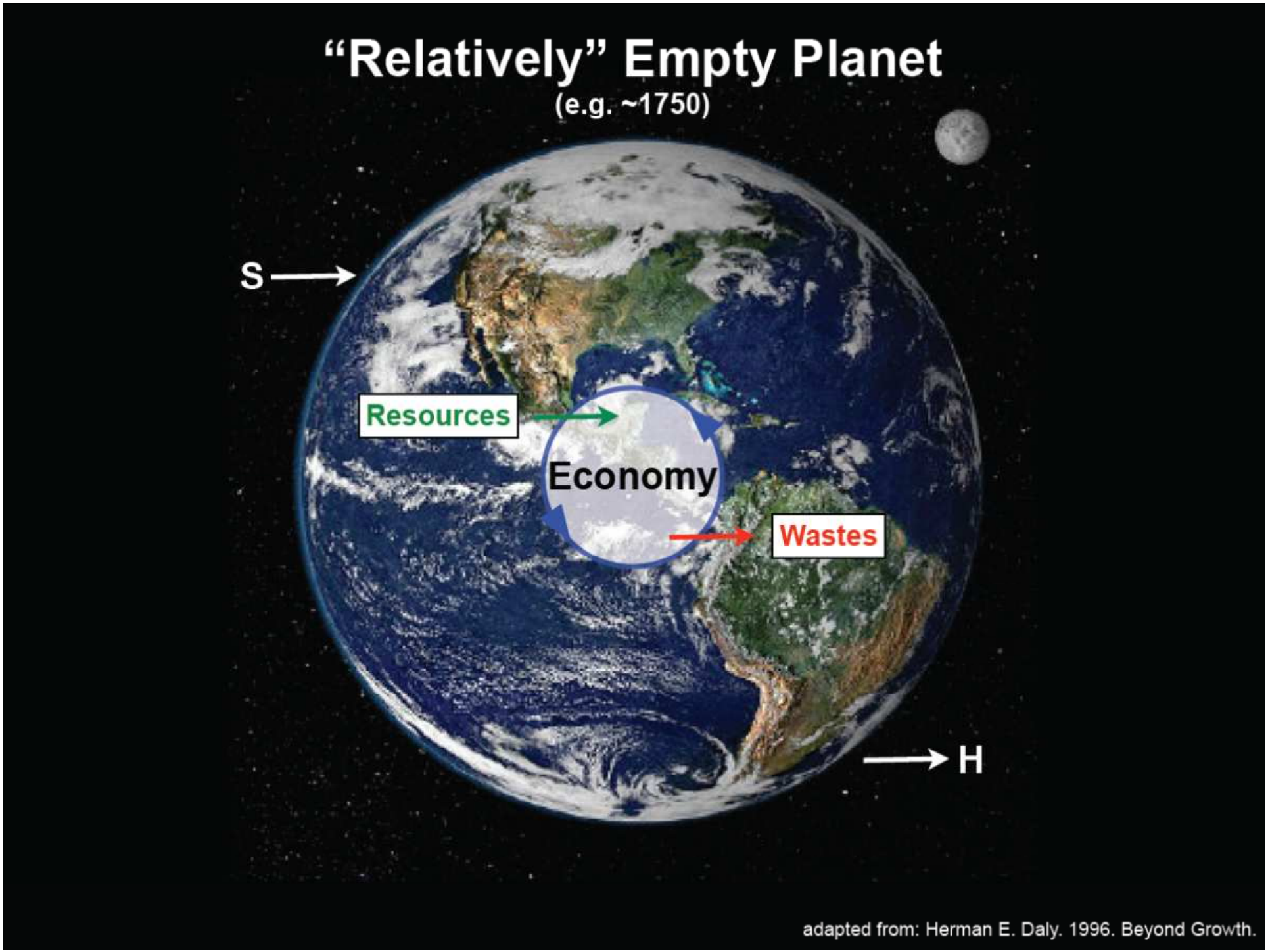
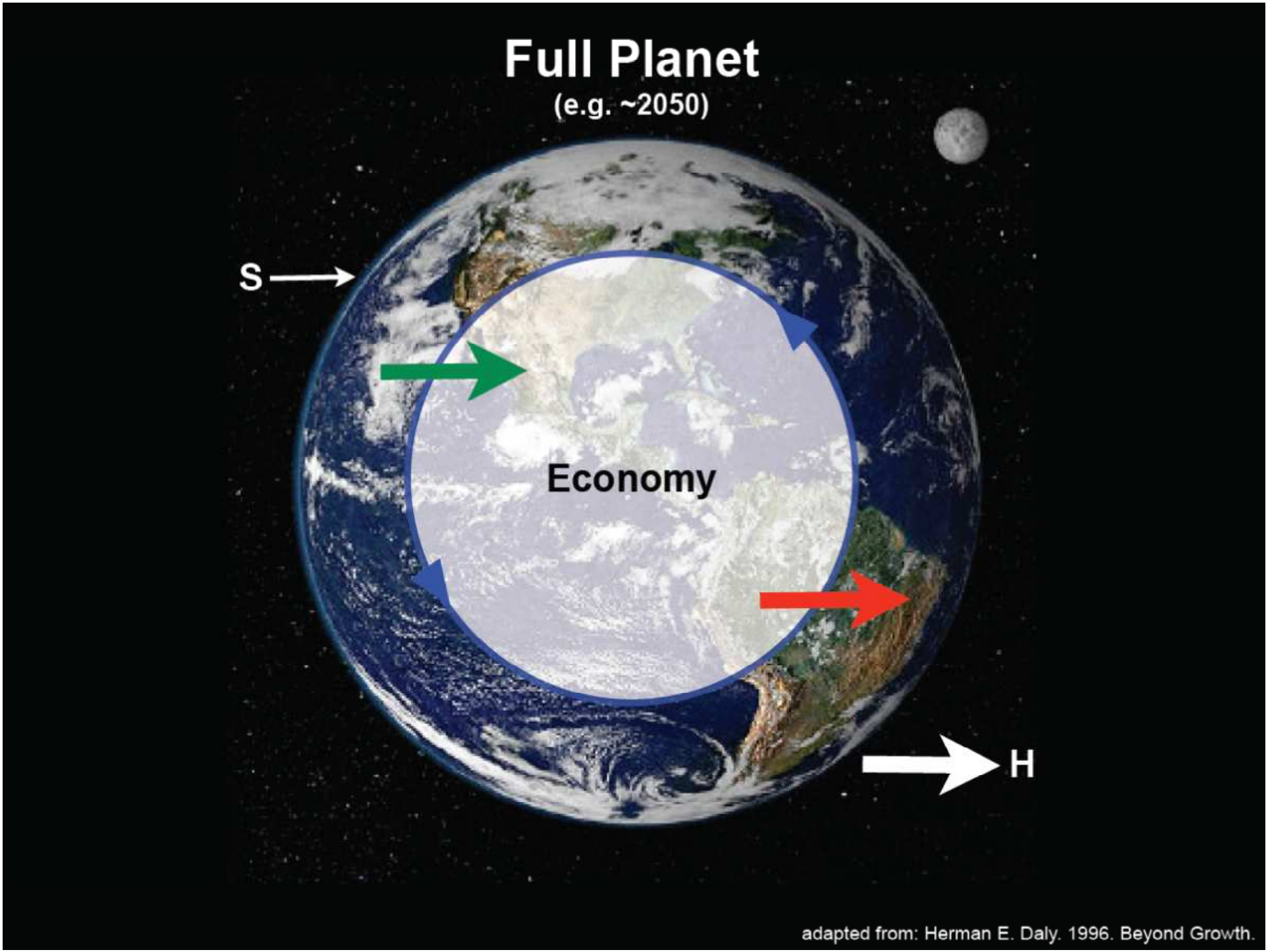
Eco-systems of agricultural landscapes
and sustainable land use: Livestock systems

05 - Livestock Environment Interaction - 2

The Ecological Footprint

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz


"Relatively" Empty Planet
(e.g. ~1750)
S
Resources
Economy
Wastes
H
adapted from: Herman E. Daly. 1996. Beyond Growth.


Full Planet
(e.g. ~2050)
S
Economy
H
adapted from: Herman E. Daly. 1996. Beyond Growth.

Ecological Footprint Definitions

Ecological footprint - is the corresponding area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a defined population at a specified material standard of living, wherever on Earth that land may be located.

Bio-capacity - The capacity of ecosystems to produce useful biological materials, and to absorb waste materials generated by humans, using current management schemes and extraction technologies.

Useful biological materials - are defined as those used by the human economy. Hence what is considered “useful” can change from year to year (e.g. use of maize stover for ethanol production would result in stover becoming a useful material, and so increase the bio-capacity of maize cropland).

Ecological Footprint Definitions (continued)

Ecological footprint and bio-capacity accounts express the use of built-up areas, and the consumption of energy and renewable resources - crops, animal products, timber, and fish – in standardized units of biologically productive area, termed global hectares. Each global hectare represents an equal amount of useful biological productivity.

Equivalence factors describe potential crop yields attainable in an area at an explicit level of inputs, regardless of current rates of biomass production, by representing the world average potential productivity of a given bio-productive area relative to the world average potential productivity of all bio-productive areas. Equivalence factors, which can change over time, thus convert physical hectares to global hectares.

Equivalence factors for the footprint accounts, 2003

Bio-productive Area	Global Hectares / ha
All Cropland	2.1
Primary Cropland	2.2
Marginal Cropland	1.8
Pasture	0.5
Forest	1.4
Fishing Grounds	0.4
Built-up Area	2.2
Hydropower Area	1.0
Fossil Fuel (Forest)	1.4

Source: Meadows et al. 2004. Land Use Policy, 21.

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World Ecological Footprint and Bio-capacity, 2003

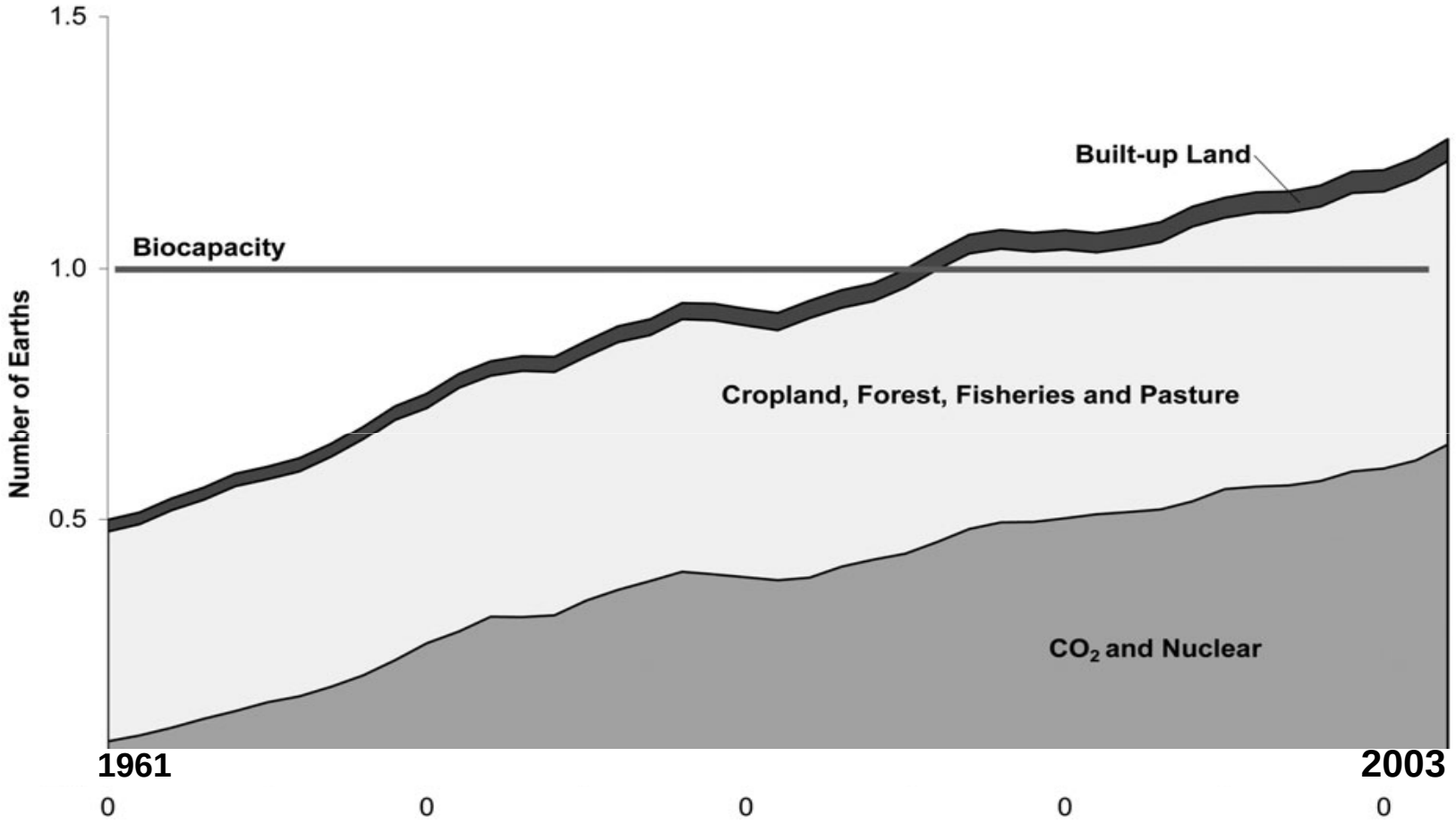
Land Type	Ecological Footprint	Bio-capacity
Cropland	3 040 000	3 305 000
Pastures	914 000	1 683 000
Fishing Grounds	936 000	859 000
Forest	1 438 000	4 898 000
Carbon and Nuclear	7 263 000	
Built-up Area	483 000	483 000
Total	14 073 000	11 198 000

Both Ecological Footprint and bio-capacity are expressed here in global hectares.

Source: Meadows et al. 2004. Land Use Policy, 21.

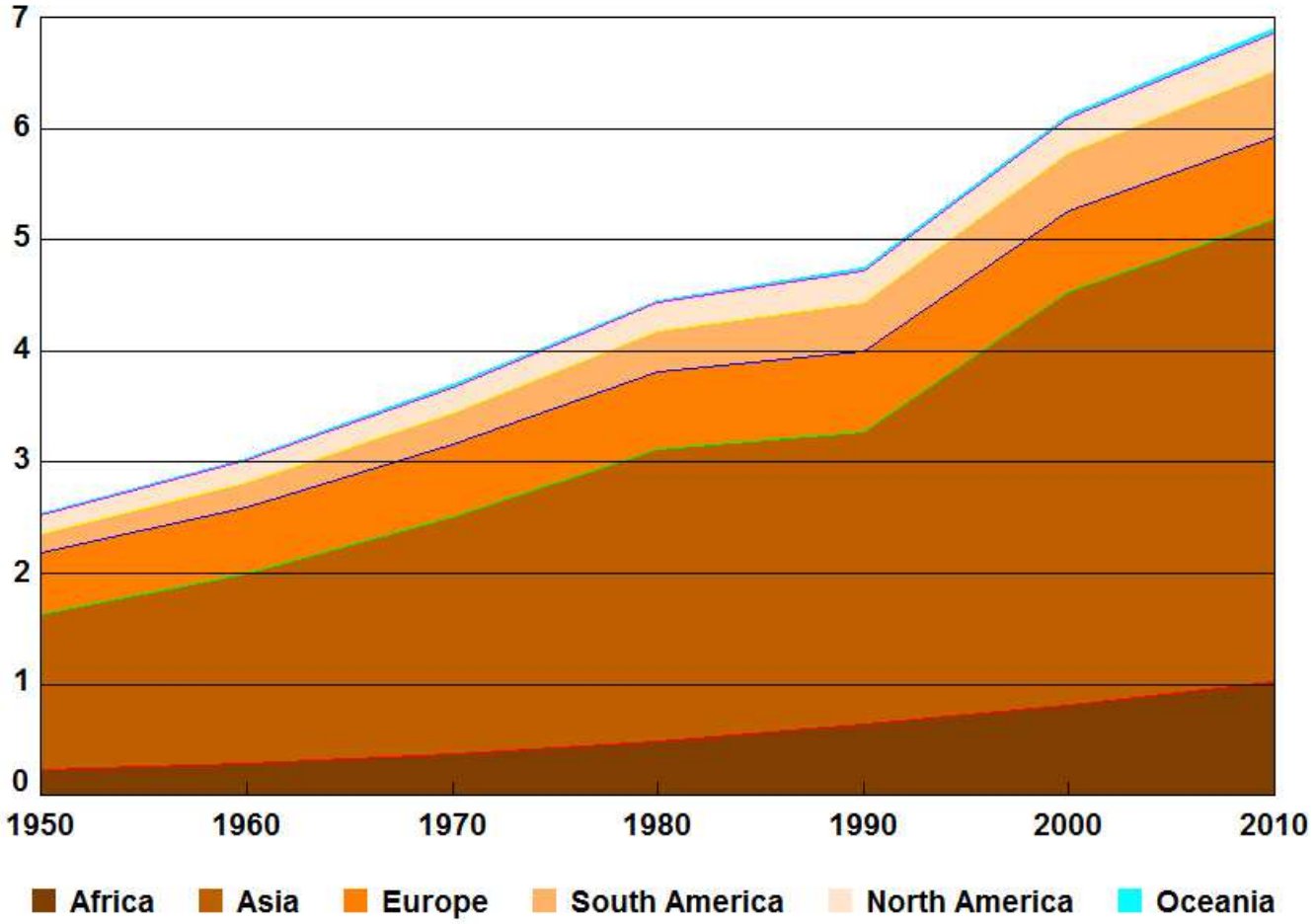
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Global Ecological Footprint and Bio-Capacity



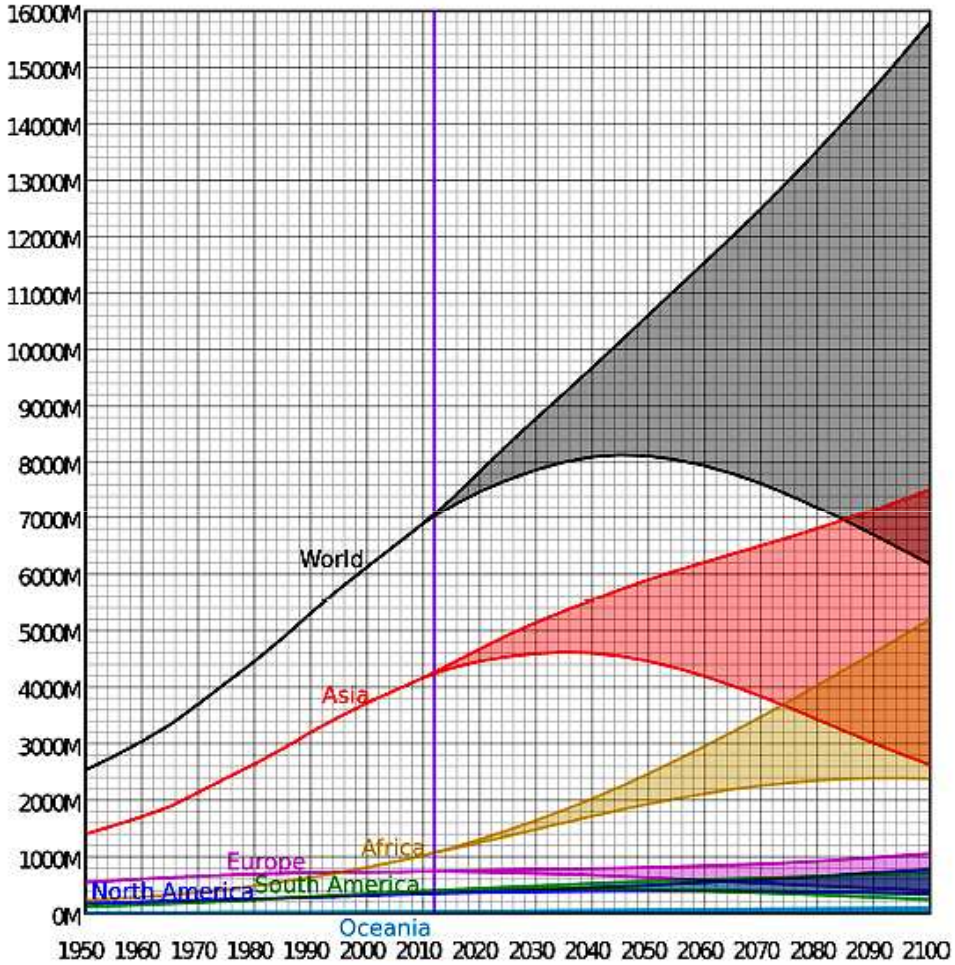
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World Population Growth [billion]

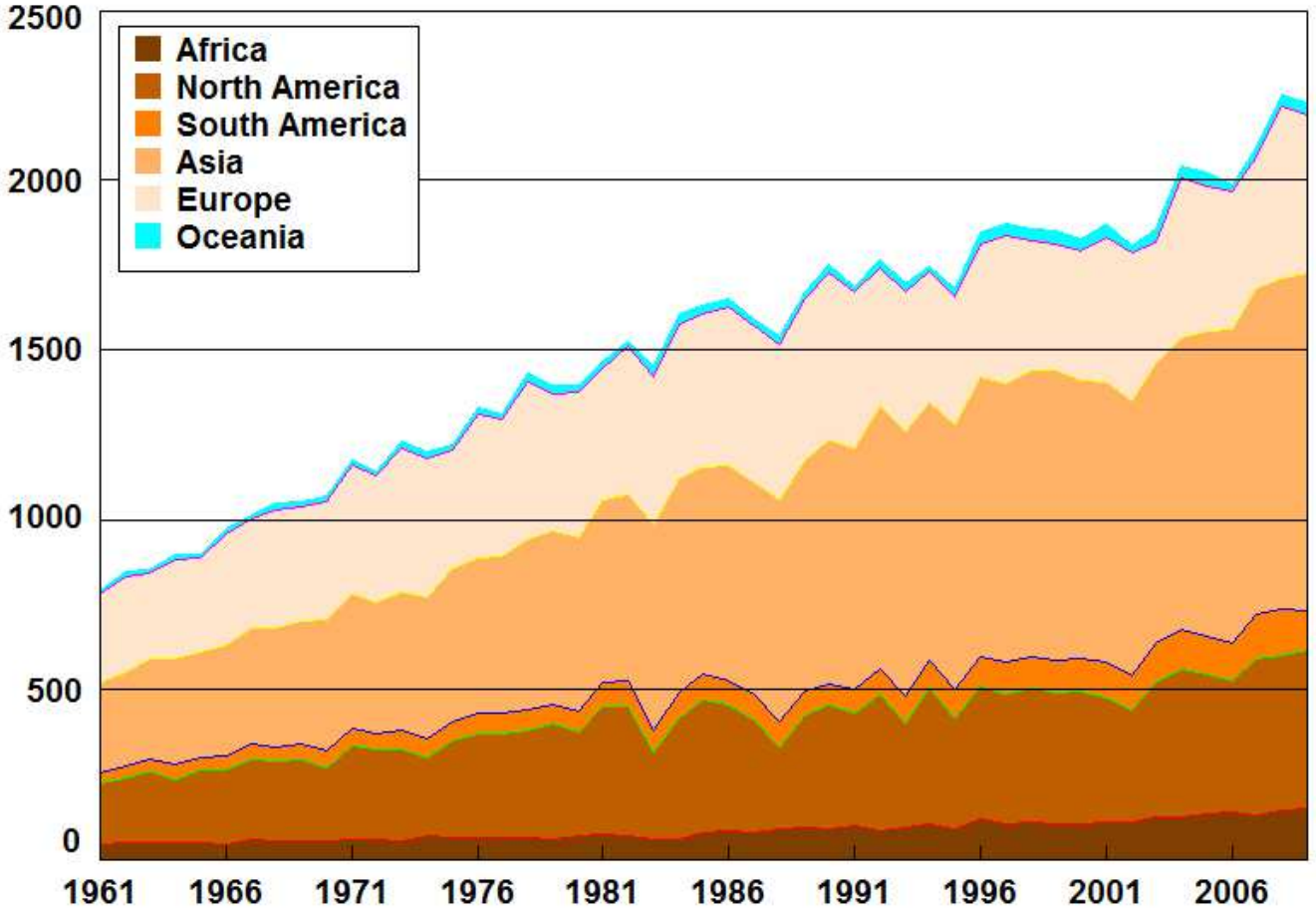


Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World Population Growth Projections



World grain production [million tonnes] since 1961

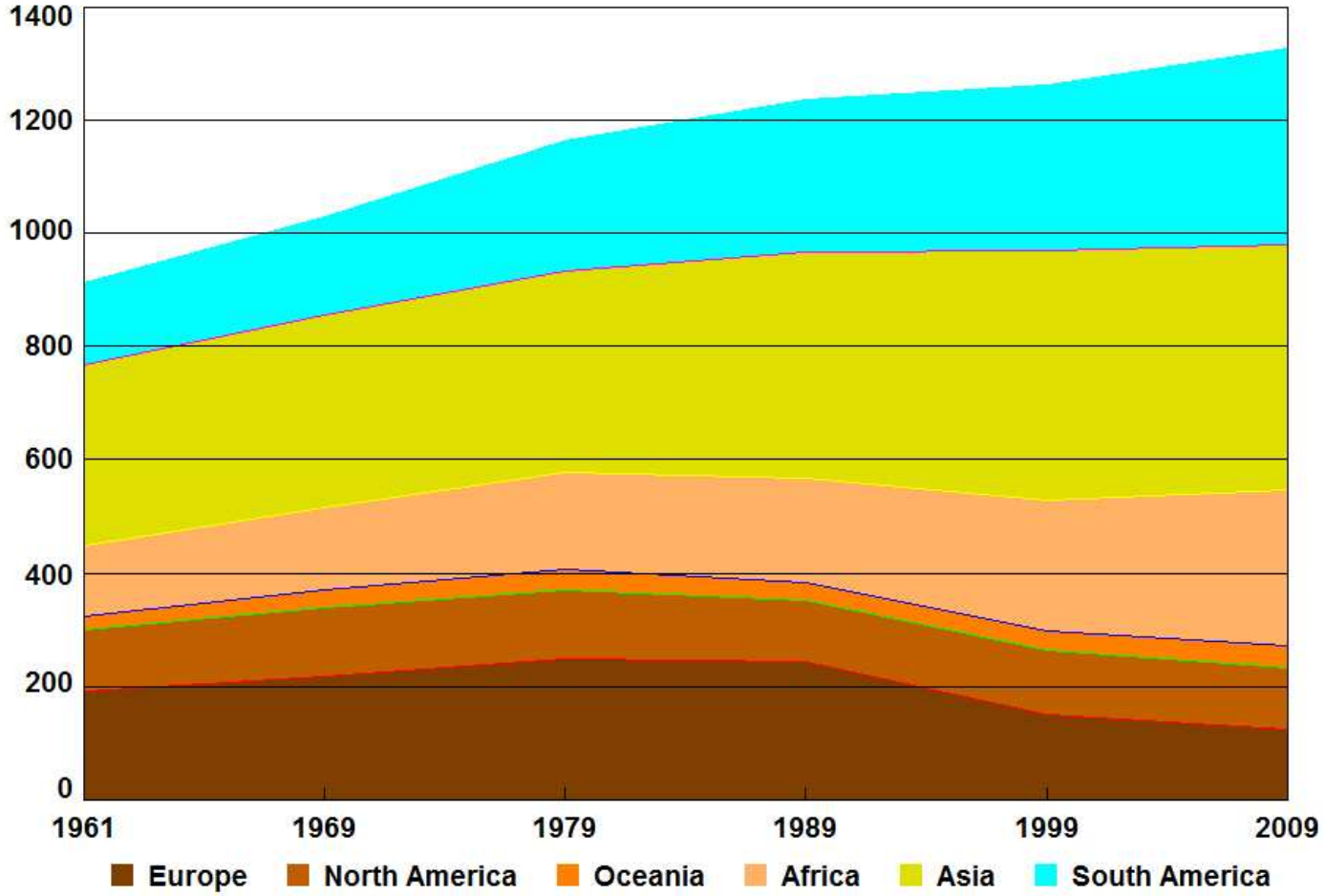


Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Nature Food News Volume 466 29 July 2010

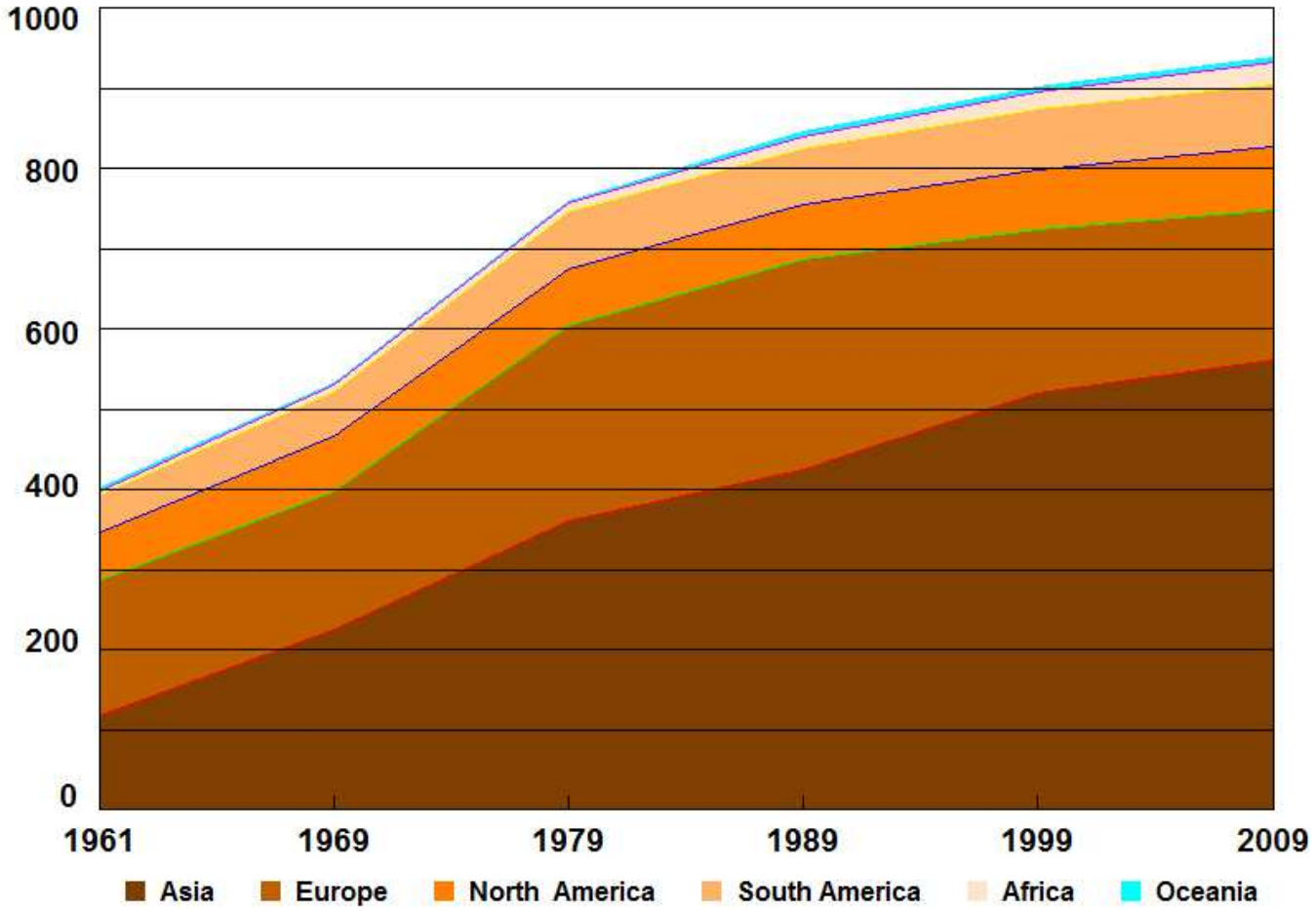
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World cattle numbers since 1961 [million]



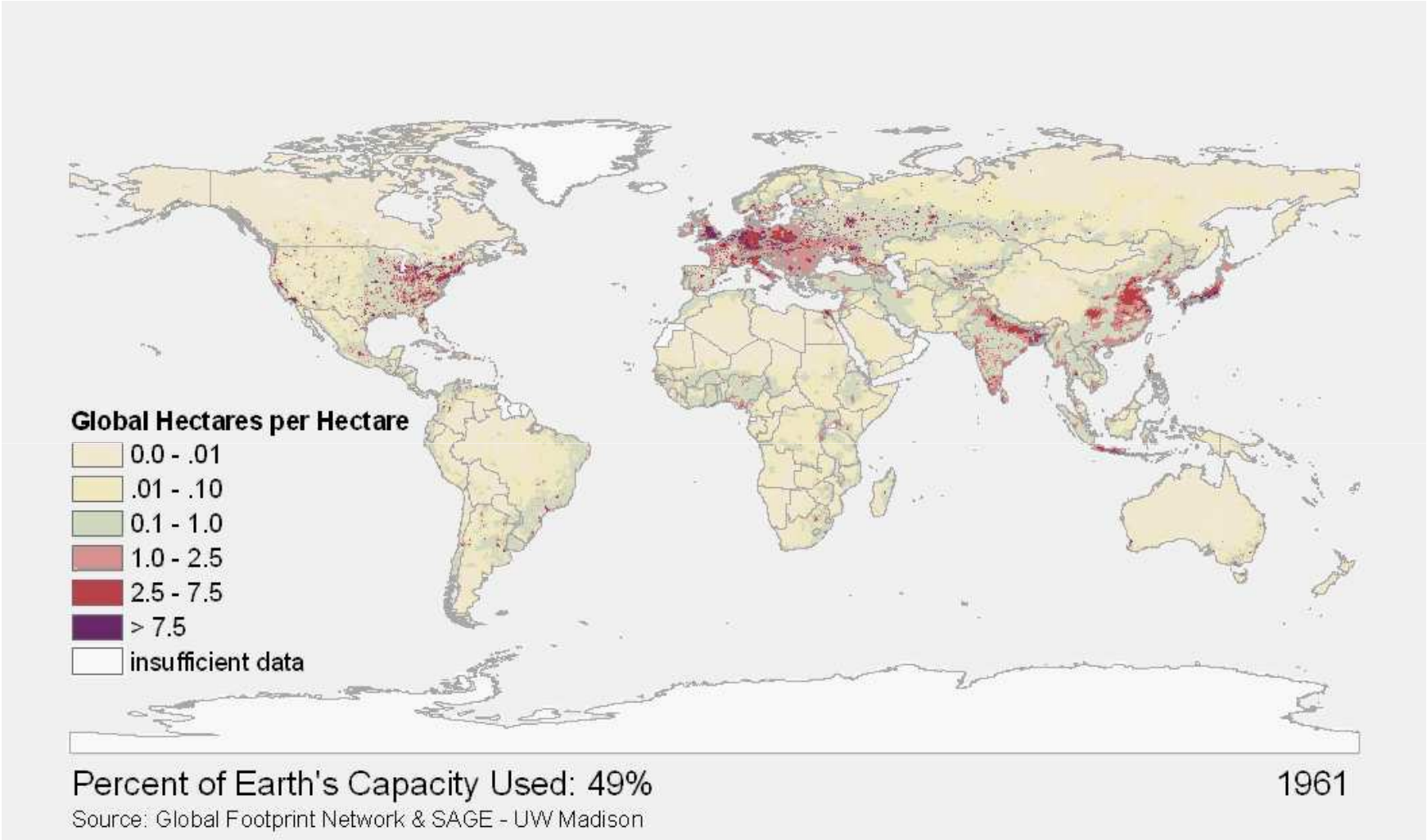
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World pig numbers since 1961 [million]



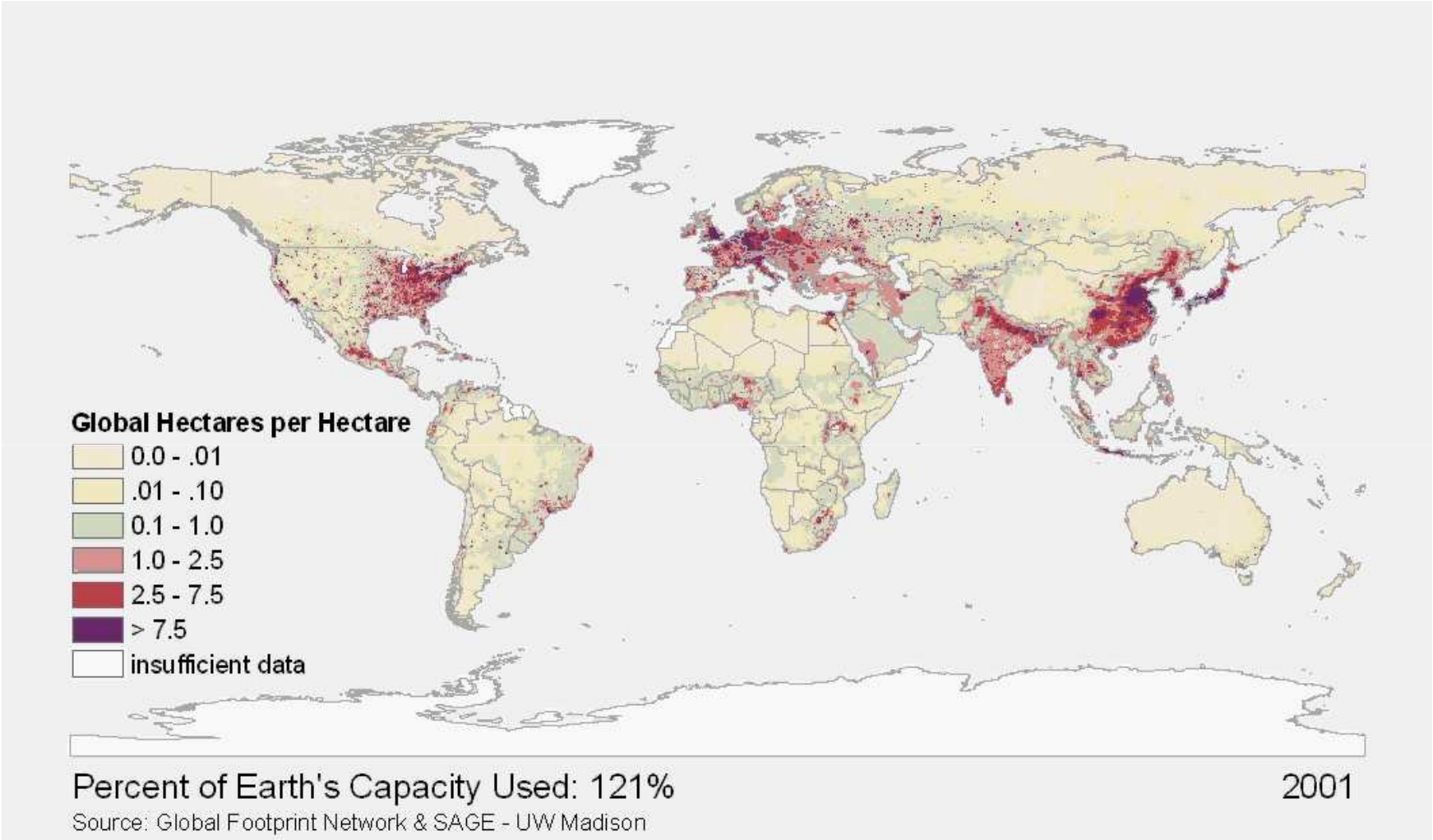
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World's Land Use Intensity **1961** [Global Hectares / Hectare]



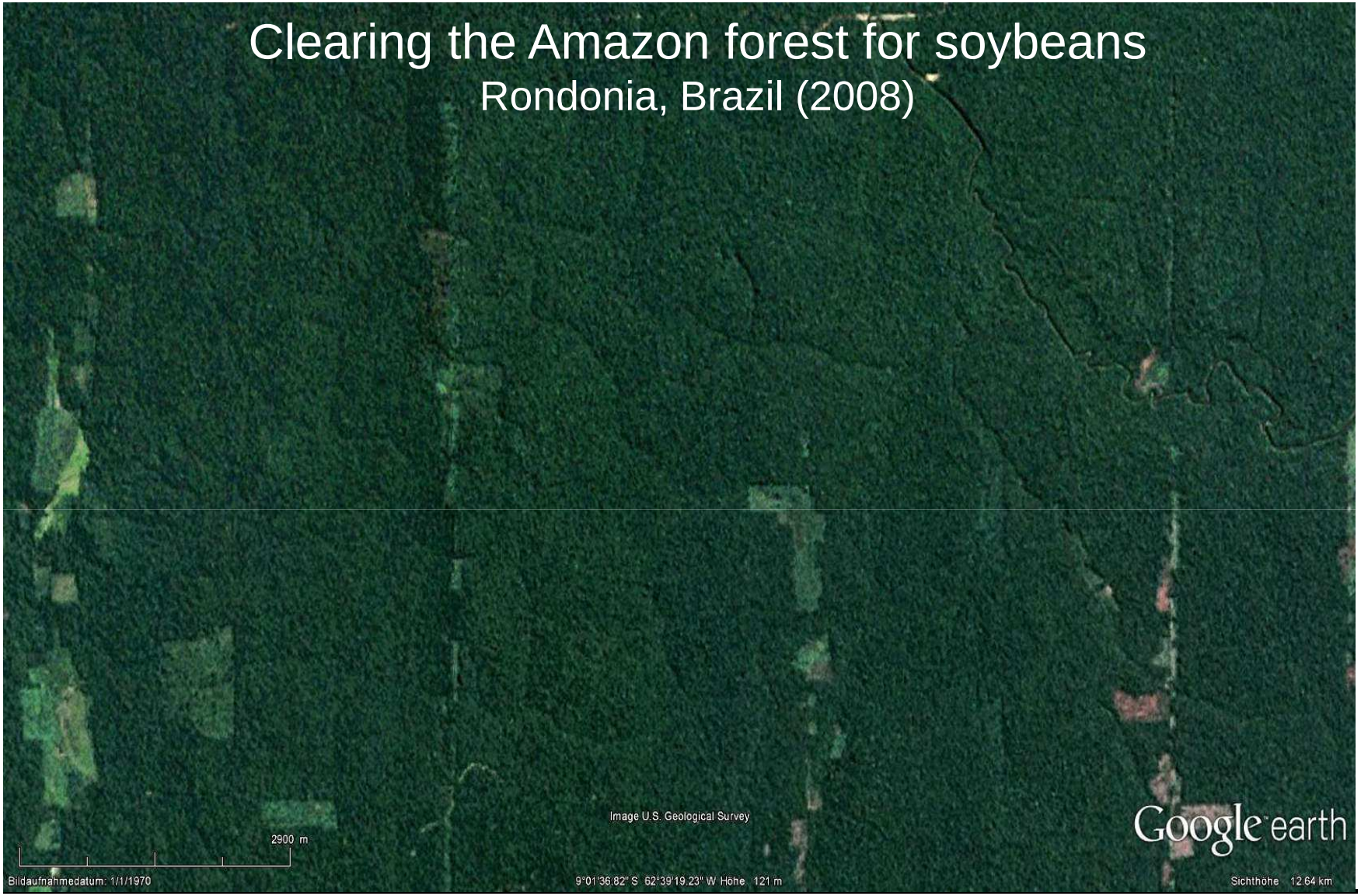
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

World's Land Use Intensity **2001** [Global Hectares / Hectare]



Clearing the Amazon forest for soybeans

Rondonia, Brazil (2008)



Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Clearing the Amazon forest for soybeans

Rondonia, Brazil (2010)

Clearing the Amazon forest for soybeans

Rondonia, Brazil (2010)

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Large scale clearing the Amazon forest for soybeans

Rondonia, Brazil (2012)

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

The biophysical limits to growth

Premise: The economy, in its physical dimensions, is an open subsystem of our finite and closed ecosystem.

The increase in throughput (i.e. growth) of the economy is limited by the fixed size of the host ecosystem, through its dependence on:

- sources of low-entropy inputs (materials & energy)
- sinks for high-entropy wastes, and
- the complex ecological connections that are easily disrupted as economic throughput grows

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

The biophysical limits to growth (continued)

Finitude would not be so limiting if everything could be recycled, but entropy (i.e., the 2nd law of thermodynamics) prevents complete recycling.

Entropy would not be so limiting if sources and sinks were infinite, but both are finite.

Disrupting ecological connections would not be so limiting if we could substitute between ecological services, but we can't.

Living beyond the limits ...

can overwhelm the source and sink capacities of eco-systems, and that usually breaks the complex biophysical connections that are needed to maintain ecosystem services, but ...

ecological limits are hard to detect as many of the symptoms and consequences of resource extraction and pollution are time delayed and subject to non-linearities (e.g. the effects of groundwater drawdown, deforestation, soil erosion, the spread invasive species, GHG emissions among many others), moreover ...

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Living beyond the limits ... (continued)

landscape amnesia (within society) often induces a sense of “It’s always been like this ...” that leads to societal inertia and denial in preventing crossing of thresholds, also ...

environmental problems can affect people that did very little to cause them (water pollution due to excessive fertilizer use, increase in malaria incidence as a result of climate change etc). This is the “Tragedy of the Commons”.

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

“Thou shalt not exceed the carrying capacity of any environment.”

G. Hardin 1976. Carrying capacity as an ethical concept. *Soundings* 59: 120-137.

http://www.garretthardinsociety.org/articles/art_ethical_implications.html

G. Hardin 1968. The Tragedy of the Commons

http://www.garretthardinsociety.org/articles/art_tragedy_of_the_commons.html

Carrying capacity definitions

Conventional carrying capacity - the maximum population size of a given species that an area can support without reducing its ability to support the same species in the future.

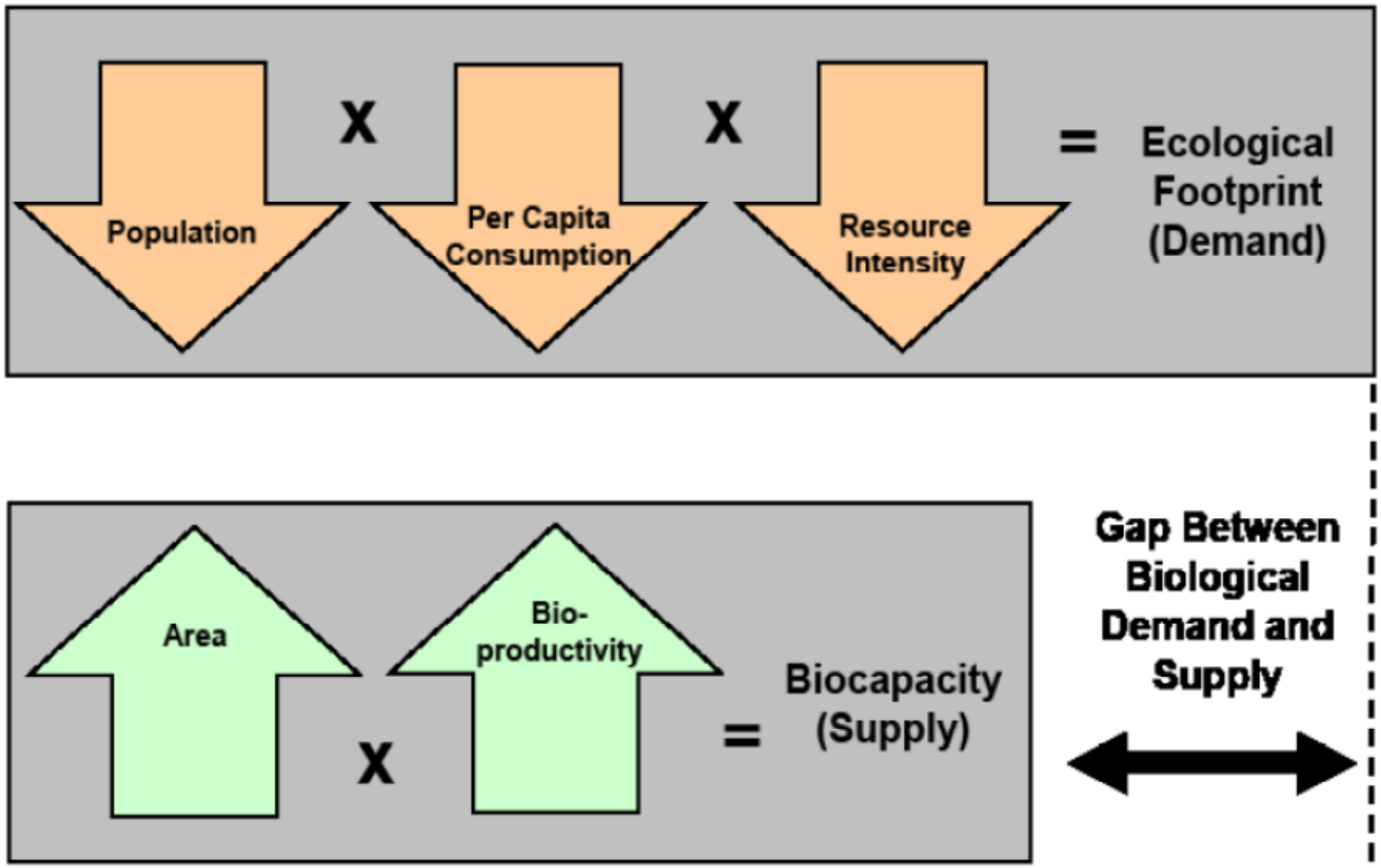
Human carrying capacity - the maximum rates of resource harvesting and waste generation that can be sustained indefinitely without progressively impairing the productivity and functional integrity of relevant ecosystems wherever these may be located (on earth).

Overshoot - growth beyond an area's (human) carrying capacity, potentially leading to ...

Societal collapse - e.g., historically Easter Island, Aztec Empire etc., more recently resource conflicts and genocides in Somalia, Rwanda, Sudan among many examples of overshoot-driven local societal collapse

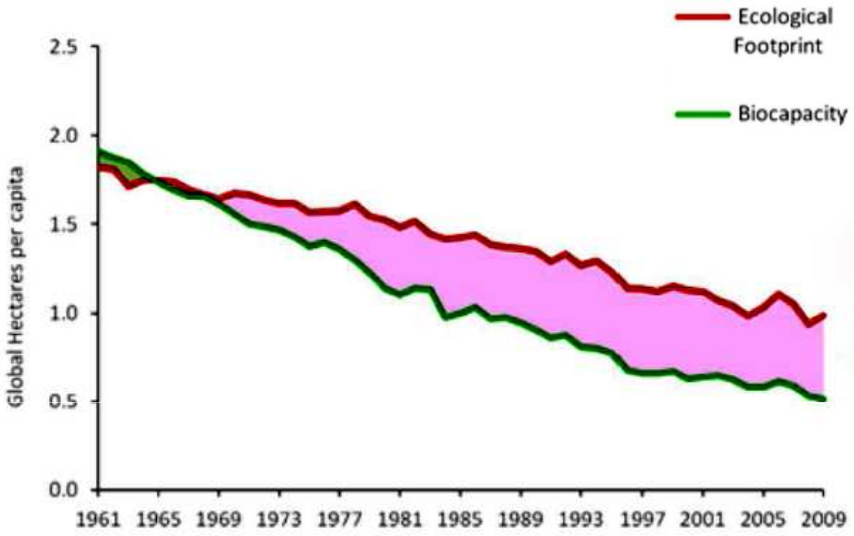
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Five factors of Biological Supply and Demand

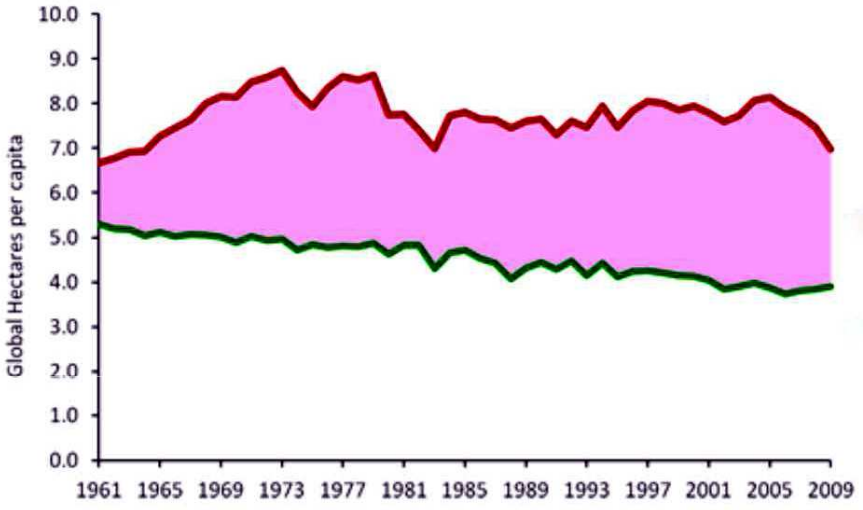


Source: Global Footprint Network: Africa's Ecological Footprint – 2006 Factbook

Kenya's Ecological Footprint and Bio-capacity 1961-2009

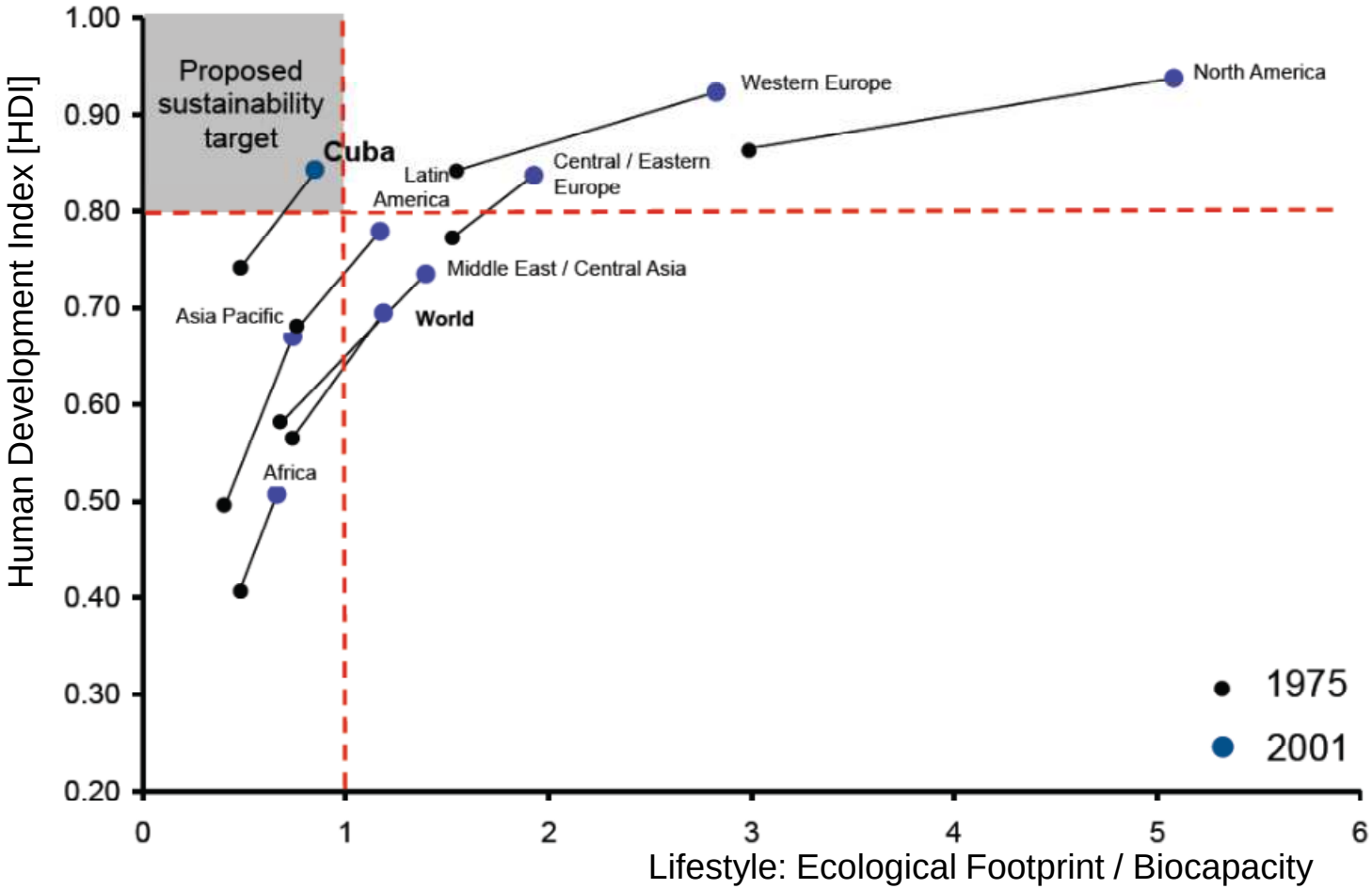


USA's Ecological Footprint and Bio-capacity1961-2009



Comparison, in absolute terms, of the average per person resource demand (Ecological Footprint) and per person resource supply (Bio-capacity) in Kenya and the USA over a 48 year period. Bio-capacity varies each year with ecosystem management, agricultural practices (such as fertilizer use and irrigation), ecosystem degradation, and weather.

Global lifestyles and Human Development



reproduced from: Moran et al., 2007 (in press), *Ecol. Economics*.

What ecological footprint accounts do not consider

Ecological Footprint - persistent pollutants other than CO2 (e.g. plutonium, PCB's, & CFC's), freshwater use and pollution etc. In general human demands on the biosphere for which there is insufficient data.

Bio-Capacity - Processes that irreversibly damage the biosphere such as species extinctions, fossil-aquifer depletion, deforestation, soil erosion, desertification etc. Though these would be reflected as reductions in future bio-capacity assessments.

Also for consistency and to keep the global hectares additive, each area is only counted once in the Ecological Footprint and Bio-Capacity estimates, even if an area provides more than one ecological service.

Footprint accounts thus tend to underestimate to Ecological Footprint, and to overestimate the bio-capacity (i.e. they are conservative).

Principle of competitive exclusion

Bio-capacity appropriated from global totals by humans is irreversibly not available to competing species. In short, "What we get, they don't."

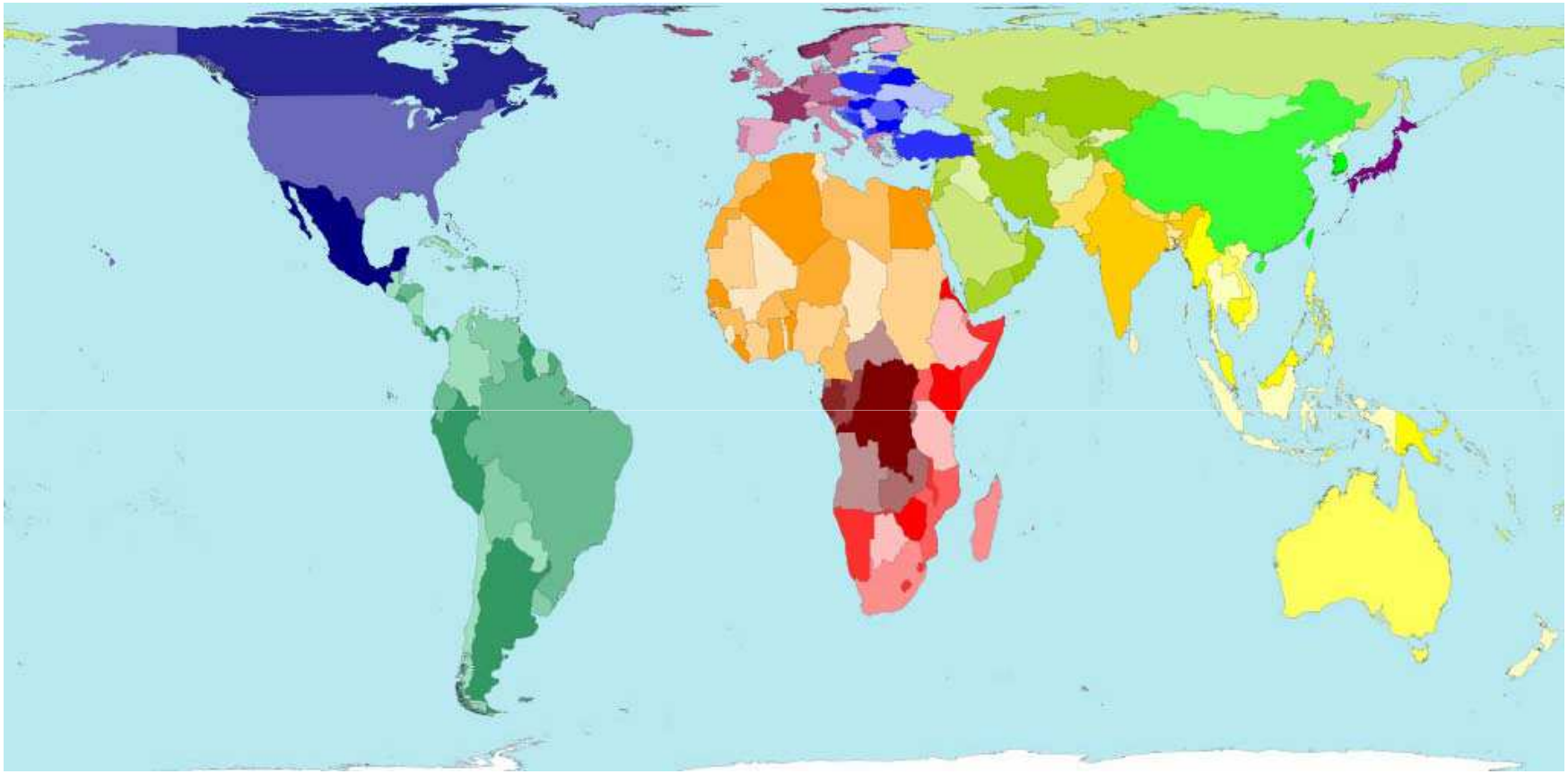
As a result of growing human demand, 12% of birds, 25% of mammals and 32+ % of amphibians are threatened with extinction during this century.

The current rate of species extinction is as much as 1000 times the pre-industrial rate.

The competitive exclusion principle also applies to the "they" in human societies. This is the man-made component of global poverty.

Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

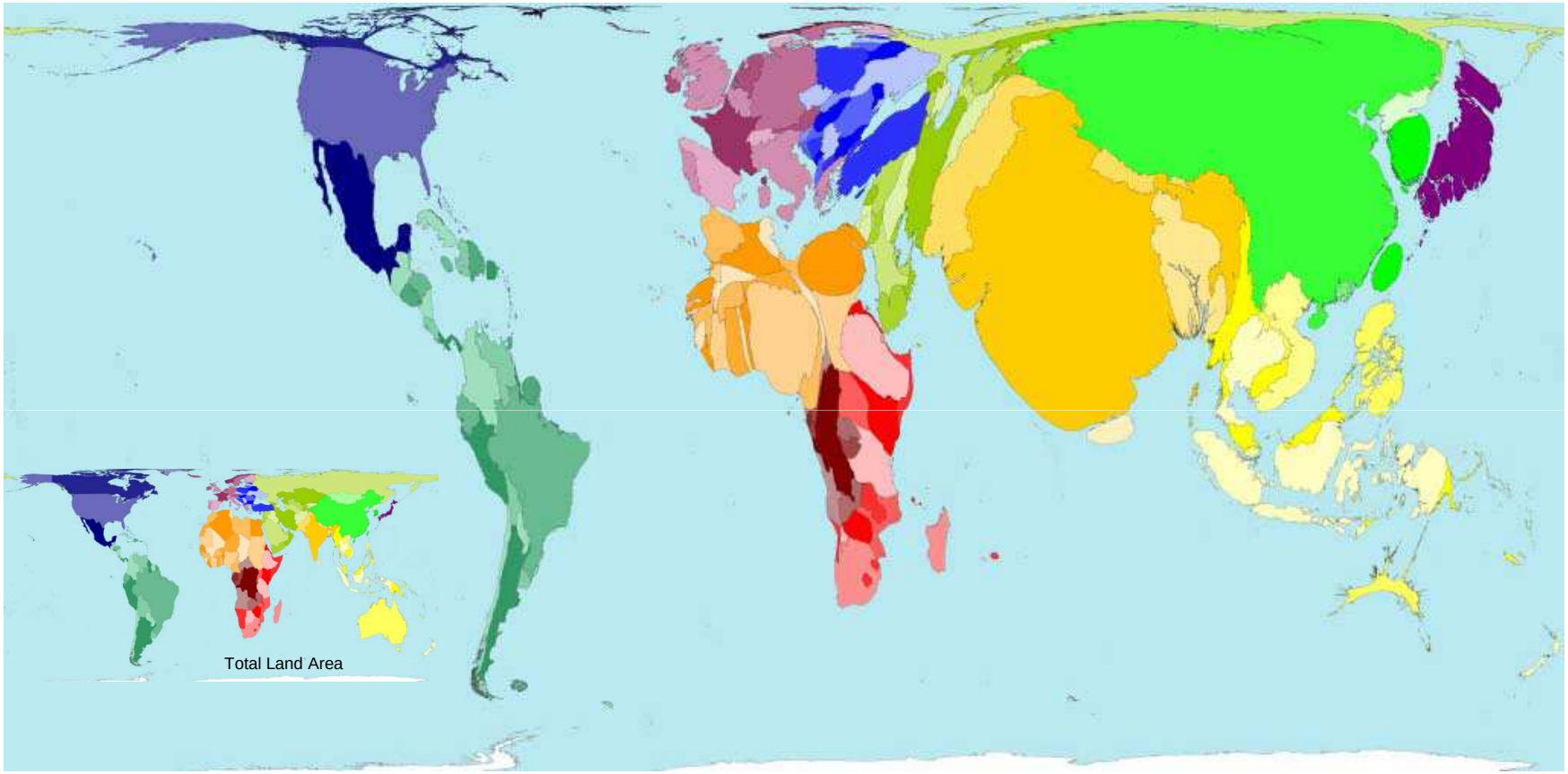
Total Land Area



http://www.worldmapper.org/

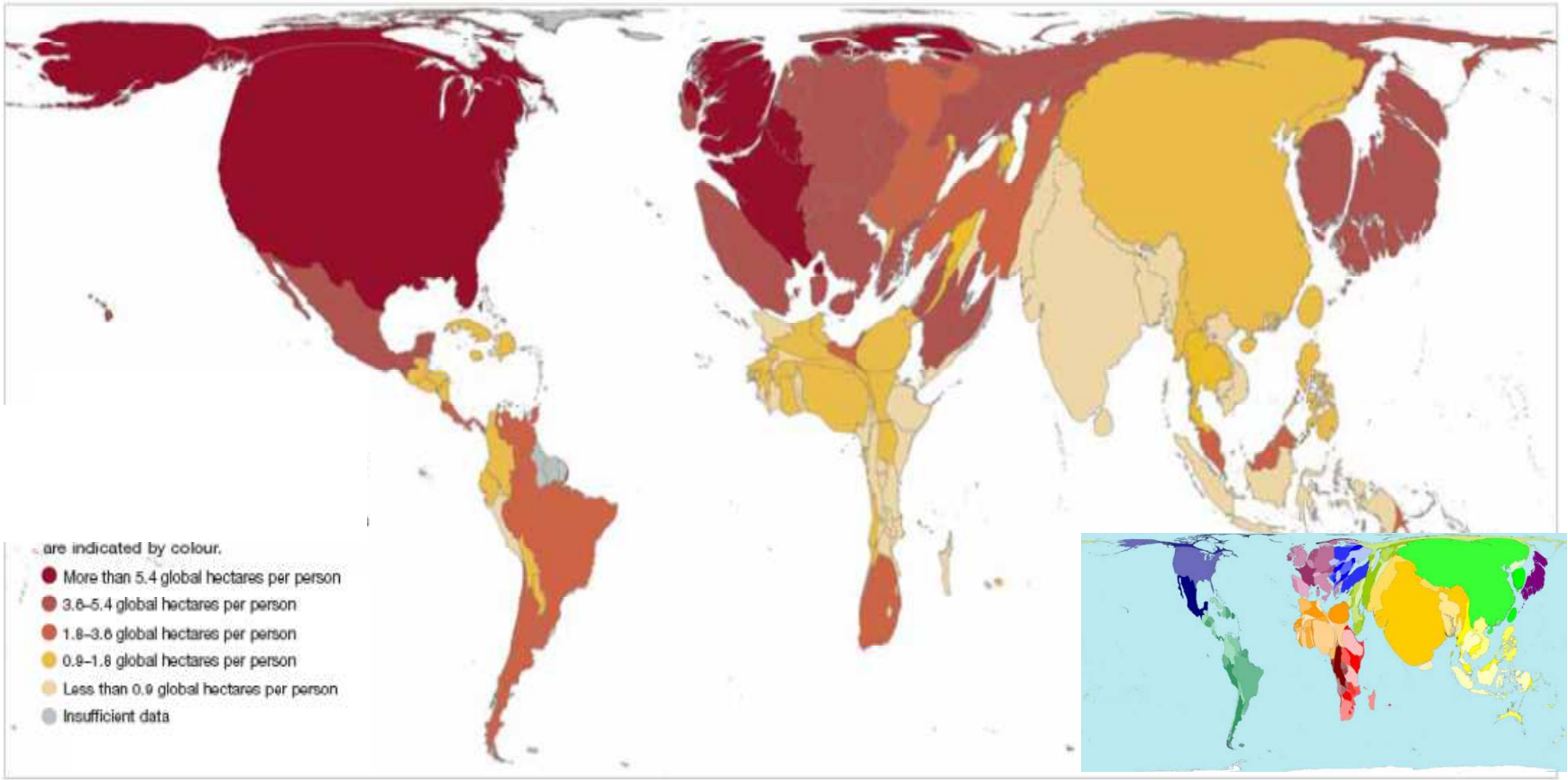
Faculty of Life Sciences
Albrecht-Daniel-Thaer Institute for Agricultural
and Horticultural Sciences
Prof. (retired) Dr. agr. H. J. Schwartz

Total Population



http://www.worldmapper.org/

Ecological Footprints around the World, 2003

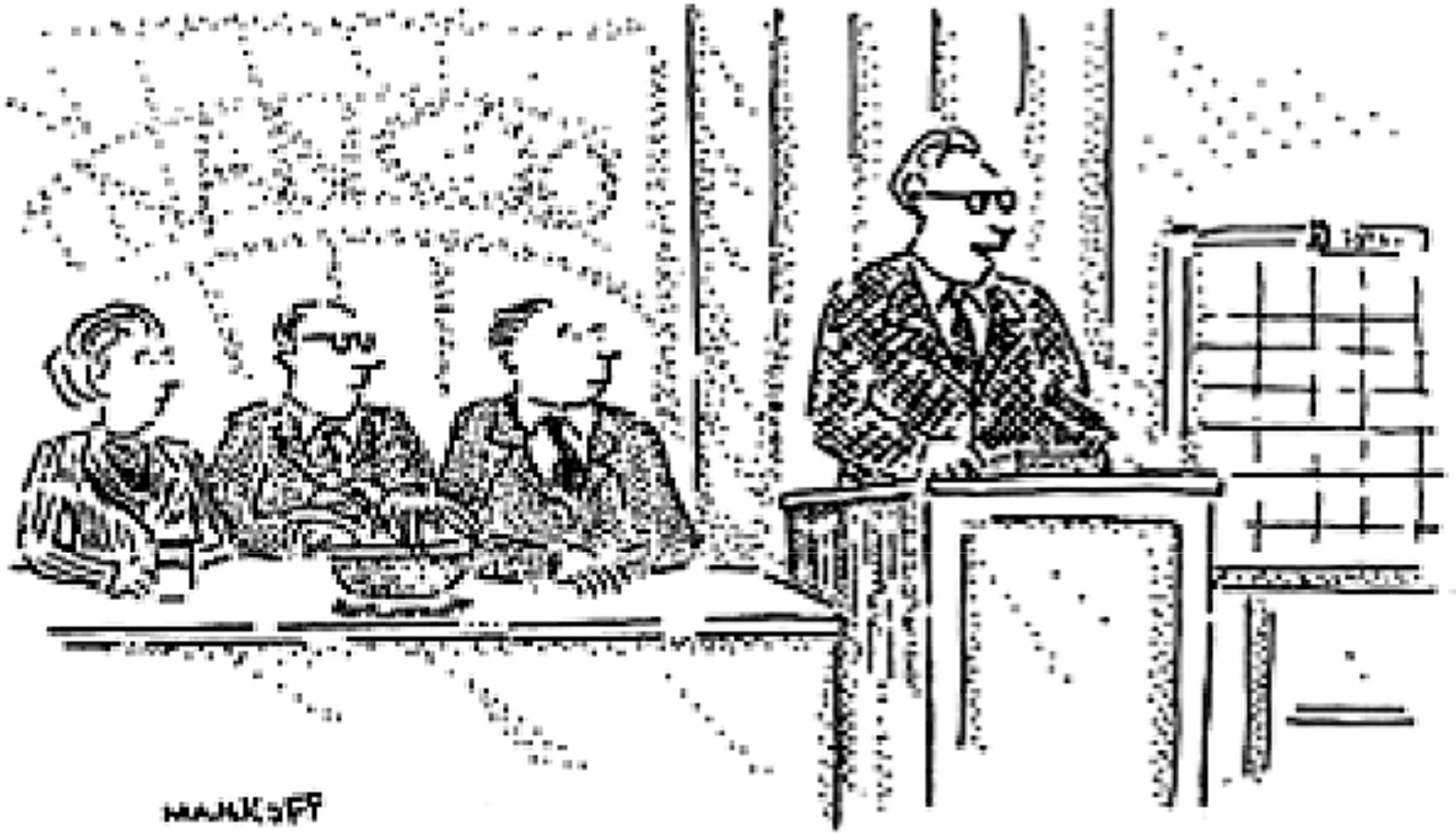


Source: WWF The Living Planet Report 2006

Nairobi, Mathare Valley

Source: Google Earth, Dec 2008


Nairobi, Muthaiga
Source: Google Earth, Dec 2008



And so, while the end-of-the-world scenario will be rife with unimaginable horrors, we believe that the pre-end period will be filled with unprecedented opportunities for profit.

from: W. Rees lecture, 2005 Iowa State University