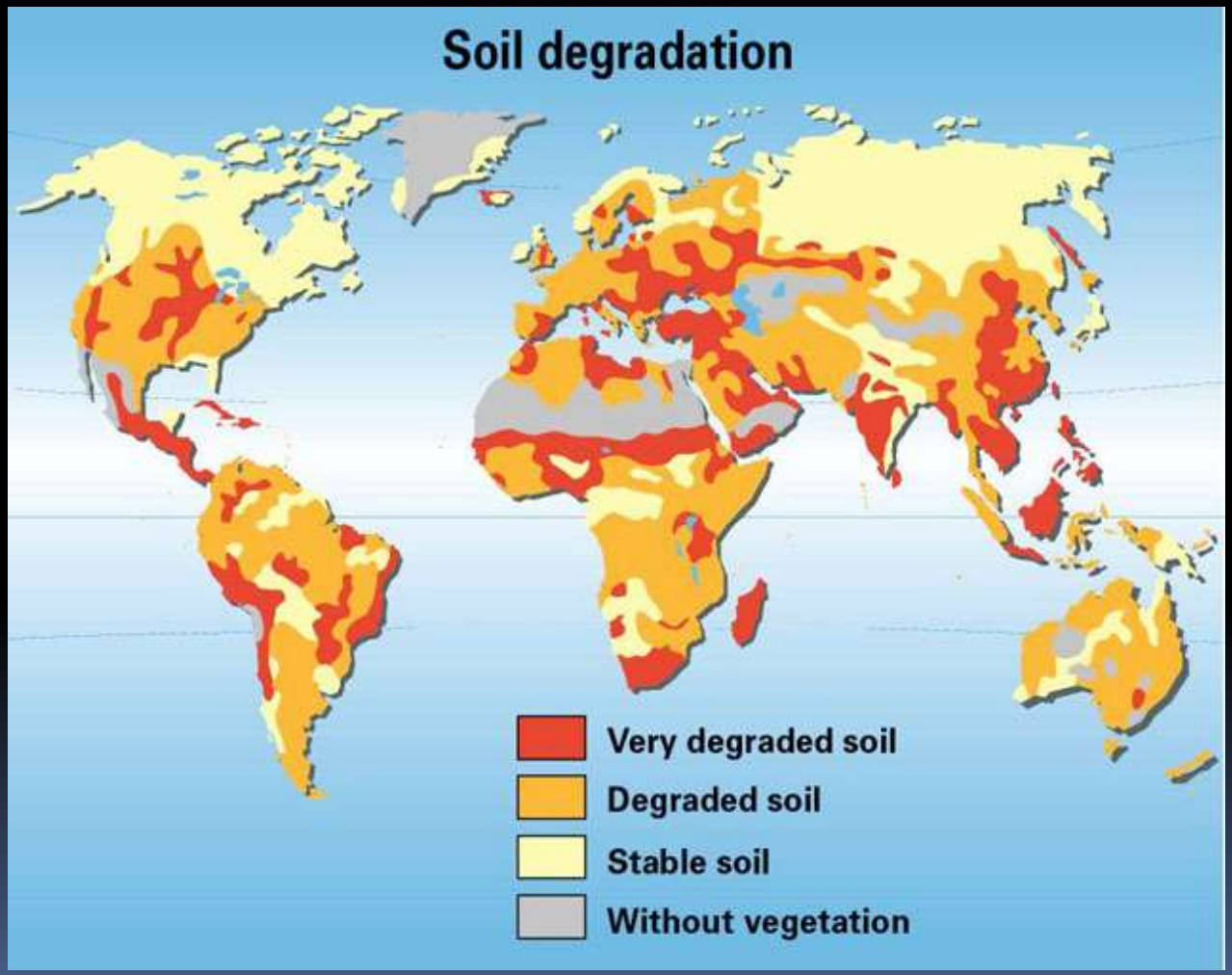
The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

Natural Capital: Forests



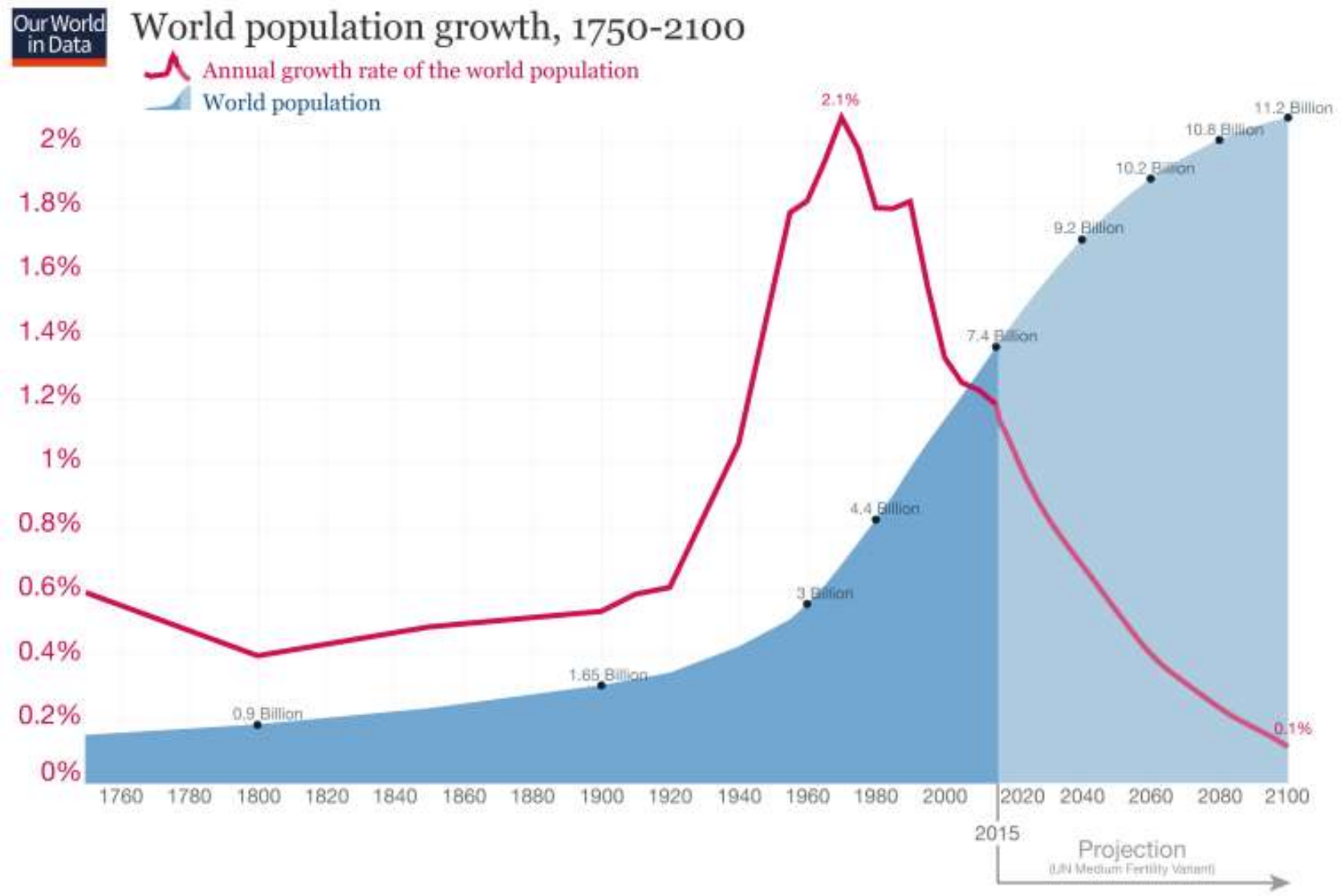
http://www.isd.org/wcfsd/worldmap.jpg

Natural Capital: Soils



http://www.povertymap.net/mapsgraphics/index.cfm?data_id=23360&theme=

Human Population – A Trigger



Data sources: Up to 2015 OurWorldInData series based on UN and HYDE. Projections for 2015 to 2100: UN Population Division (2015) – Medium Variant.
The data visualization is taken from OurWorldInData.org. There you find the raw data and more visualizations on this topic.

Growth to a Stable Population

- Logistic Growth - Growth slows as the population approaches carrying capacity.

What is the carrying capacity of the Earth for humans?

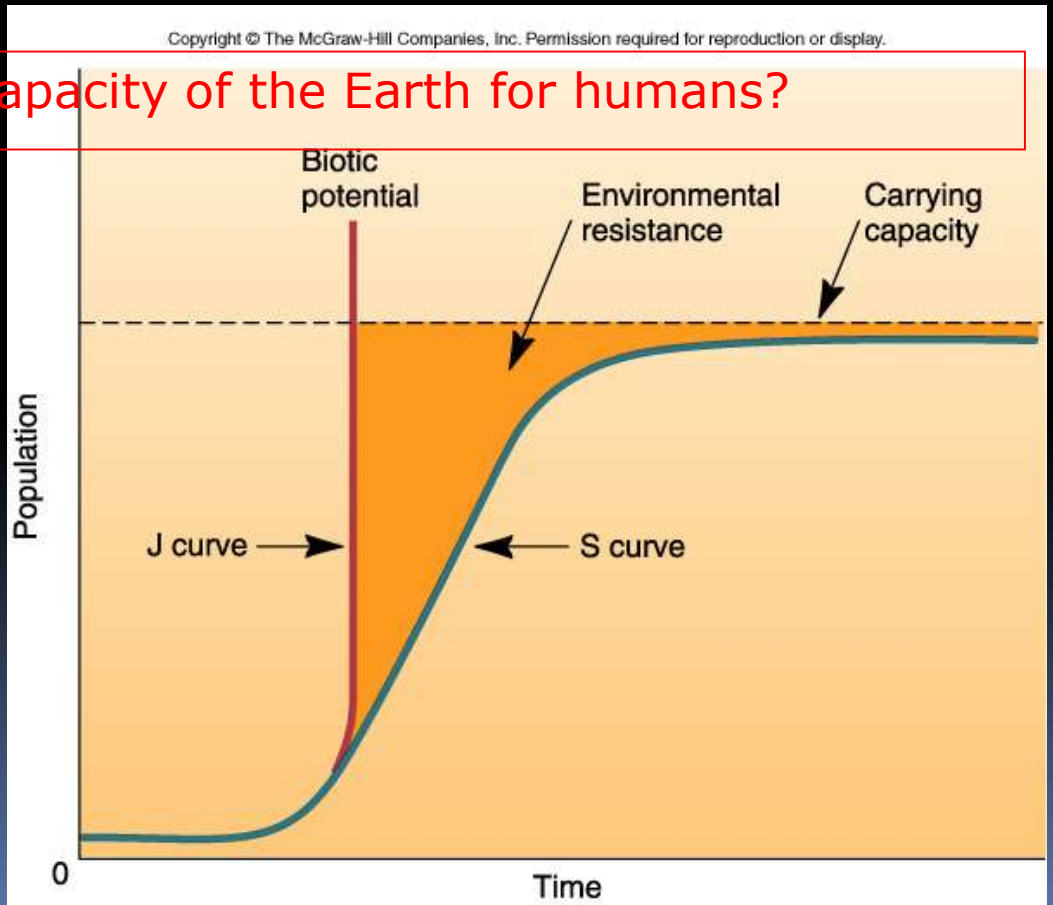
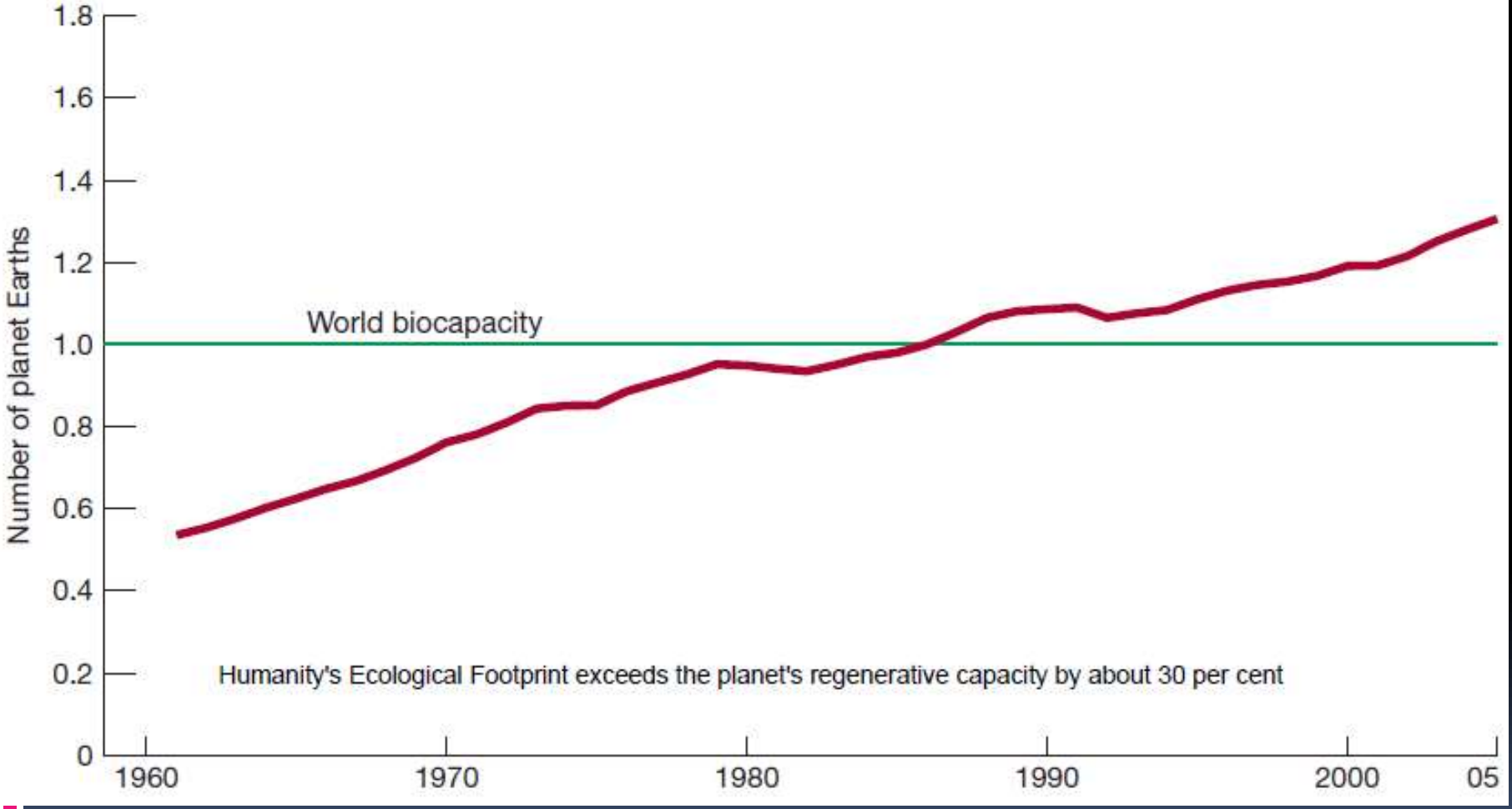
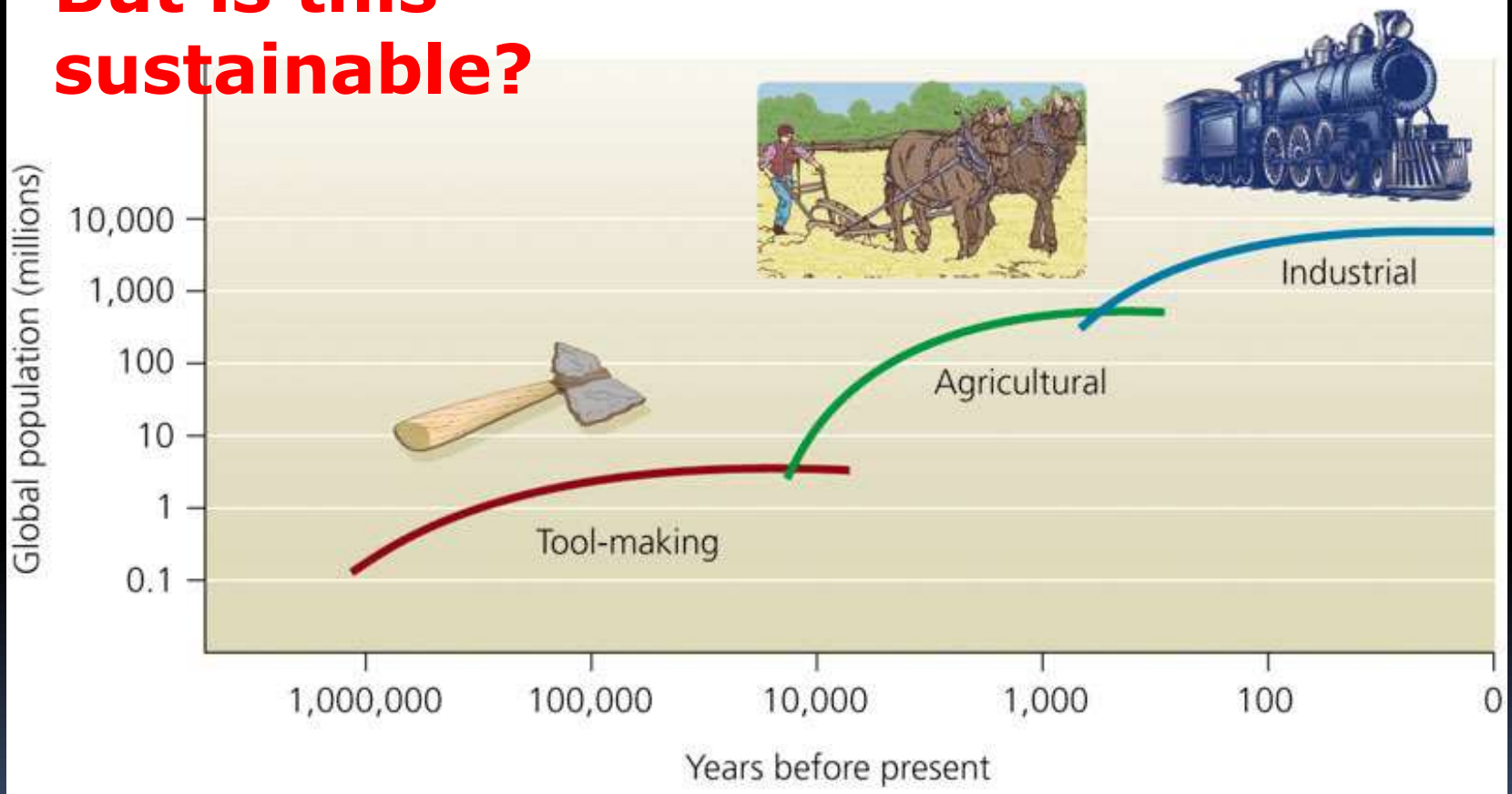


Fig. 2: **HUMANITY'S ECOLOGICAL FOOTPRINT,** 1961-2005



Human carrying capacity

But is this sustainable?



Human Impact Model
I = PAT

- **I:** impact of humans on the environment
  - Doesn't need to be zero to be sustainable - it just needs to be below the "healing capacity" of the Earth
- **P:** population of humans in the environment
  - Definitely increasing for the foreseeable future
- **A:** affluence of the human population
- **T:** technology that controls impact per unit wealth

Ecological Footprints

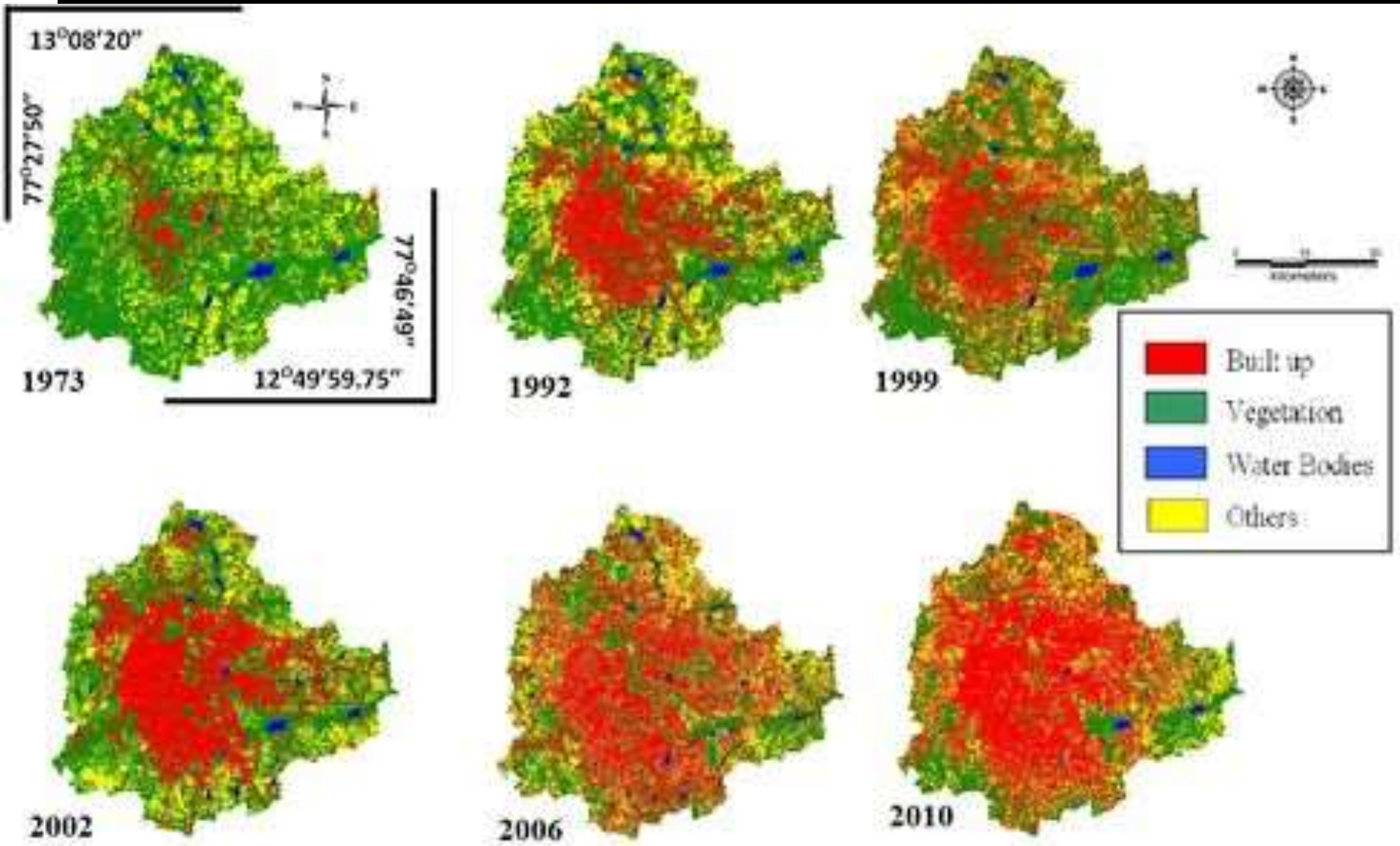
- The amount of ecologically productive land used by individuals, cities, countries, etc.
- Production and use of goods and services involve land use: have ecological footprints

Ecological Footprints

- **Consumed Land**
  - **Built environment**

Urban Footprints

- **Bangalore City Land use changes**



Ecological Footprints

- **Forest Land**
  - **forest products**

Transportation Footprints

- If one person travels 5 kilometers twice each workday:
  - **Bicycle: 122 sq meters**
  - **Buses : 301 sq meters**
  - **Cars: 1,442 sq meters**

Agricultural Footprints

- Open Field production of tomatoes takes up more land than greenhouse production
- But Greenhouse production has a much larger ecological footprint (10-20x)
  - Energy
  - Fertilizer
  - Other inputs

WATER FOOT PRINTS

WATER FOOT PRINTS

Cotton plant → Harvesting → Seed-cotton → Ginning

Ginning → 0.63/0.18 → Cotton seed → Hulling/extraction

- Hulling/extraction → 0.16/0.47 → Cotton seed oil → 1.07/1.00 → Cotton seed oil, refined
- Hulling/extraction → 0.51/0.33 → Cotton seed cake
- Hulling/extraction → 0.10/0.20 → Cotton linters

Ginning → 0.35/0.82 → Cotton lint → 1.00/1.00 → Cotton, not carded or combed → Carding/Spinning

- Carding/Spinning → 0.05/0.10 → Garnetted stock
- Carding/Spinning → 0.95/0.99 → Cotton, carded or combed (yarn) → Knitting/weaving

Knitting/weaving:

- 0.95/0.99 → Grey fabric → Wet processing → 1.00/1.00 → Fabric → Finishing → 1.00/1.00 → Final textile
- 0.05/0.10 → Yarn waste

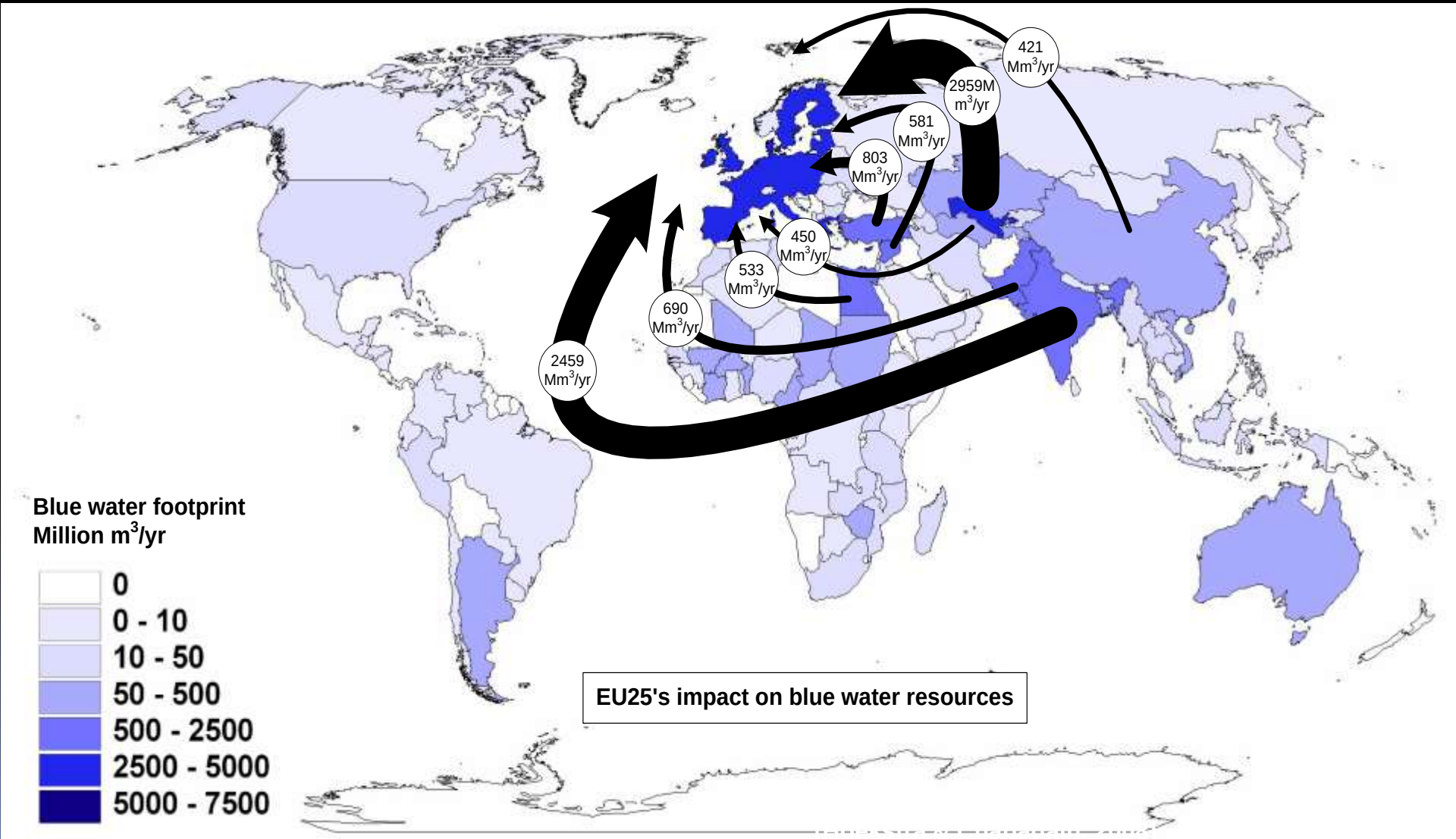
Legend

0.35 / 0.82

- Product fraction
- Value fraction

Polluted Waters – River Noyyal

Water footprint of EU's cotton consumption (blue water)



National Footprints

- Holland population 15 million
- Density = 4.4 People per Hectare
- Consumption is less than in U.S.
- Still, Dutch people require 15x more land than is within their country for
  - Food
  - Forest Products
  - Energy Use
- Therefore, the ecosystems that support Holland lie far beyond their national borders

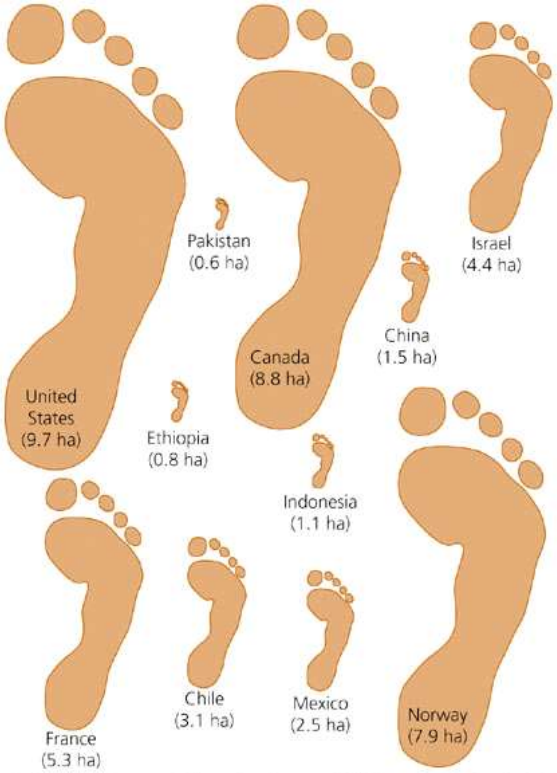
National Footprints

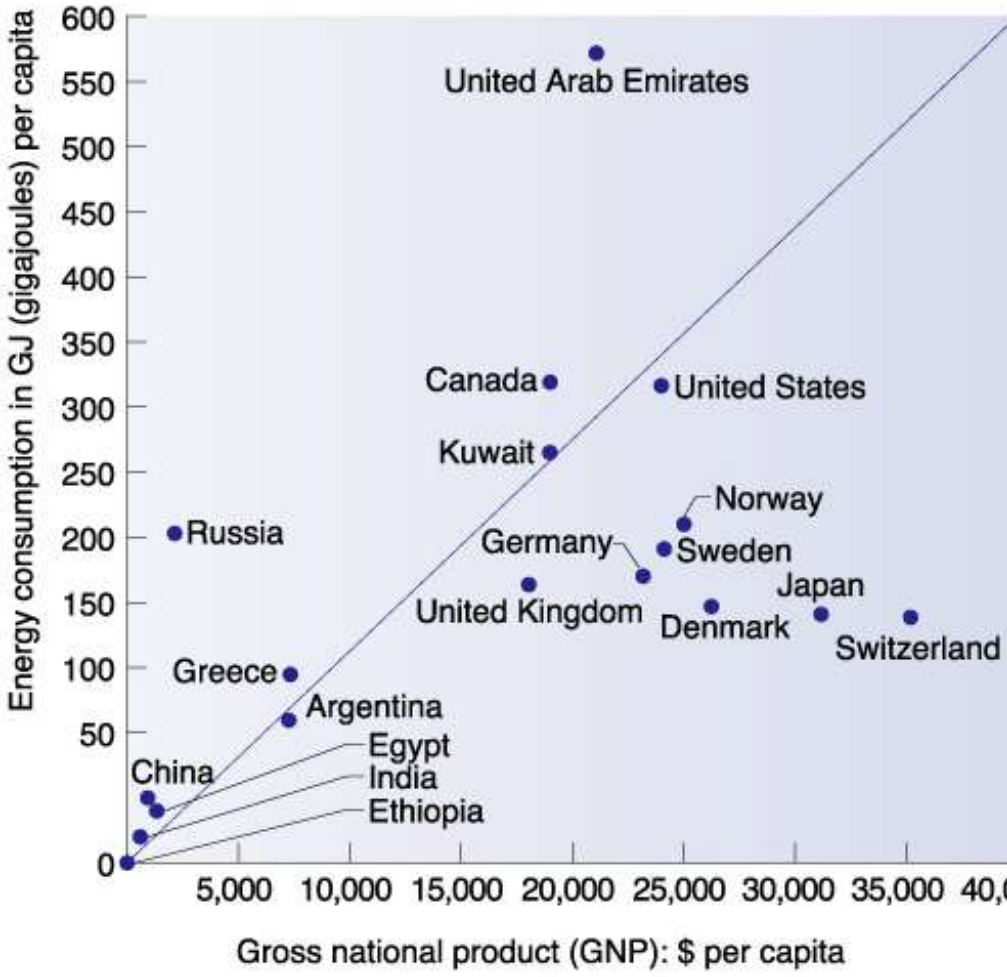
- In U.S. each person uses about 4.5 hectares/person
- Worldwide average = 1.5 hectares/person
- Therefore if everybody were to adopt the U.S. consumptive style, we would need 3 planets



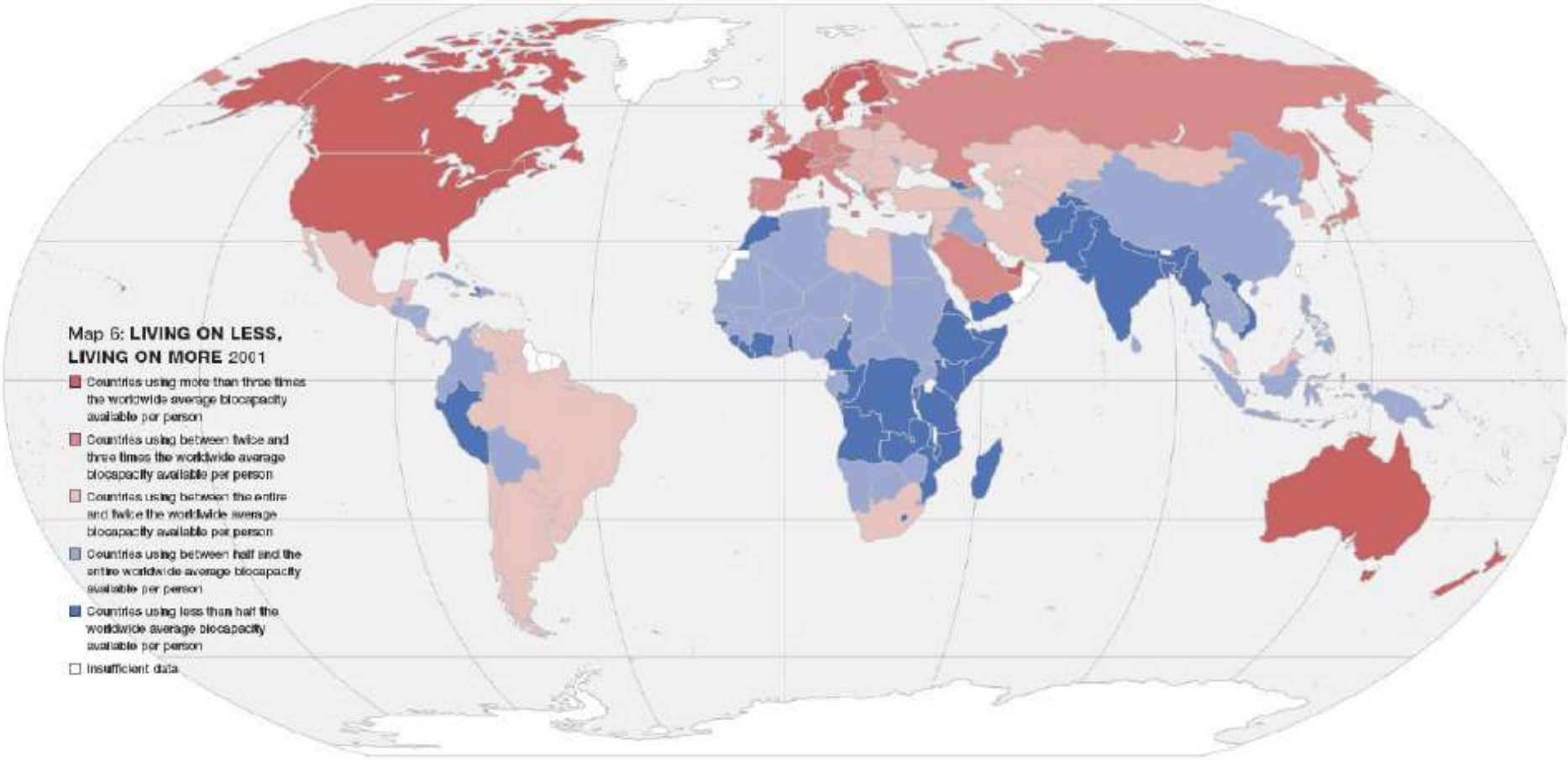
Ecological Footprints

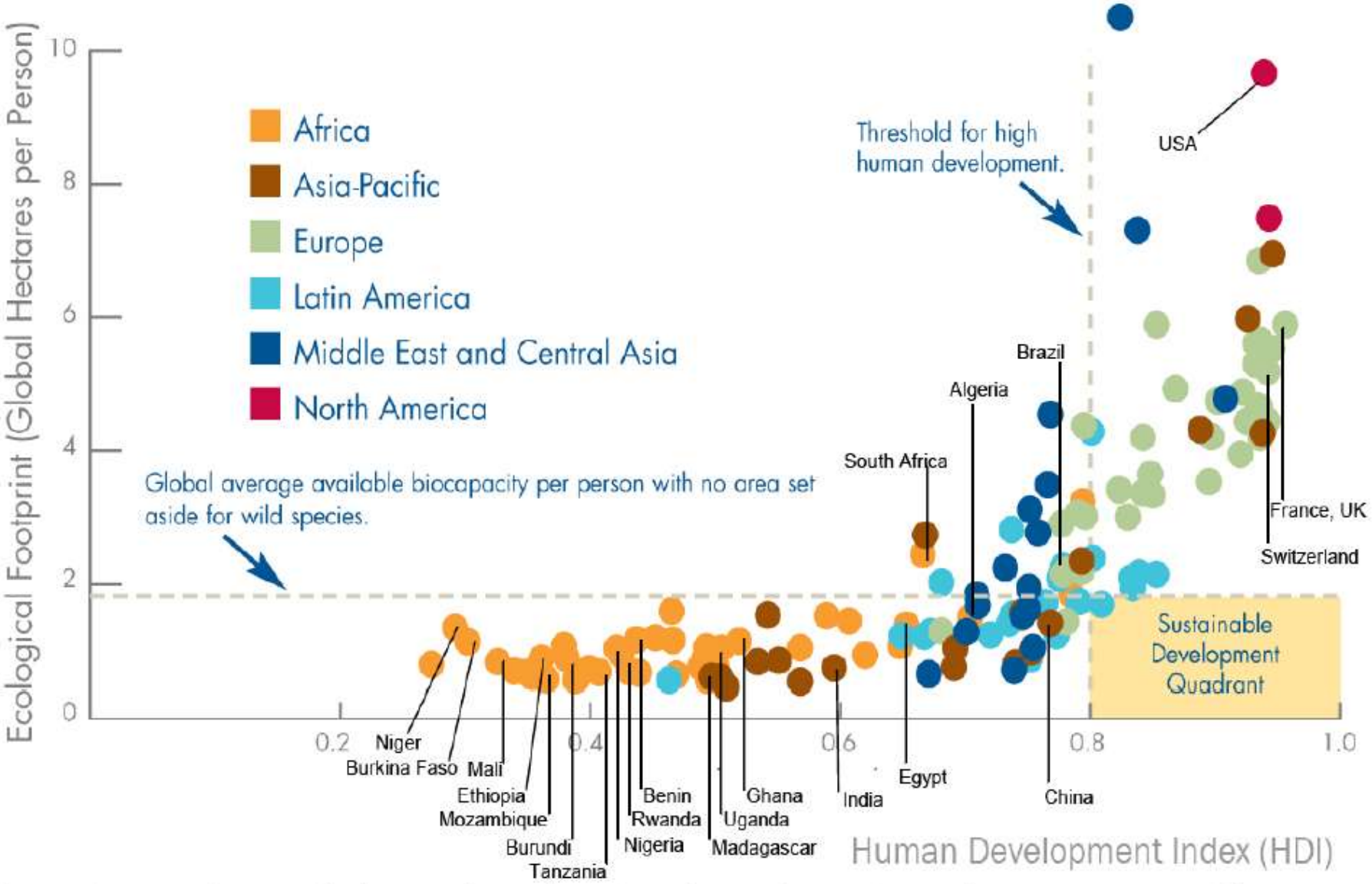
These "footprint" models are pretty sloppy, but for example…





Living on Less, Living on More, 2001





Development Index (HDI) as an indicator of socio-economic development, and the Ecological Footprint as a measure of human demand on the biosphere. The United Nations considers an HDI of over 0.8 to be "high human development." An Ecological Footprint less than 1.8 global hectares per person makes a country's resource demands globally replicable. Despite growing adoption of sustainable development as an explicit policy goal, most countries do not meet both minimum requirements.

Pollinators and specific floral characteristics

ees:

- fls. showy, colorful, fragrant, with:
- **nectar guides**
- landing platforms

utterflies:

- fls showy, colorful, fragrant
- no nectar guides
- long tubes or spurs

oths:

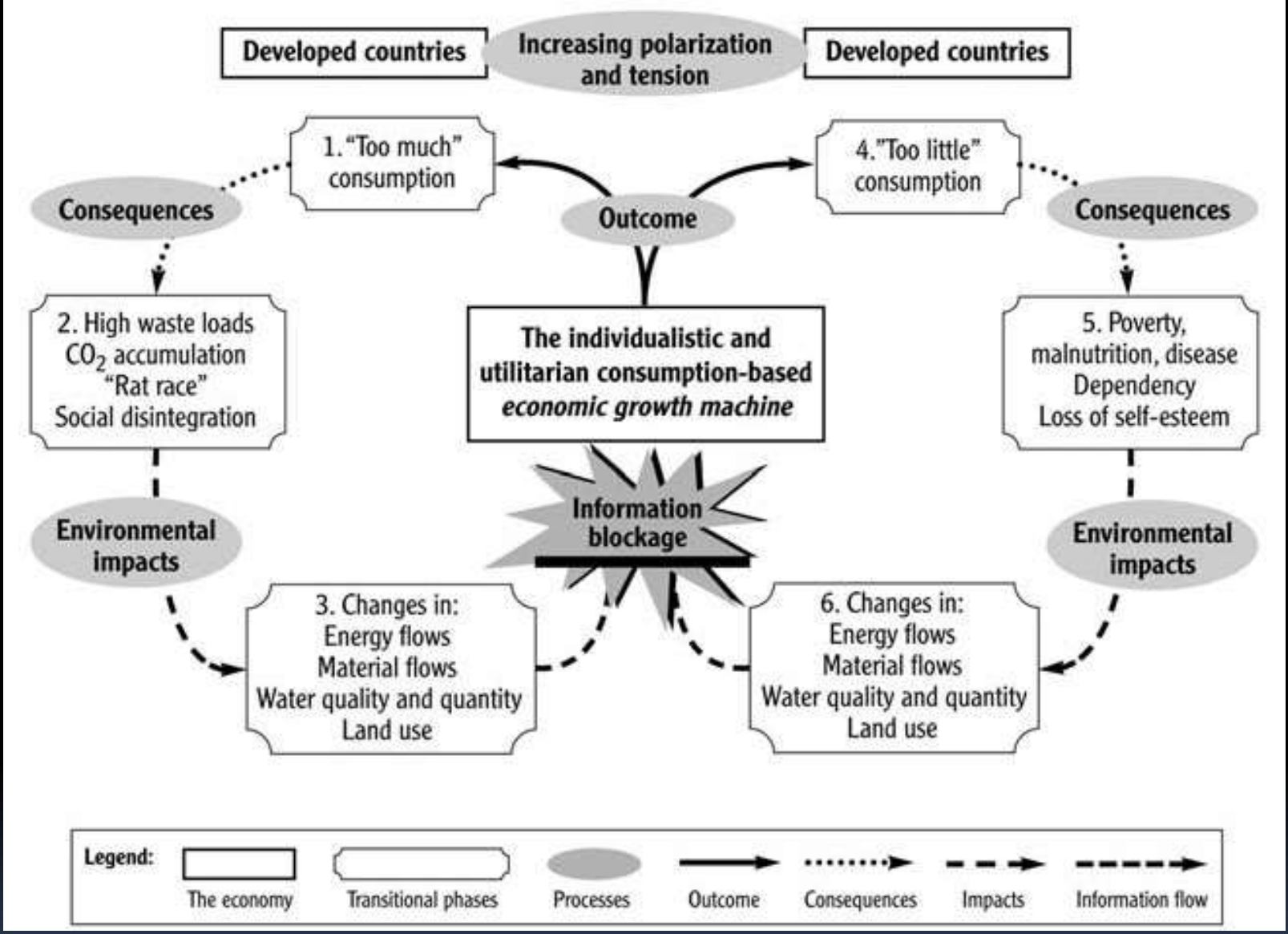
- large, white, fragrant
- no nectar guides
- usually tubes or spurs

Medicinal Plants

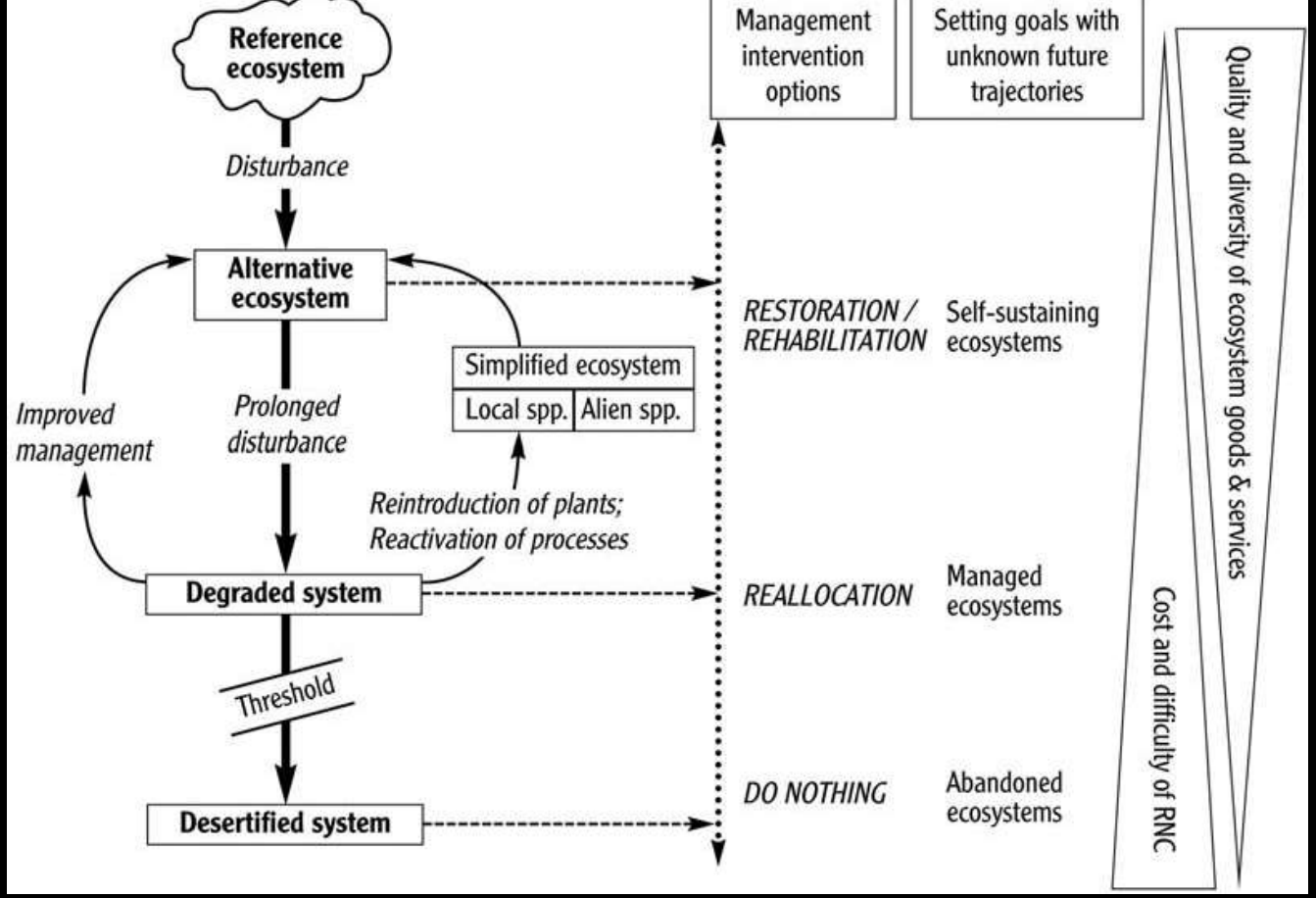
According to WHO medicinal plants plays an important role in the health care of about 80 percent of World population in developing countries of which herbal medicines constitutes the most prominent part (Farnsworth et al. 1988).

The number of medicinal plants in India (indigenous and introduced) has been estimated to be between 3,000 to 3,500 species of higher plants.

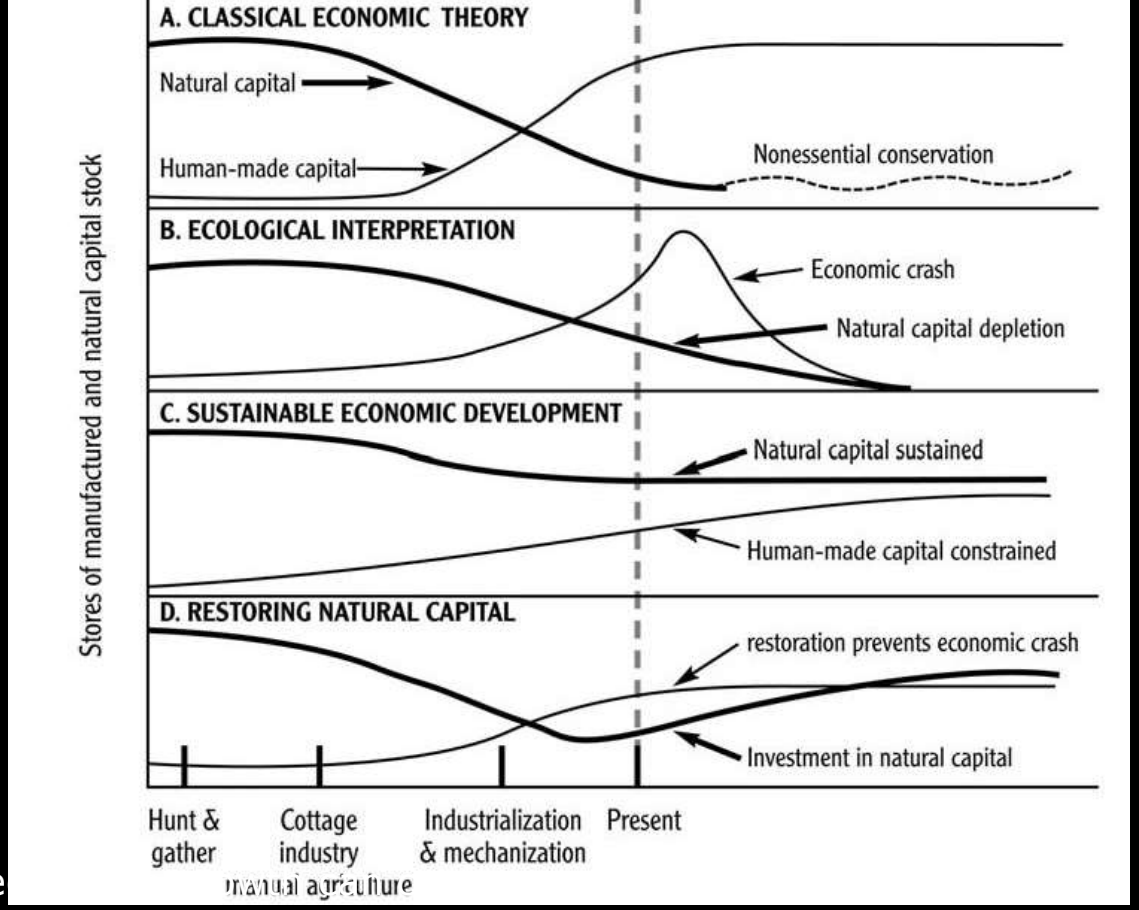
The Western Ghats houses of about 700 medicinal plants. Some are used for traditionally while many are exploited commercially.



Simplified state and transition model of the global, consumption-based economic growth machine with indications of its various outcomes and environmental impacts. Overexploitation (often begun during colonial periods) combined with inequity and maldistribution confounds the problem of underconsumption.



General model of ecosystem degradation and possible responses, modified from Aronson et al. (1993). In this scheme, disturbance refers to undesirable anthropogenically induced change. On the right-hand side of the figure, quantity and diversity of ecosystem goods and services refers to their availability, while cost and difficulty of restoration of natural capital are the relative financial and other expenditures and investments required for a continuum of management intervention options. The exact positions of transformed ecosystems, with a range of restoration inputs, depend on many variables, with the most plausible outcomes indicated.



Neoclassical perspective: e
depleted.
(B) Environmentalist pessimistic perspective: predicting an economic crash following natural capital depletion.
(C) Ecological economic vision wherein tradeoffs to growth are accepted in favor of maintaining natural capital and a more sustainable economy through qualitative improvement of ecosystem and
resource management.
(D) The possible effects of restoration of natural capital on quantity and stability of human-made capital.
Panels A and B are redrawn from Folke et al. (1994), with permission from the authors and the publisher.
Panels C and D are original and previously unpublished.