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Ecological Footprints

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February 11, 2014

Ecological Footprint (EF) analysis is an accounting framework that measures human appropriation of ecosystem products and services in terms of the amount of bioproductive land and sea area needed to supply these products and services.

There are different types of EFs:

- **personal**
- **regional (*e.g.*, town, city, state)**
- **national**
- **global**

The Two Components of an EF Analysis

EF of consumption: an estimate of the renewable biological resources required for consumption by a specified human population and for assimilation of its carbon wastes.

Biocapacity: The amount of biological productivity available within the six land-use types.

Both are converted into an abstract land unit (global hectares or gHa) representing the bioproductivity of a world-averaged hectare (1 Ha = ~2.5 acres).

EF and biocapacity calculations cover six land use types:

- cropland
- grazing land
- fishing ground
- forest land
- built-up land
- uptake land to accommodate the carbon footprint

Ecological Footprint accounting is based on six fundamental assumptions (adapted from Wackernagel *et al.*, 2002)

- The majority of the resources people consume and the wastes they generate can be quantified and tracked.

- An important subset of these resource and waste flows can be measured in terms of the biologically productive area necessary to maintain flows. Resource and waste flows that cannot be measured are excluded from the assessment, leading to a systematic underestimate of humanity's true Ecological Footprint.

- By weighting each area in proportion to its bioproductivity, different types of areas can be converted into the common unit of global hectares, hectares with world average bioproductivity.

- Because a single global hectare represents a single use, and each global hectare in any given year represents the same amount of bioproductivity, they can be added up to obtain an aggregate indicator of Ecological Footprint or biocapacity.

- Human demand, expressed as the Ecological Footprint, can be directly compared to nature's supply, biocapacity, when both are expressed in global hectares.

- Area demanded can exceed area supplied if demand on an ecosystem exceeds that ecosystems regenerative capacity.

Table 1. Calculation of biocapacity and footprint of consumption in non-carbon land-use types.

Land-Use Category	Biocapacity	Footprint of Consumption	Comment
Cropland	Combined annual productivity (net growth) of all cropland.	Annual harvests (production) of primary and derived crop products.	Since biocapacity and footprint of consumption are by definition always roughly equal [18], the methodology cannot detect any substantial depletion or surplus of natural capital in croplands. Hence, the EF is currently unable to indicate the sustainability or unsustainability of this land-use category.
Grazing land	The amount of above-ground net primary production in grasslands per year.	Total annual feed requirement for livestock minus cropped feeds.	As with croplands, the footprint of consumption usually closely matches—and never exceeds—the biocapacity. The EF is, therefore, currently unable to indicate the sustainability or unsustainability of this land-use category.
Forest	Net annual increment of merchantable timber.	Annual harvests of fuelwood and timber to supply forest products.	The EF is able to register depletion or surplus of natural capital, in the form of wood biomass. Biocapacity has exceeded footprint of consumption by an average of 224% between 1961 and 2008 [21]. In other words, less than one third of annual growth in biomass is harvested for human use. Note, however, that the EF does not register declines in global forest area [47] or ongoing losses of primary forests in exceptionally biodiverse tropical regions [33].
Fishing ground	Total sustainably harvestable primary production per year, based on estimates of sustainable annual production converted to primary production by accounting for the trophic level of each harvested species, transfer efficiency of biomass between trophic levels, and the discard rate for bycatch.	Annual primary production required to sustain the harvested fish, converted to primary production in the same way as for biocapacity.	The surplus shown by the EF's thermodynamic methodology stands in contrast to other data on fisheries, with the FAO reporting 87% of stocks either fully exploited or overexploited [25]. As Kitzes et al. (2009) note, this category "ignore[s] the importance of availability and quality of fishing stocks (including large variation in harvest rates across different target species) in determining actual regenerative capacity in a given year."
Built-up land	The area covered by human infrastructure, including transportation, housing, industrial structures, and reservoirs for hydroelectric power generation. Both the footprint of consumption and biocapacity of built-up land are defined as the bioproductivity of an equivalent area of cropland. This land-use category is always in equilibrium, since both quantities capture the amount of bioproductivity lost to encroachment by physical infrastructure [18].		The constant equilibrium of this component means that the EF is unable to illustrate the sustainability of this land-use type; neither about cities and infrastructure as such (they always count for the same), nor about the expansion of built-up land (one land-use type in equilibrium replaces another with no effect on the global ecological surplus or deficit).

doi:10.1371/journal.pbio.1001700.t001

Table 2. Net carbon sequestration in forest plantations.

Climate Domain	Ecological Zone	Above-Ground Net Carbon Sequestration (t C ha^{-1} yr^{-1})
Tropical	Rain forest	7.1
	Moist deciduous forest	4.7
	Dry forest	3.8
	Shrubland	2.4
	Mountain systems	2.4
Subtropical	Humid forest	4.7
	Dry forest	3.8
	Steppe	2.4
	Mountain systems	2.4
Temperate	Oceanic forest	2.1
	Continental forest	1.9
	Mountain systems	1.4
Boreal	Coniferous forest	0.5
	Tundra woodland	0.2
	Mountain systems	0.5

Note: Approximate above-ground net carbon sequestration in forest plantations (t C ha^{-1} yr^{-1}) by ecological zone, as reported in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories [48].

doi:10.1371/journal.pbio.1001700.t002

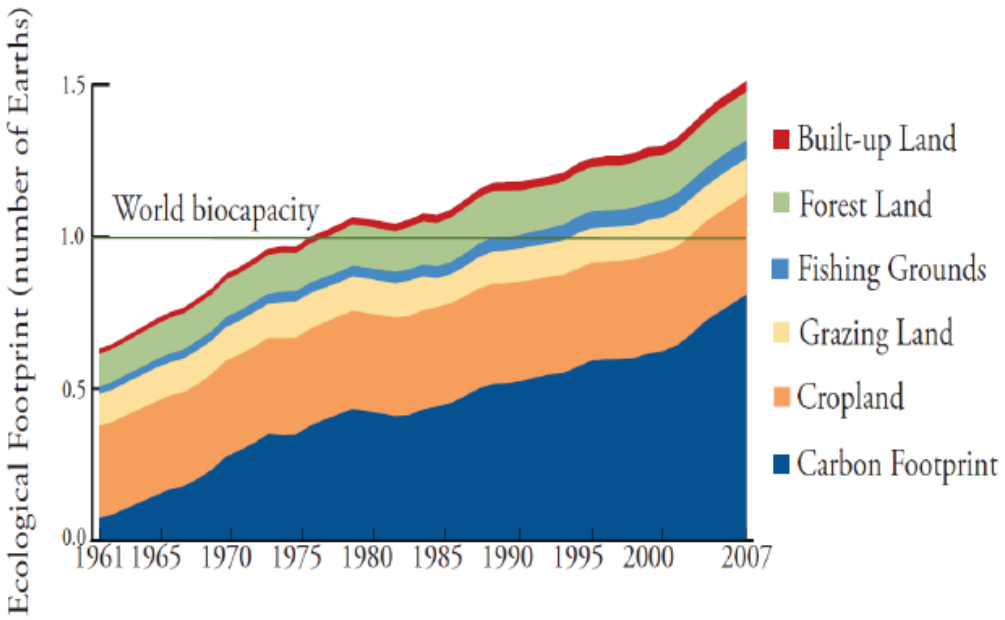


Figure 5: *World overshoot according to the 2010 Edition of the National Footprint Accounts.* Humanity's Ecological Footprint, expressed in number of planets demanded, has increased significantly over the past 47 years.

1961 is the first year for which National Ecological Footprints are available.

Human demand first exceeded the planet's biocapacity in the mid-1970's.

The largest absolute change in the six components that comprise the NEF since 1961 has occurred in the carbon footprint.

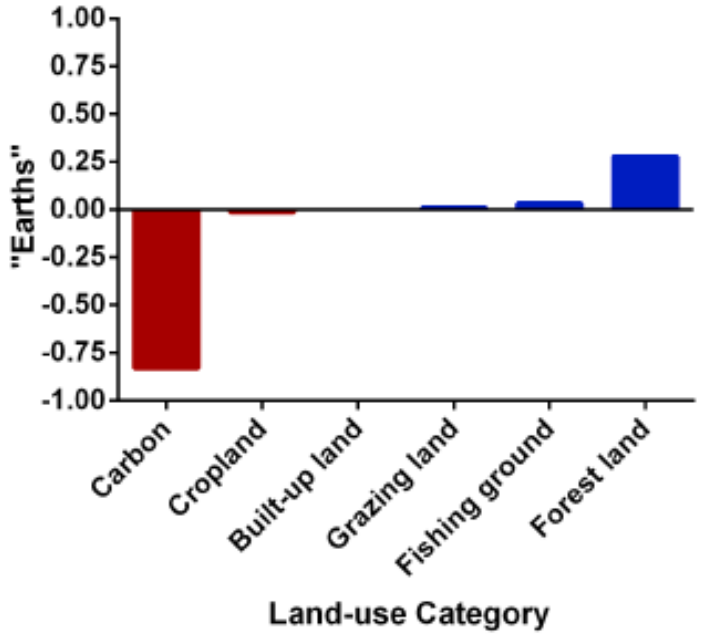


Figure 1. Net biocapacity (biocapacity minus footprint of consumption) by land-use category, shown as a fraction of total global biocapacity (one "Earth") in 2008. Red bars indicate deficit, blue bars surplus. The sum of the net biocapacity of all land-use types is approximately −0.5, corresponding to the claim that humanity is using "1.5 Earths" worth of biocapacity every year [21].
doi:10.1371/journal.pbio.1001700.g001

Blomqvist *et al.*, *PLOS Biology* **2013**, *11*, e1001700

When the global EF is decomposed into its six components, none of the five non-carbon land-use categories has any substantial ecological deficit. Virtually all of the ecological overshoot comes from the EF's measure of the rate at which CO_2 is accumulating in the atmosphere.

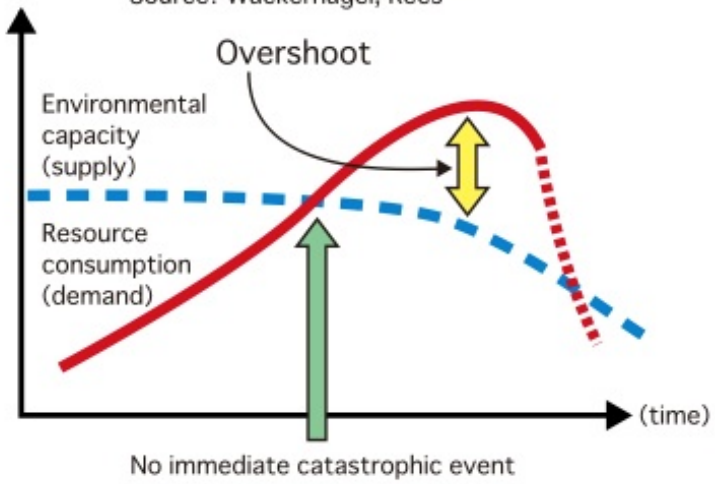
Humanity's global EF is practically equivalent to its carbon footprint.

Carbon footprint area is essentially calculated by dividing total anthropogenic carbon emissions remaining after accounting for ocean uptake (*i.e.*, 72% of net human emissions) by the rate at which existing forests sequester carbon.

Slight adjustments to the assumed carbon sequestration rate can produce wildly different outcomes ranging from global ecological surplus to infinite overshoot.

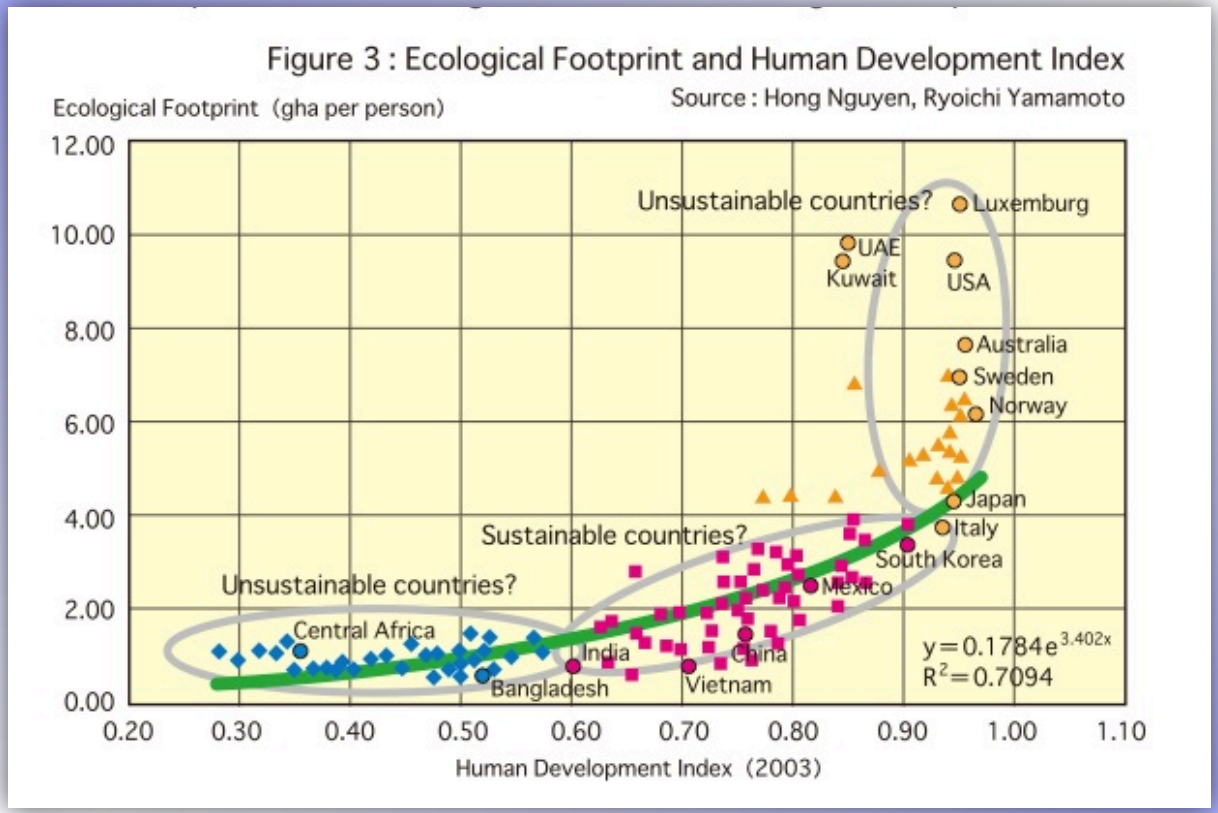
Figure1: The Concept of Overshoot

Source: Wackernagel, Rees [8]



Overshoot occurs when the environment's capacity and the limits to growth are exceeded. If there are large stocks of natural resources, exceeding the limit will not result in immediate catastrophe. Ecological limits can easily be surpassed. Harvests can continue to increase, as can profits and prices. There may be some signs of strain on the ecosystem, but in general, everything seems to be going fine. However, this depletion of natural resources may lead to large ecosystem disasters, as well as smaller incidents in the long term.

Relationship between EF and the HDI



HDI is calculated using lifespan, education level and earnings per capita.

Table 1
The advantages and limitations of the ecological footprint

Advantages	Limitations
	Is an areal unit a suitable measure?
Unambiguous message	A static analysis
Simple to calculate	Ignores technological change
Includes trade	Ignores underground resources
It is a stock	Ignores flows
	Lacks measures of equity
	No policy prescriptions

Moffatt, I., *Ecol. Econ.* **2000**, *32*, 359-362

Class Assignment – see Sakai

Personal Ecological Footprint

Institute for Sustainable Energy

www.sustainenergy.org

860-465-0256

Complete an online Ecological Footprint calculator http://www.myfootprint.org/

Acres Calculated _____ Number of Earths _____

- How did the online calculation differ from your paper calculation?
- Which calculator do you feel, portrays your lifestyle more accurately? Why?
- What items would you value differently in the paper calculator? Would revaluing those numbers affect other people's Calculation?
- Make a commitment to reducing your Ecological footprint!