Australian National University

Promise the Earth:

on the necessary relationships between Earth system science and international environmental law

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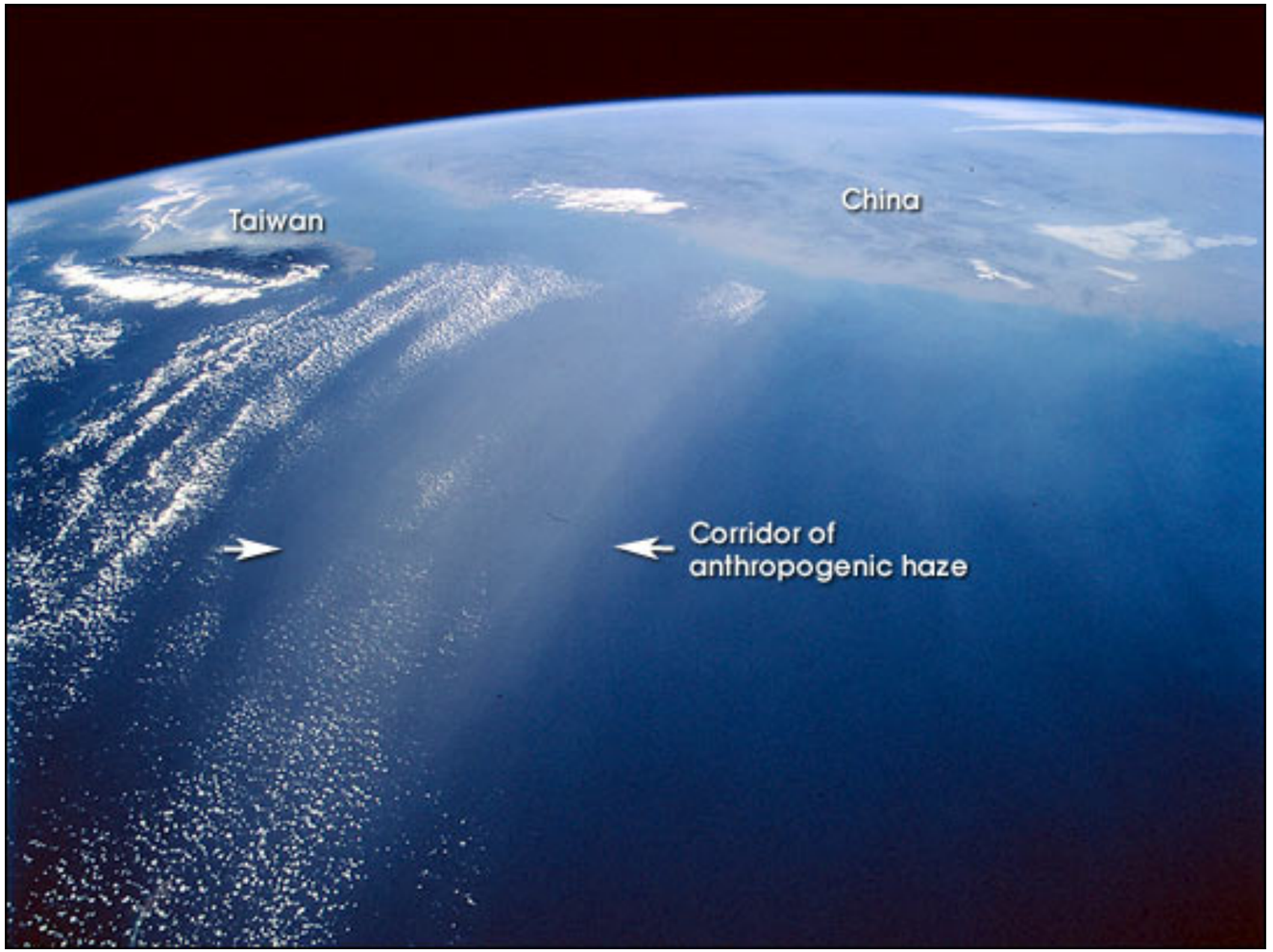
What kind of system is Earth?



Mainstream scientific understanding of Earth

- Earth is a ‘thermodynamic system’ driven by energy from the sun
- Earth is materially a closed system
- Earth is a ‘living planet’ or at least a ‘planet full of life’
- Earth’s physical environmental conditions have ‘co-evolved’ with life
- Earth is a complex adaptive system comprised of coupled sub-systems, ‘non-linear’ feedbacks, and remains ‘full of surprises’
- Earth has ‘planetary boundary conditions’ within which the human endeavour must learn to live within in order for life-supports systems to continue to support ‘life as we know it’

PLANETARY BOUNDARIES

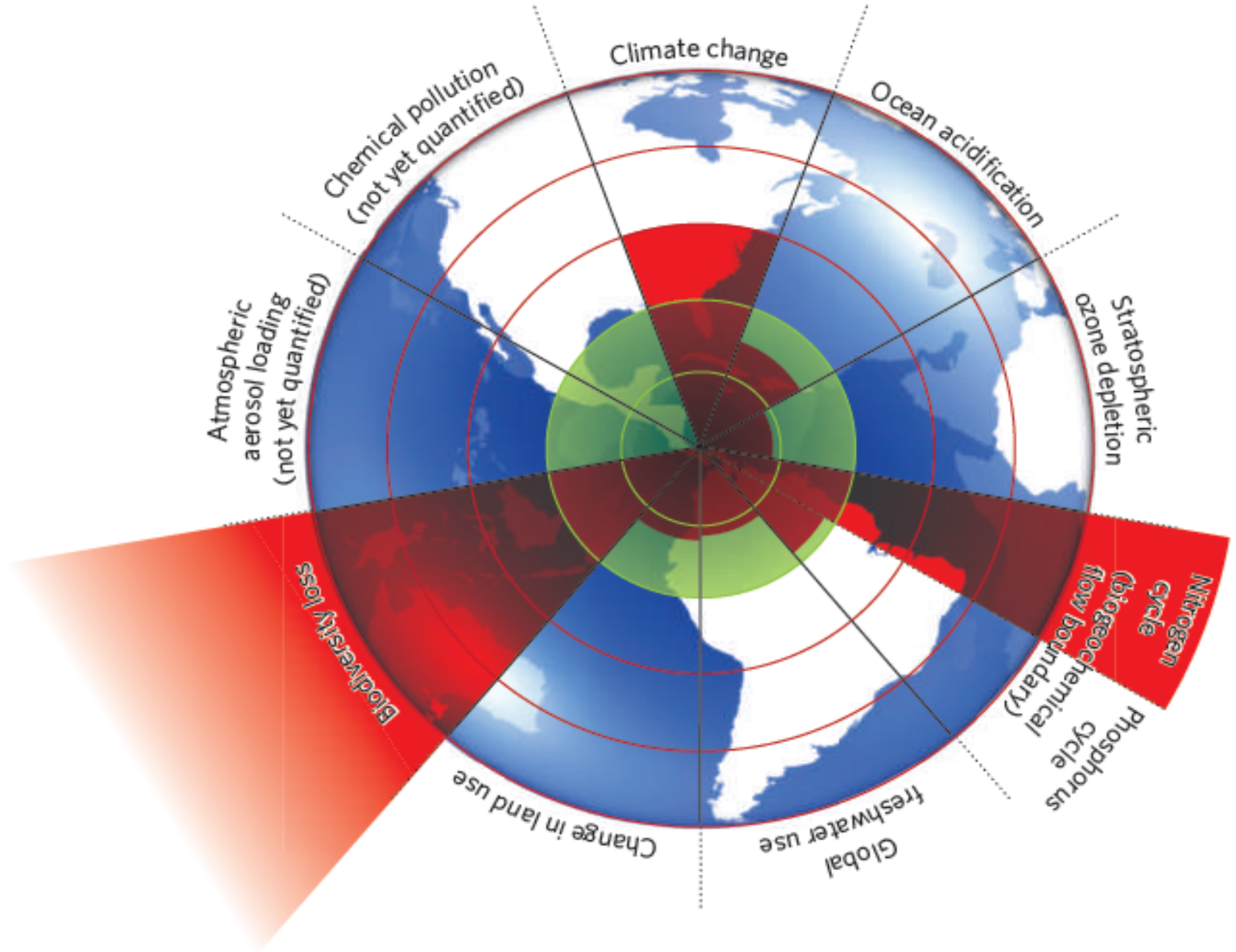
Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

Each boundary threshold value represents a scientifically-based 'tipping point' beyond which the probability of serious global environmental is likely

Together these 10 planetary boundary conditions define a 'safe operating space' for the aggregate impact of the human endeavour

Source: Rockstrom et al. NATURE|Vol 461|24 September 2009

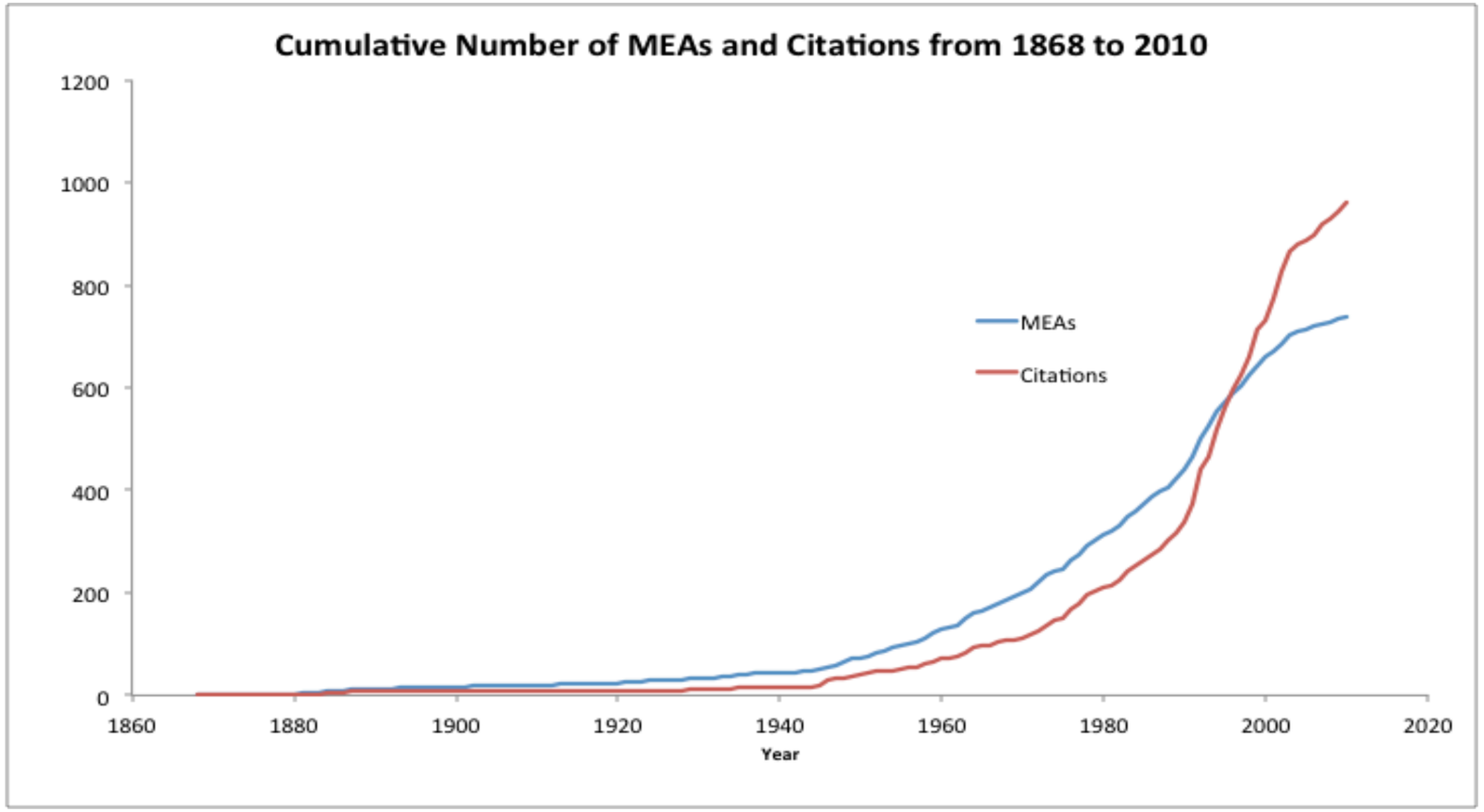


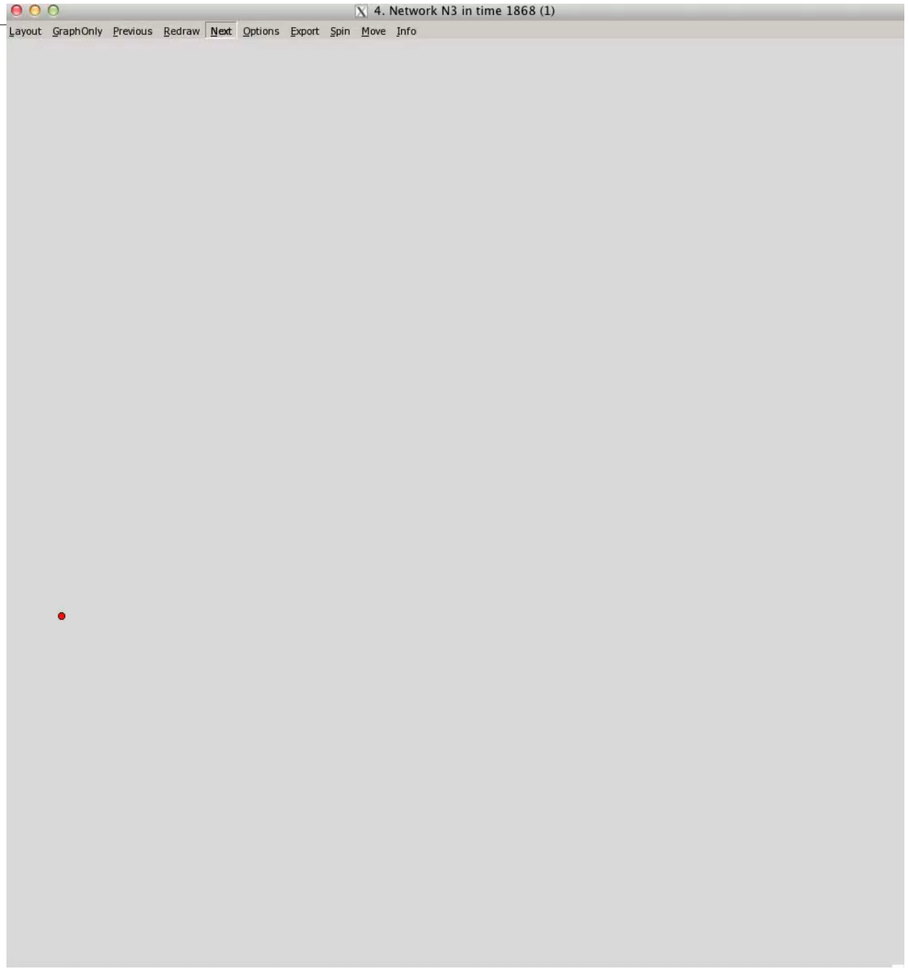
The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

Is current system of international environmental law up to the challenge?

- There are 738 Multilateral Environmental Agreements (MEAs)
- With 961 cross-references
- We can use these MEAs and cross references to explore the structure of this system using network analysis theory and tools

MEA network evolution 1868-2010

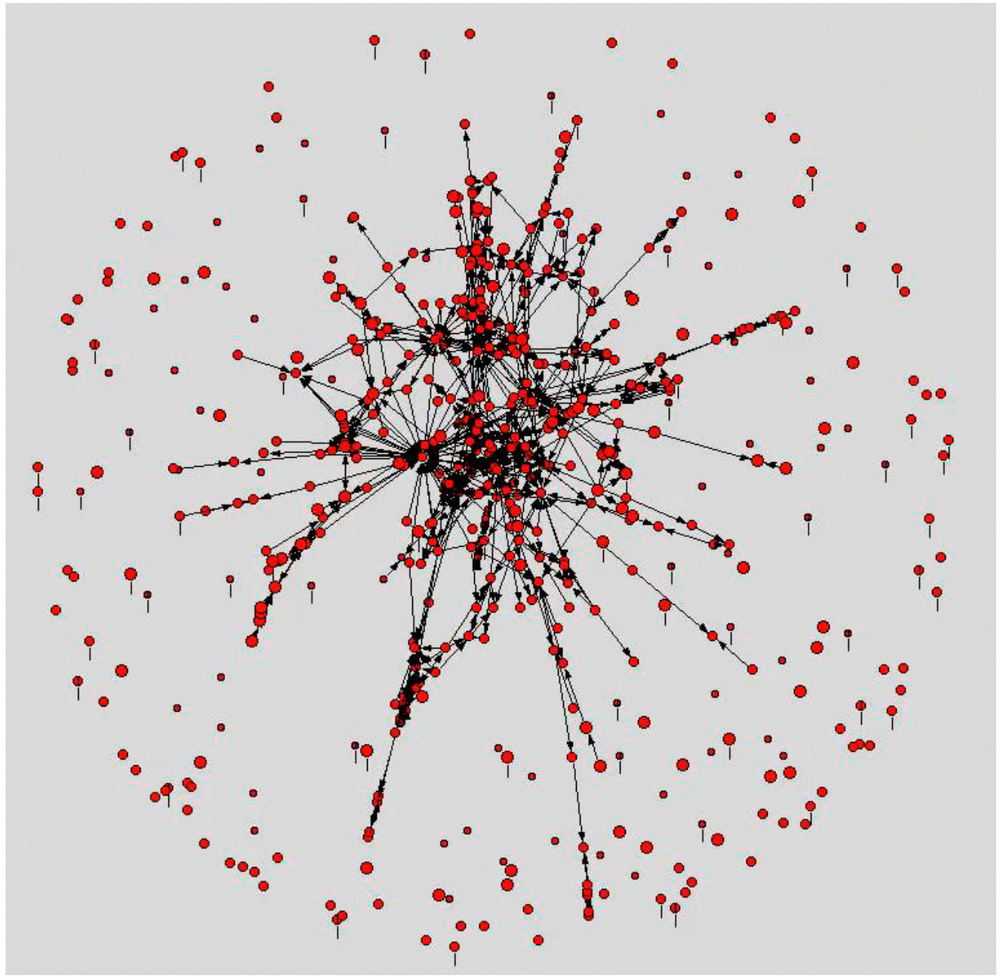




MEA network in 2010

- **Complex network structures evident**
  - A ‘giant’ connected component apparent
  - Small-world (short path lengths, high clustering)
  - Scale-free & “the rich gets richer”
  - Modular (communities of clusters)
- **Multi-objective**

(output from Pajek network analysis tool)



Despite a growing network, there are gaps and dis-functionality

- **'Structural connections' do not ≠ a healthy functioning network but structure does influence system function**
- **MEAs focus on problems which emerge in parts of Earth's subsystems but many problems 'fall between the cracks':**
  - Ocean acidification is the result of anthropogenic CO_2 emissions but is not a climate change problem
  - Increasing sea levels is the consequence of global warming
  - Biodiversity on land and in the oceans is a vital component of the global C cycle but this function is unrecognized by UNFCCC and CBD

Gaps (cont'd)…

- Law of Sea has binding provisions (international tribunal for enforcement) but is not proving effective in dealing with emerging problems of ocean acidification, sea level rises, and loss of biodiversity, including collapse of 'marine biological C pump'
- UNFCCC is ineffective in dealing with ocean acidification and loss of biodiversity for both its normative and functional values
- CBD does not deal with the functional values of biodiversity for global C cycle

Ocean acidification

This is not a climate change problem

- The oceans absorb roughly 30% of global carbon emissions making them more acidic than they have been for tens of millions of years. If current trends continue, it could rise by another 100 percent by the end of this century exceeding the levels of the past 20 million years

- The higher acidity will affect growth, reproduction, disease resistance and other biological and physiological processes in many species. It threatens marine organisms like hard corals, clams and crabs that create calcium carbonate shells and skeletons. Ultimately, ocean acidification could transform the oceans, leaving them far less diverse and productive and making the lives and livelihoods of those who depend on them far more uncertain.

- The planetary boundary threshold for ocean acidification is '350ppm'

Source: www.oceania.org/climate

Table 2: Past and future chemistry of surface sea water under a "Business-as-Usual" emissions scenario[56]

YEAR	ATMOSPHERIC CO_2 CONCENTRATION (ppm)	SURFACE OCEAN pH
1750	280	8.19
2008	385	8.09
2020	440	8.03
2040	510	7.97
2060	600	7.91
2080	700	7.85
2100	850	7.78

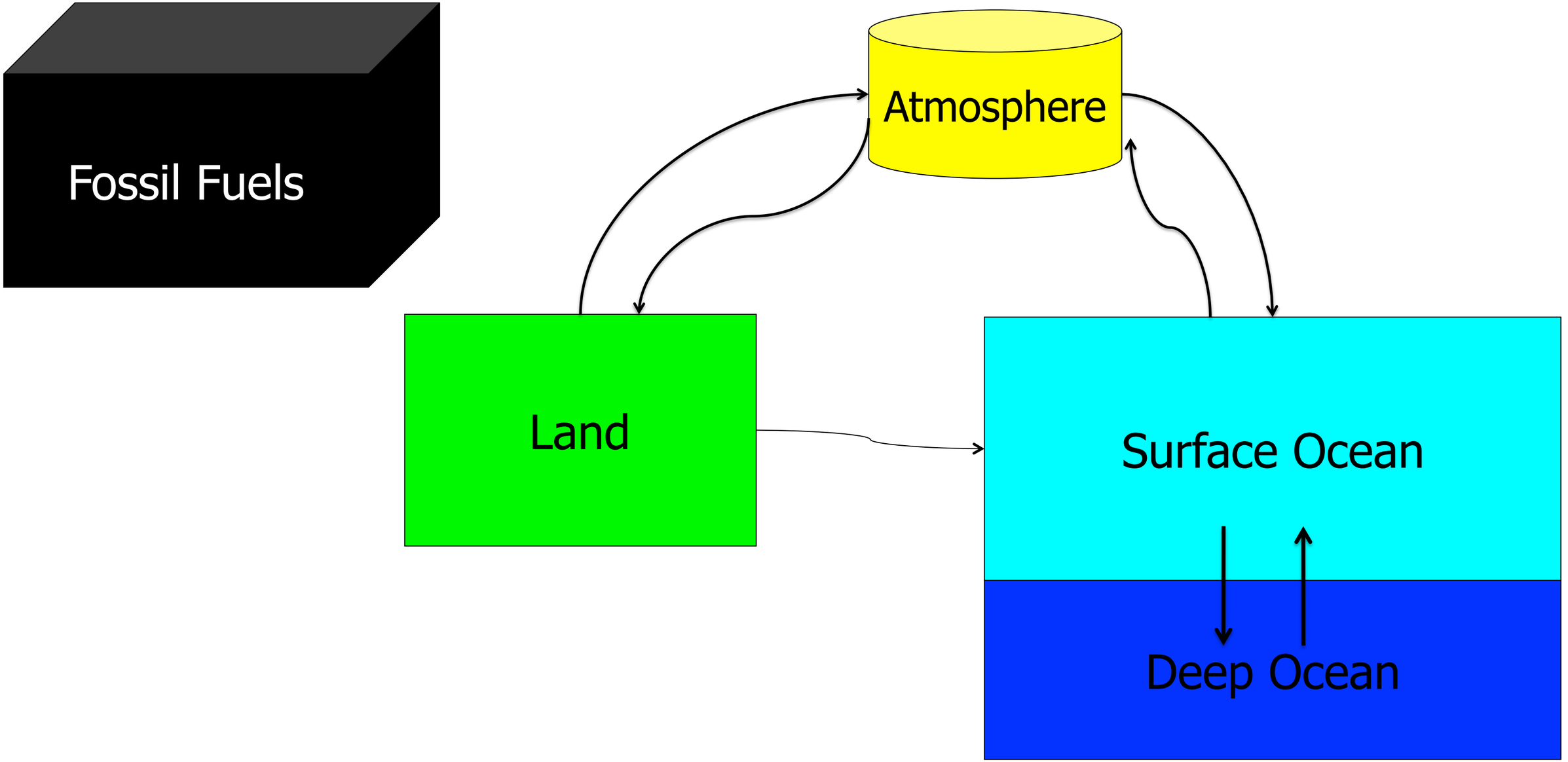
Plus perverse outcomes galore!

- **UNFCCC mitigation decisions can have perverse outcomes**
  - make adaptation efforts more difficult
  - can hasten biodiversity destruction, and
  - even increase greenhouse gas emissions!
- **Why? Because (i) UNFCCC CoP decisions are the consequence of political accommodations which 'drift away' from what climate change science recommends and (ii) lack of reference to other components of Earth system**

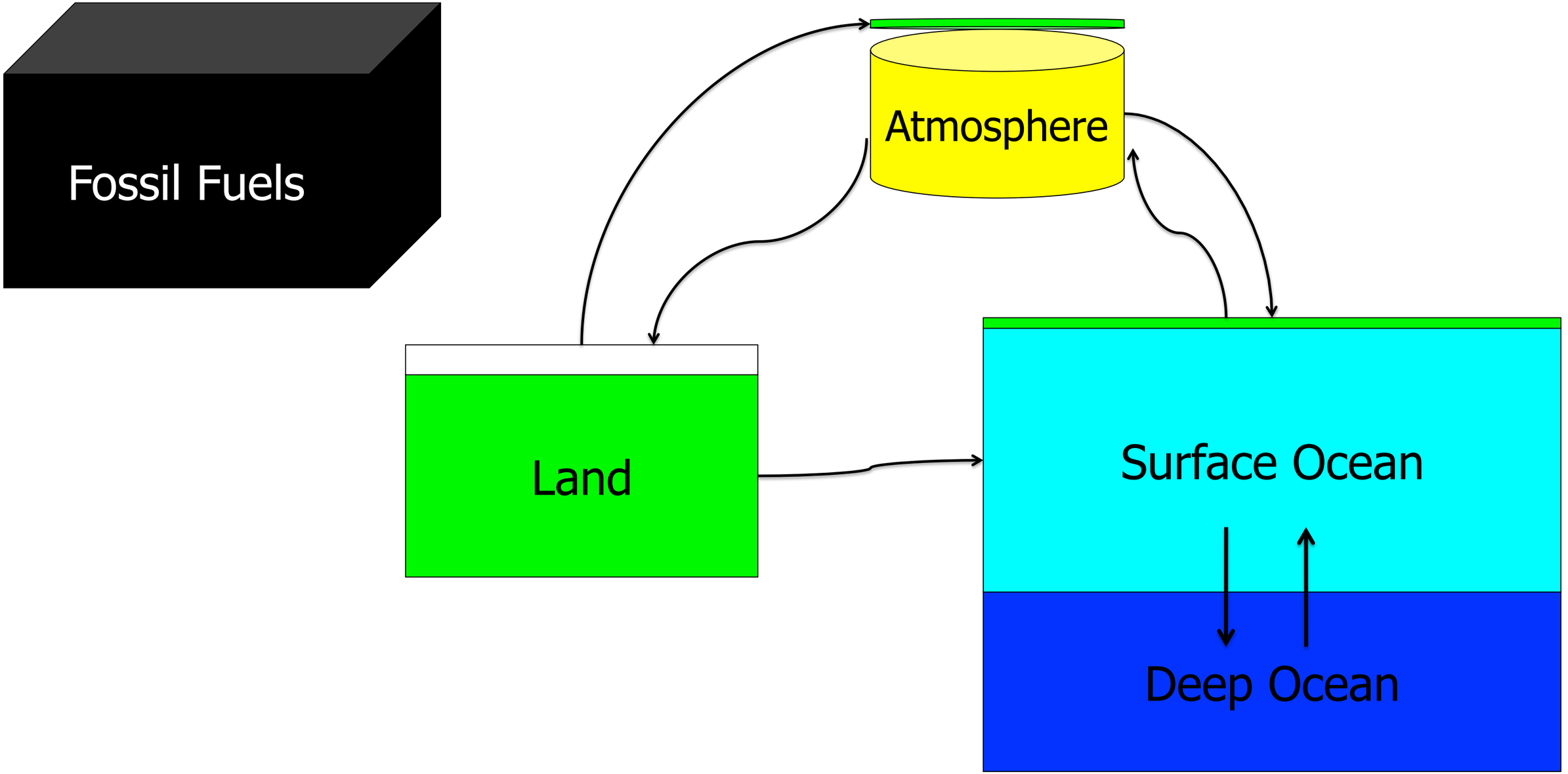
For example,

- Let's consider what IPPC science says about the global C cycle…

Pre-Human/Hunter-Gatherer Carbon Cycle

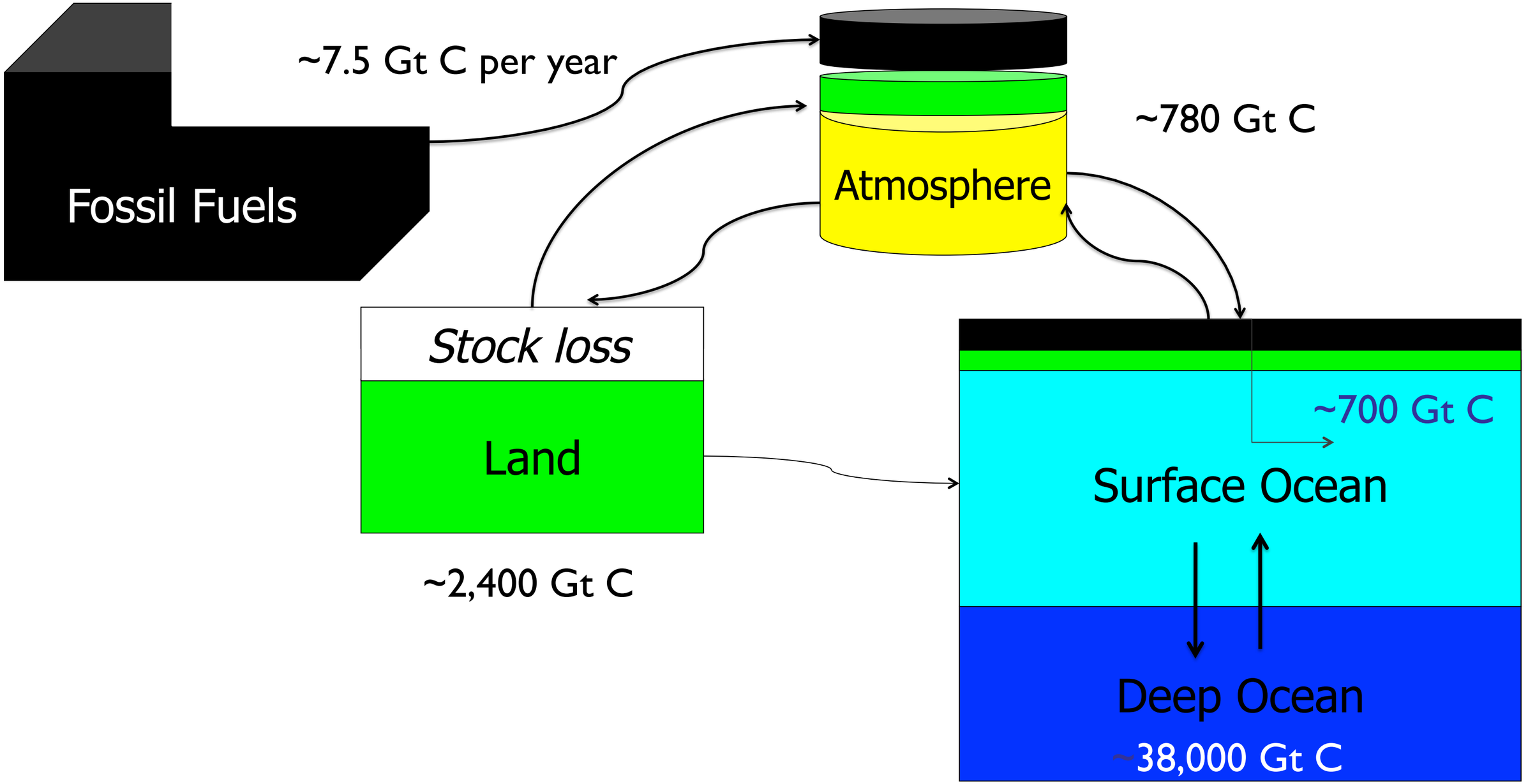


Early Agriculture Carbon Cycle

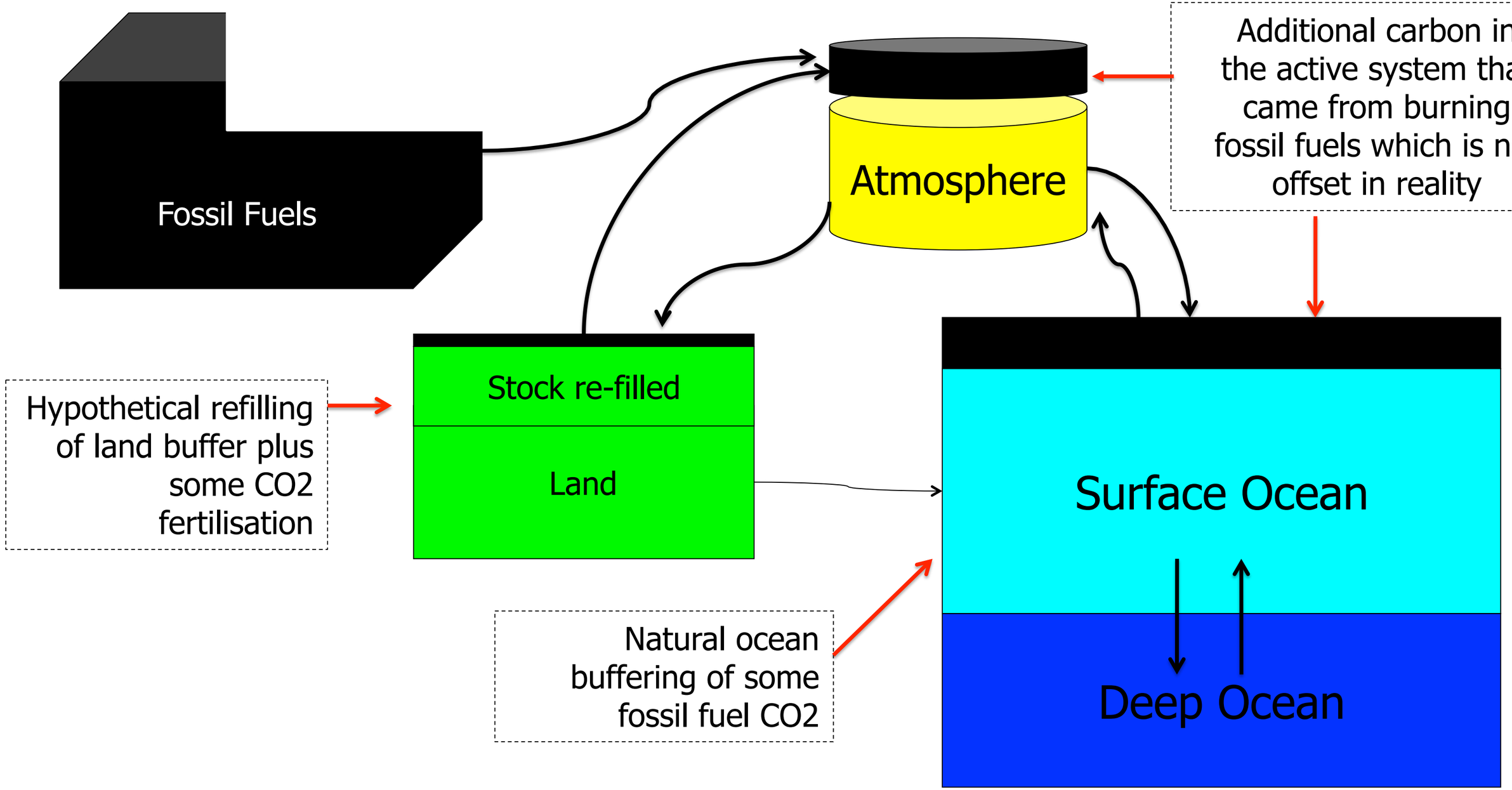


N.B. Figure is only indicative of relative stock sizes

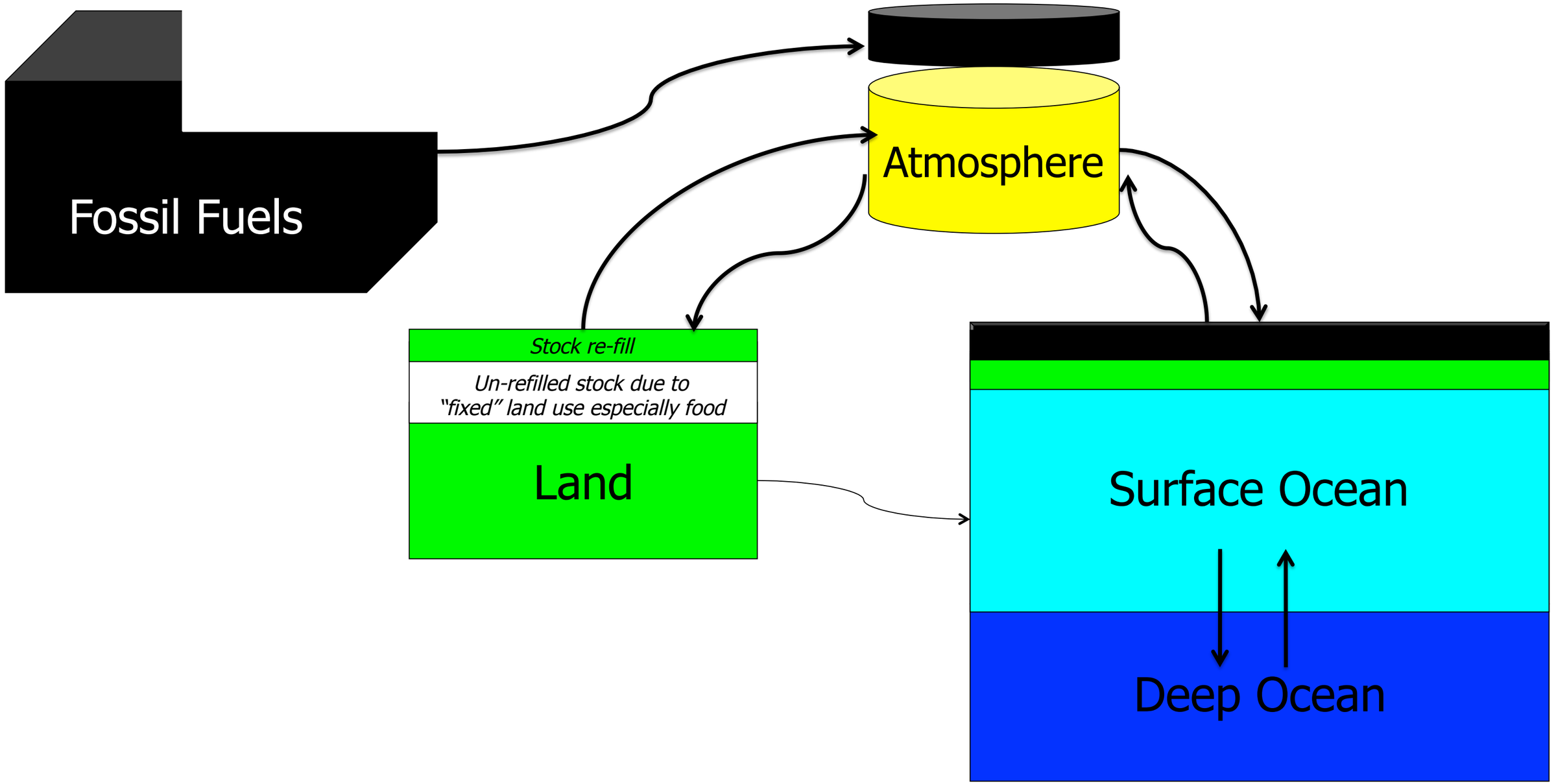
Contemporary (post-industrial) Carbon Cycle



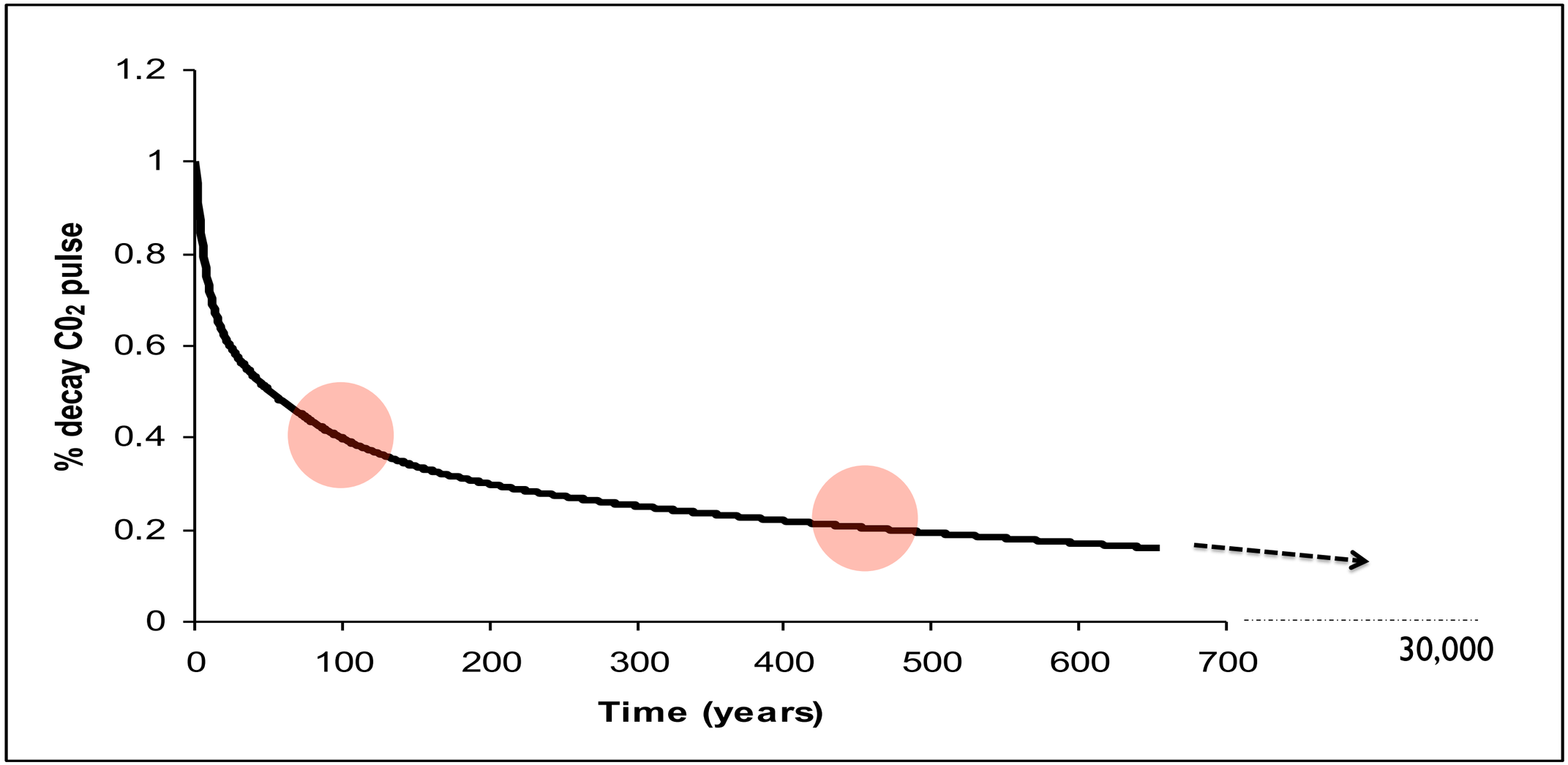
Fossil fuel "offset" approach is physically impossible!



In any case, the land buffer can only be partially re-filled due to competing land uses



Life-time of the air-borne fraction of a CO_2 pulse



Adopted from Berne global C model

It follows that…

- **A pulse of fossil fuel CO_2 is only offset when it has worked its way to bottom of ocean**
  - 100 years for 60% of pulse, after 450 years 20% remains and another 30,000 years for all to be removed from the atmosphere
- **And, a depleted ecosystem can be refilled but this only repays the carbon debt**
- **Yet, politically negotiated rules plus national legislation assumes otherwise**
  - proposed finance mechanisms based on offsetting, and
  - so doing allows industrial fossil fuel users to keep emitting on assumption that FFC-stocks and ecosystem-C stocks are equivalent whereas in reality they differ in quality (longevity, stability)

For example…

- Under the Kyoto Protocol rules, Australia can woodchip old growth native forest, convert it to a plantation, and not have to account for any of the carbon emissions

Solution?

- To solve the climate change problem we have to stop using fossil fuel, stop the clearing and logging of natural forests and other ecosystems, and in so doing prevent perverse outcomes to other planetary boundaries

- This is the kind of integrated outcome our MEA network should be delivering

Fixing the MEA network's 'shortfall

- How can MEA network be improved to plug gaps and avoid perverse outcomes?
- Greater concordance is needed between the MEA network system and the Earth system
- Neither have a single 'commander and controller', rather both are self-organising and adaptive
  - MEA connections are growing at a faster rate than MEAs are emerging which is consistent with a system of increasing complexity
- So, how can we make use of these desirable system characteristics?

Recommendations

1. Establish a planetary-scale goal(s) to which all MEAs must subscribe in addition to their specific objectives

   - Adopt universal, shared normative values as defined by the *Earth Charter*

2. Establish a new treaty to identify and promulgate "network protocols" to plug gaps between MEAs to better mesh with Earth system structure and dynamics

   - e.g. the Vienna Treaty on the Law of Treaties (outdated but designed to address problem of relationships between treaties)

   - operationalize using measurable *Planetary Boundary* conditions as framework

3. Establish an 'overseeing' international organisation with an Earth system mandate?