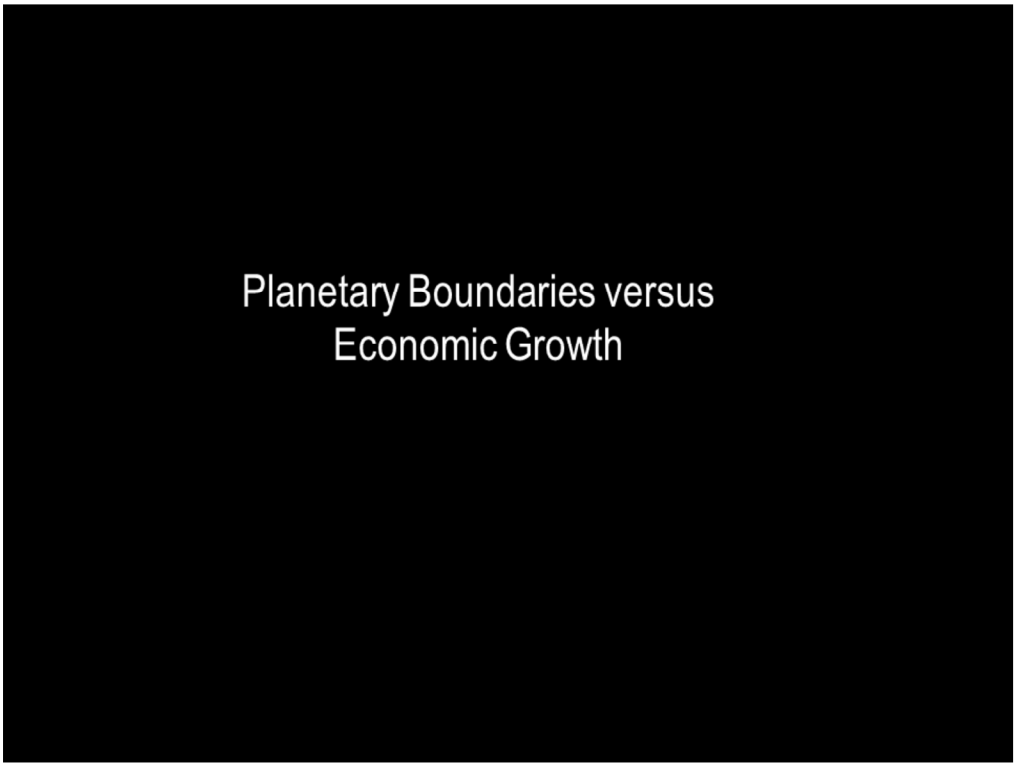
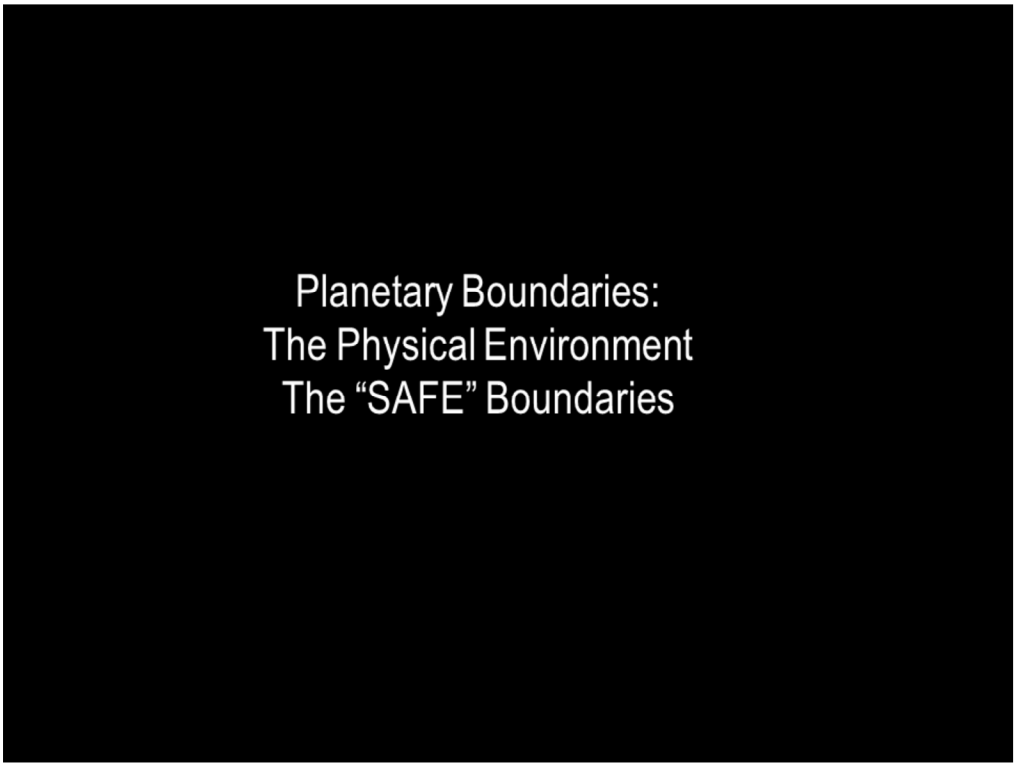
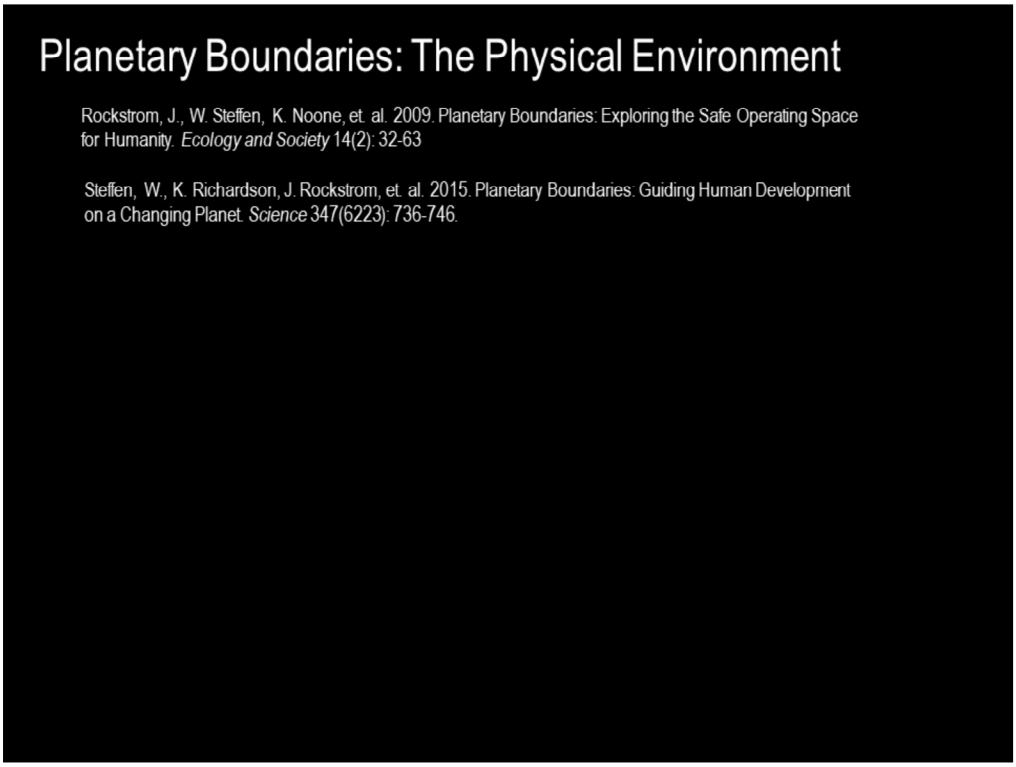


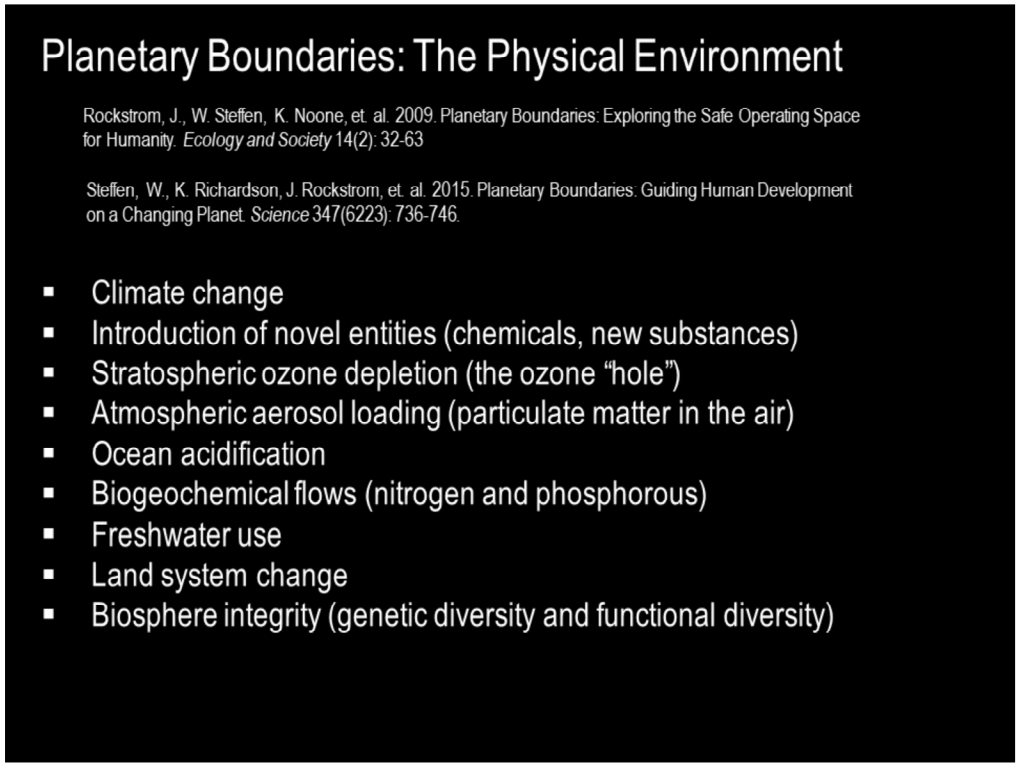
- The idea behind planetary boundaries is to define the “operating space” that humanity has on planet Earth.
- It rests of the premise that humanity cannot expand indefinitely.
- It contains two aspects: (1) boundaries related to the physical environment, and (2) boundaries related to the social foundations of society.



- The first aspect of planetary boundaries involves the physical environment.
- These physical/environmental boundaries constitute what is known as the “SAFE” component of the operating space is which humanity operates.



- This “safe” operating space for humanity was originally defined in 2009 and updated in 2015.
- They defined nine planetary boundaries that define the space in which humanity can develop without jeopardizing the relative stability of the current Earth system.
- The goal is to develop quantitative indicators for each.



These are the nine boundaries they identified (they are listed in the order they appear in the graphic on the next slide):

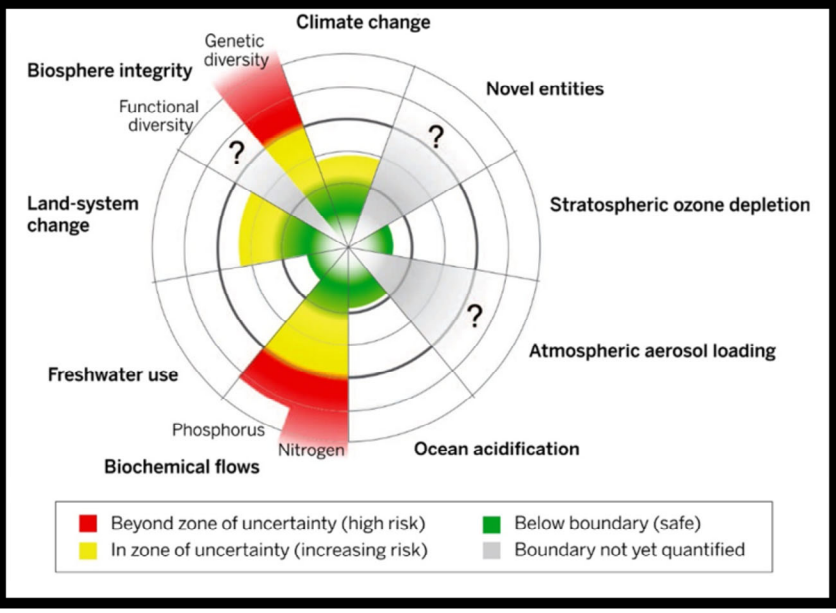
- Climate change is measured by the changes that have occurred in the last 140 years to the amount of CO2 in the atmosphere and the amount of radiative forcing that occurs (processes that drive changes to the climate).
- A substantial number of novel entities such as chemicals and other new substances have been introduced onto the planet, and their impact on humans is uncertain. Note that no quantitative measure has yet been developed tor these even though it is certain that they have effects on humans.
- Stratospheric ozone is the protection from UV radiation from the sun that this layer in the upper atmosphere provides. It is well known that human activity has caused this layer to thin.
- Atmospheric aerosol loading is the amount of particulate matter in the air. Note that no quantitative measure has yet been developed tor this even though it is certain that it has effects on humans.
- Ocean acidification is the extent to which the global ocean is becoming more acidic. This negatively impacts the many oceanic organisms that produce calcium-based shells, and a decreased presence of these organisms poses substantial risks for life on the planet.
- Biogeochemical flows, particularly the nitrogen and phosphorous cycles

which are naturally occurring but have been substantially altered by fertilizer use.

- Freshwater use entails surface water in lakes and rivers and also groundwater.
- Land system change affects the exchange of energy, water, and momentum between the land surface and the atmosphere
- Biosphere integrity entails both genetic diversity and functional diversity which are, respectively, the rate at which species are going extinct and how ecosystems are changing.

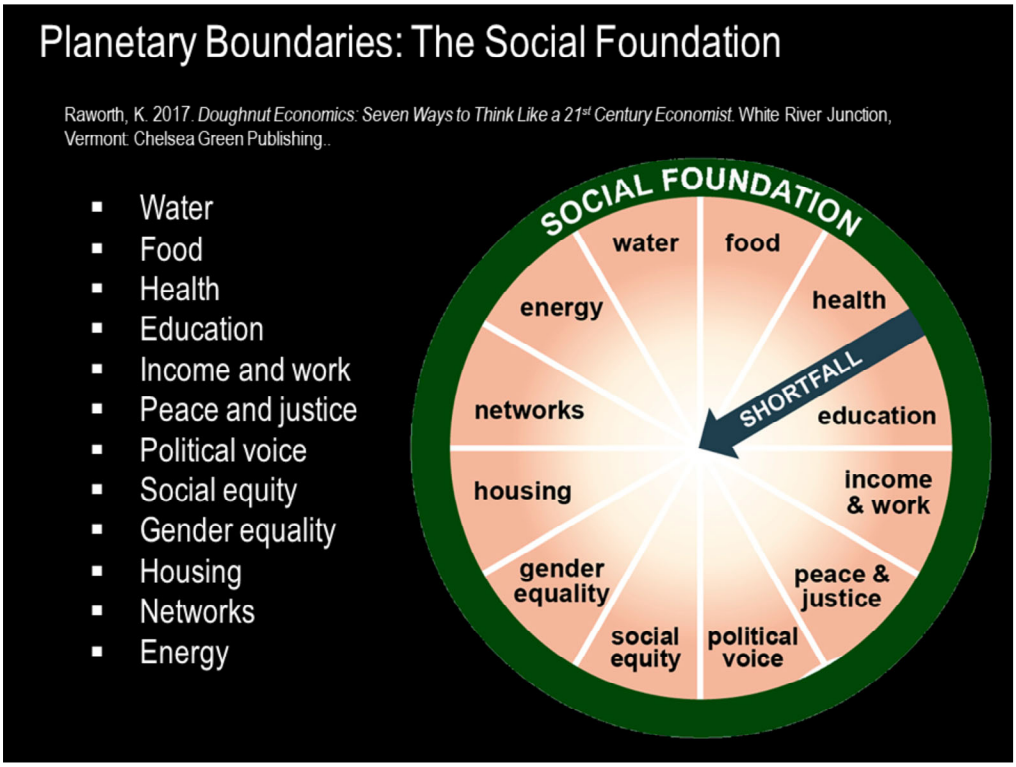
Planetary Boundaries: The Physical Environment

Steffen, W., K. Richardson, J. Rockstrom, et. al. 2015. Planetary Boundaries: Guiding Human Development of a Changing Planet. *Science* 347(6223): 736-746.



- The status as of 2015 for these planetary boundaries is shown in this figure. The green zone is the safe operating space (below the boundary), yellow represents the zone of uncertainty (increasing risk), and red is the high-risk zone.
- Note that four of the “safe” boundaries had been exceeded at this time and two of those are in the “high risk” area.

- In addition to the physical environment, boundaries have also been defined for what has been called the “social foundation.”
- These reflect what is known as the “JUST” boundaries for an operating space that achieves the fundamental social needs that should be attained by all people.
- These have been expressed in a number of ways including the United Nations Sustainable Development Goals.



Kate Raworth drew from the various expressions of these to develop twelve foundations for which she provided quantitative indicators.

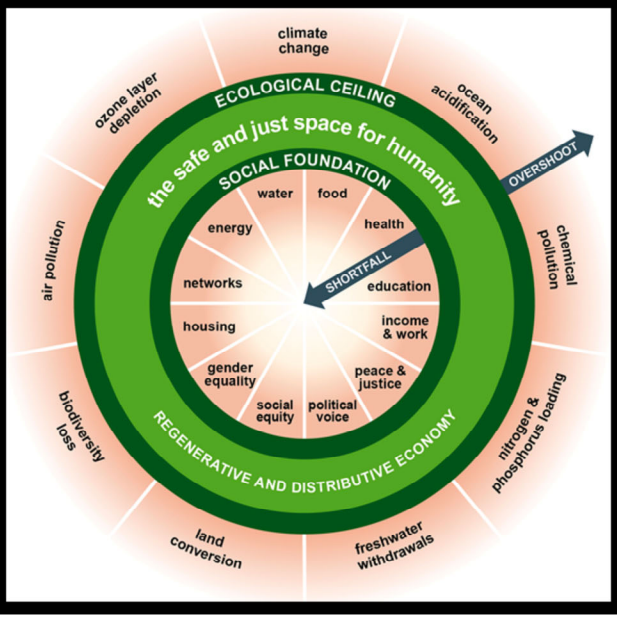
- Water and Sanitation – measured by the percent of the population without access to improved drinking water and the percent of the population without access to improved sanitation.
- Food – measured by the percent of the population that is undernourished
- Health – measured by (1) the percent of the population living in countries with under-five year old mortality exceeding 25 per 1,000 live births; and (2) percent of the population living in countries with life expectancy at birth of <70 years.
- Education – measured by (1) percent of adult population (aged 15+ years) who are illiterate; and (2) percent of population aged 12-15 who are out of school.
- Income and work – measured by (1) percent of population living on less that the international poverty limit of $3.10 per day; and (2) percent of young people (aged 15-24 years) seeking but unable to find work.
- Peace and justice – measured by (1) percent of the population living in countries scoring 50 or less out of 100 on the Corruption Perceptions Index; and (2) percent of the population living in countries with a homicide rate of 10 or more per 10,000.

- Political voice – measured by the percent of the population living in countries scoring 0.5 or less out of 1.0 on the Voice and Accountability Index.
- Social equity – measured by the percent of the population living in countries with a Palma ratio of 2 or more (the ratio of the income share of the top 10% of people to that of the bottom 40%).
- Gender equality – measured by (1) the representation gap between women and men in national parliaments; and (2) the worldwide earnings gap between women and men.
- Housing – measured by the percent of the population in developing countries living in slum housing.
- Networks – measured by (1) the percent of the population stating that they are without someone to count on for help in times of trouble; and (2) percent of the population without access to the Internet.
- Energy – measured by (1) the percent of the population lacking access to electricity; and (2) percent of the population lacking access to clean cooking facilities.

- The third definition of planetary boundaries combines the SAFE and JUST boundaries, that is, the physical and social foundations boundaries, respectively.
- This produces what is known as the “safe and just operating space for humanity.”

Planetary Boundaries: A Safe and Just Operating Space

Raworth, K. 2017. *Doughnut Economics: Seven Ways to Think Like a 21st Century Economist.* White River Junction, Vermont: Chelsea Green Publishing..



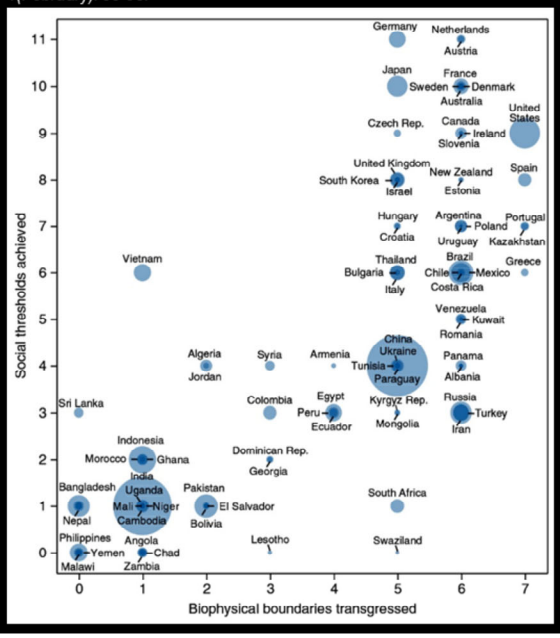
- This graphic shows the “doughnut” that Kate Raworth developed which shows the safe and just operating space for humanity.
- The “doughnut’ is the space shown in green where the just social foundations are met within the constraints imposed by the physical environment.
- Note that this graphic shows neither the extent to which either the social foundations are met or the physical/environmental boundaries are transgressed.

- This graphic shows the status of the “safe” boundaries and the “just” social foundations as of 2017.
- Note that four of the “safe” boundaries have been exceeded (climate change, nitrogen and phosphorous loading, land conversion, and biodiversity loss) and none of the social foundations have been met.

- In 2018, O'Neill and his colleagues used similar but slightly different safe and just planetary boundaries, for which they used quantitative indicators.
- What they added was a "conceptualization of how resource use and social outcomes are linked" (89).
- They investigated "what level of biophysical use is associated with meeting people's basic needs, and whether this level of resource use can be extended to all people without exceeding critical planetary boundaries" (89).

Planetary Boundaries: A Safe and Just Operating Space

O'Neill D. W,, A. L. Fanning, W. F. Lamb, and J. K. Steinberger. 2018,. A Good Life for All within Planetary Boundaries. *Nature Sustainability 1(February): 88-95.*



- Unfortunately, their results were not encouraging.
- This figure from their research shows the number of social thresholds achieved versus the number of biophysical boundaries transgressed for different countries (scaled by population).
- Ideally, countries would be located in the top-left corner, but this is not the case.
- As the authors state, "No country performs well on both the biophysical and social indicators. In general, the more social thresholds a country achieves, the more biophysical boundaries it transgresses and vice versa. Many wealthy nations achieve the majority of the social thresholds, but at a level of resource use that is far beyond the per capita biophysical boundaries" (pp. 90-91).

- Humphries states that "The 'safe' boundaries and the 'just' ones are thus not merely in tension but potentially in outright contradiction" (2).
- O'Neill and colleagues state that their findings "represent a substantial challenge to current development trajectories" (92) and that the concept of "development" needs to be fundamentally restructured. They state that a hopeful scenario would see development "shift away from growth towards an economic model where the goal is sustainable and equitable human well-being" (93).