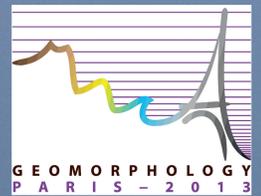


TRANSFORMATION OF EARTH'S SURFACE BY HUMANS

Martín Duque, J.F.¹, Hooke, R.L.², Pedraza, J.³

¹ Department of Geodynamics and Geosciences Institute (CSIC, UCM), Madrid, Spain; josefco@ucm.es
² School of Earth and Climate Sciences and Climate Change Institute, Orono, Maine, USA; rogerhooke@gmail.com
³ Department of Geodynamics, Complutense University, Madrid, Spain; javierp@ucm.es



ABSTRACT

Earth is moved and the landscape modified, commonly degraded, by many human activities (Fig. 1). Most of these activities have indirect effects well beyond the area directly affected, so the full impact of land transformation is much larger than suggested by Figure 1. Both the direct and the indirect impacts compromise ecosystem services that are essential for human survival. Continued degradation of agricultural land and expansion of urban land at the expense of prime agricultural land, together with our continuing disruption of crucial ecosystem services, will limit Earth's ability to provide an acceptable standard of living for even current populations.

We are already in a state of overshoot; our population, together with our standard of living, exceeds Earth's carrying capacity. This long-term sustainability issue is more serious than, but exacerbated by, climate change. The only viable long-term solution is to adopt measures that will first slow population growth and then reverse it.

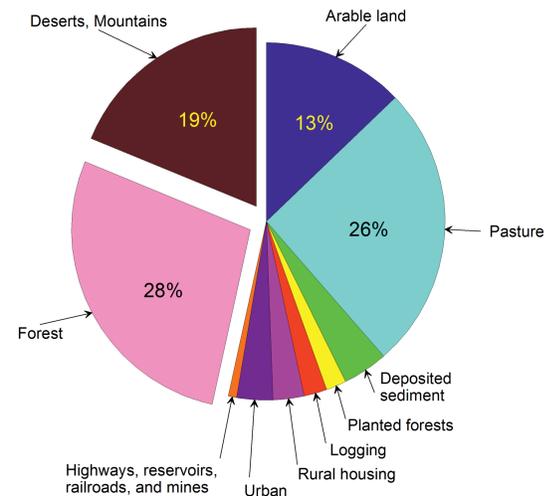


Figure 1. About 53% of Earth's ice free land area has been modified by human action (Hooke et al., 2012)

CROPLAND - The land use of most immediate concern in our effort to feed 7,000,000,000 people

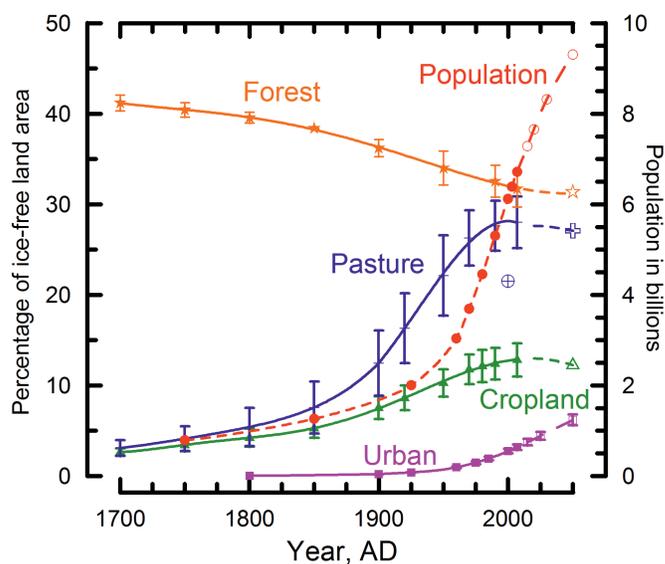


Figure 2. Extrapolating trends in cropland and pasture forward in time, we see a possible tendency for both to peak and then decrease

75% of Earth's land area is unsuitable for agriculture due to poor soils, steep topography, or adverse climate (Fisher et al., 2000)

Soil is degraded by:
 Erosion
 Depletion of nutrients
 Decrease in soil organic matter
 Decrease in soil biological activity

- As of 1990, soils on 40% of the global cropland and pasture had been degraded
- Of this, over half was so degraded that local farmers lacked the means to restore it (Oldeman et al., 1991)
- Nearly 0.3 Mkm² of farm land becomes non-productive annually due to soil degradation (Myers, 1992)

15,000 km² of prime agricultural land is lost to urban expansion annually (Döös, 2002)

The supply of phosphate for fertilizer is decreasing

Petroleum for operating farm machinery is becoming more expensive and less available

Water tables are declining in areas needing groundwater for irrigation (Gleick, 1993)

Pollution is adversely affecting pollinators, predators of agricultural pests, and plant growth

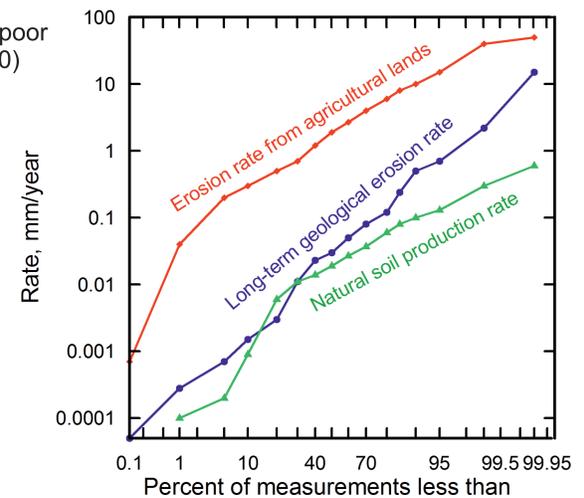


Figure 3. The erosion rate from agricultural land is 10 times the rate of soil formation (Montgomery, 2007)

WE ARE IN A STATE OF OVERSHOOT

Overshoot occurs when populations exceed the local carrying capacity

A population less than the carrying capacity is sustainable. When the population exceeds the carrying capacity, overuse of the environment sets up forces that, after a delay, first reduce the standard of living and then eventually the population (Figure 4)

Sustainability

A sustainable human population is one that (Daly, 1991):

- Uses renewable resources at a rate less than the rate at which they are renewed
- Uses non-renewable resources at a rate less than the rate at which substitutes can be found
- Discards waste at a rate less than the rate at which it can be absorbed by the environment

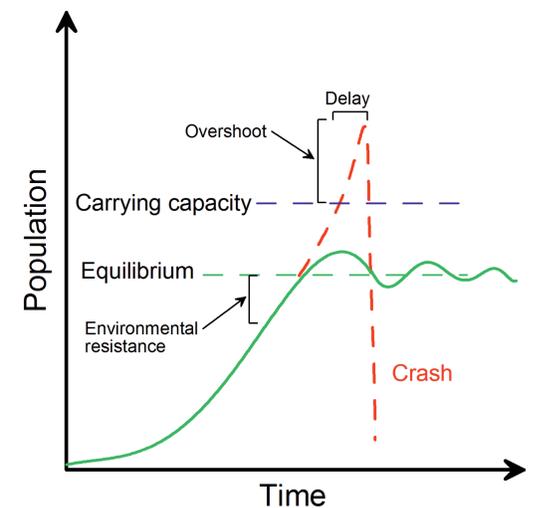
Our UNSustainable behaviour

- We harvest many renewable resources (e.g. forests, fish, groundwater) faster than they are renewed
- Our way of life is based on non-renewables (e.g. fossil fuels, phosphates, metals), accumulated over 4 billion years, with no clear plan for adequate substitutes once natural sources are exhausted
- We discard many chemicals (e.g. CO₂, N, plastics) faster than they can be absorbed, thus fouling our environment

The correction may have started

- We struggle to supply the food and water needed by the present population
- Economic growth rates are stagnant or negative; unemployment is widespread and high
- Diseases resulting from undernourishment are on the increase
- Conflict is frequently in the news

Figure 4. Populations that overshoot carrying capacity are likely to crash (after Boughey, 1973)



SOLUTIONS

Reduce demand

- Conserve energy
- Recycle
- Don't buy things we don't really need

Develop technological solutions

- Technology has enabled us to support an increasing population
- Technology can exacerbate a problem:
 - * Petroleum has increased agricultural efficiency, but has left us dependent on a non-renewable resource
 - * Mechanical well drilling and pumping facilitated irrigation, but groundwater tables are dropping

Reduce the population

- Increase women's health care and education in developing countries
- Wait, and stop at two*

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