



Conservation

Climate change

Sustainability

The feasibility of environmental limits legislation

A discussion paper for WWF-UK by Peter Roderick

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Annex – Planetary Boundaries

Table A.1 – Planetary Boundaries

Table A.2 – Commentaries on Planetary Boundaries

1. Introduction

Since the 1972 United Nations Conference on the Human Environment, the UK has seen about forty years of a government department for the environment, and close on forty years of significant public support for NGO campaigning on the environment. The huge body of environmental laws now on the statute book took another twenty years or so after that Conference to take off, pushed by the UK's membership of what is now the EU – not to mention the scores of international environmental agreements, in many of which the UK has played a prominent role.

And yet after all this time and effort, and all these laws – and 3+ billion more people - we are now facing serious and threatening environmental problems as never before. Indeed, according to many scientists, at the planetary level three biophysical preconditions necessary for human development have already been crossed – relating to climate change, biodiversity and the nitrogen cycle.

This was the context for the report 'Taking the longer view: UK governance options for a finite planet',¹ which I wrote at the end of last year, for WWF-UK and the Foundation for Democracy and Sustainable Development. In that report, one of the options suggested for further consideration was enactment of an Environmental Limits Act by the Westminster Parliament.

Partly inspired by the Climate Change Act 2008, which the Sustainable Development Commission has described as a *"robust and world-leading approach [which] needs to be extended as a matter of urgency to other environmental limits"*,² this discussion paper considers that option in more detail, and makes recommendations for how this matter might be taken forward, with a view to the UK systematically considering how the decisions we make now will affect future generations across a range of environmental media.

The paper is divided into the following sections:

- section 2 attempts to clarify the concept, and to distinguish it from other similar-sounding terms, at least for the purposes of this paper;
- sections 3, 4 and 5 consider three different strands of thought that relate to environmental limits, with varying policy, scientific and legal emphases;

¹ The report is available from here: http://www.wwf.org.uk/wwf_articles.cfm?unewsid=4545

² NEWP Discussion Document, An Invitation to Shape the Nature of England, SDC Consultation Response, December 2010, page 4, available here: http://www.sd-commission.org.uk/publications/downloads/SDC%20Response%20to%20NEWP_Discussion%20paper.pdf

- section 6 considers the replicability of the Climate Change Act 2008, taking into account the international legal regime, and scientific and political consensus;
- section 7 consider other legal regimes and environmental limits, and draws out features such as the precautionary principle, and environmental assessment;
- section 8 suggests feasible environmental limits legislation, taking the long view, and next steps are discussed in section 9.

2. Clarifying the concept

Living within environmental limits is a key aspect of sustainable development. According to a report for Defra in 2006:

*"[t]here is a broad consensus in the scientific literature that the goals of sustainable development will not be achieved unless we are better able to identify and define what environmental limits are."*³

In order to identify and define those limits, it is first necessary to clarify the concept of 'environmental limits', and to note how it relates to and/or differs from similar-sounding concepts such as 'thresholds' and 'critical loads'.

To understand the latter, the Table and Figure below, reproduced from the March 2011 report of the Parliamentary Office of Science and Technology (POST) on 'Environmental Limits',⁴ are helpful.

Table 1 - Terms used in relation to Environmental Limits

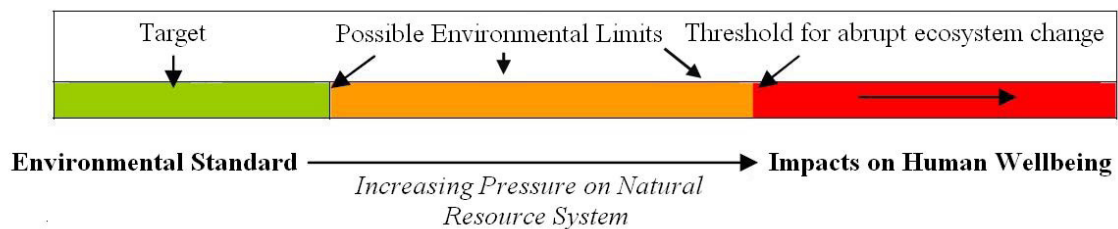
Term	Definition
Thresholds, Tipping Points and Regime Shift	An ecological or biophysical threshold is the point at which there is an abrupt change in the properties of an ecosystem or ecosystem processes in response to pressure from human activities or other drivers of environmental change. Shifts typically result from a combination of gradual changes in drivers, such as land use change, that initially appear to have little or no apparent impact up to the threshold, until an external shock such as storm, fire or disease outbreak, causes the threshold to be crossed. Some thresholds are reversible transitions, others may be extremely difficult or impossible to reverse.
Critical Natural Capital	The level of unexploited natural resources required to maintain the capacity of ecosystems to carry out processes important to human wellbeing at acceptable levels.

³ Haines-Young, R, Potschin, M, Cheshire, D, 2006, *Defining and Identifying Environmental Limits for Sustainable Development: A Scoping Study*, paragraph 12.2, available here: http://www.nottingham.ac.uk/cem/pdf/NR0102_FTR_Final.pdf.

⁴ The full 159-page report is available here: http://www.parliament.uk/documents/post/POSTLongReport_370-Environmental-Limits.pdf

Critical Loads and Levels	The amount of “pollutant” that an ecosystem can absorb before there is a change in the natural resource system and/or in a particular ecological process. For example, critical loads are used to specify the maximum rates of annual deposition of oxides of sulphur and nitrogen emissions permissible while avoiding adverse effects on soils and/or freshwater systems.
Limit Reference Point	The level of use or pressure at which the capacity of a renewable natural resource system to sustain itself is damaged, for example, the maximum values of fishing mortality that should not be exceeded, or minimum values of the biomass of fish to be maintained, to avoid collapse of a fish stock.
Carrying or Assimilative Capacity	The level of use of a natural resource system beyond which undesirable changes will happen to the system, for example, the size of a species population that can be sustained by a particular ecosystem. The carrying capacity of ecosystems to support human populations is the basis for calculating ‘ecological footprints’.
Safe Minimum Standards	Used within the context of economic analysis as the point at which it becomes unacceptable to trade-off environmental losses against economic gains because unacceptable changes will occur in natural resource systems. In cases of uncertainty, there is a requirement to err on the side of caution, with a caveat of unacceptable costs, for example, in the Water Framework Directive.

The relationship between Targets, Precautionary and Environmental Limits⁵



This paper takes as a starting point an assumption that ‘environmental limits’ is a range reflected in the orange coloured cell in the above Figure, beyond environmental standards and targets at the “safe” end (green cell), yet before a threshold or tipping point for possible abrupt change is reached (red cell). The term is not, at least initially, a numerical limit or other restriction or quality imposed by law on a particular activity that is damaging the environment, but rather a point in the natural world that needs to be understood in order to inform whether and where any limit should be legally placed. This is an important distinction to bear in mind - what’s possible legally depends, to begin with, on the reality of the natural world.

The following three sections of the paper briefly outline what might be regarded as three quite different, but overlapping, strands of thought for approaching the issue of environmental limits – with (crudely) policy, scientific and legal emphases. It is, of course, only one characterisation.

⁵ *Ibid.*

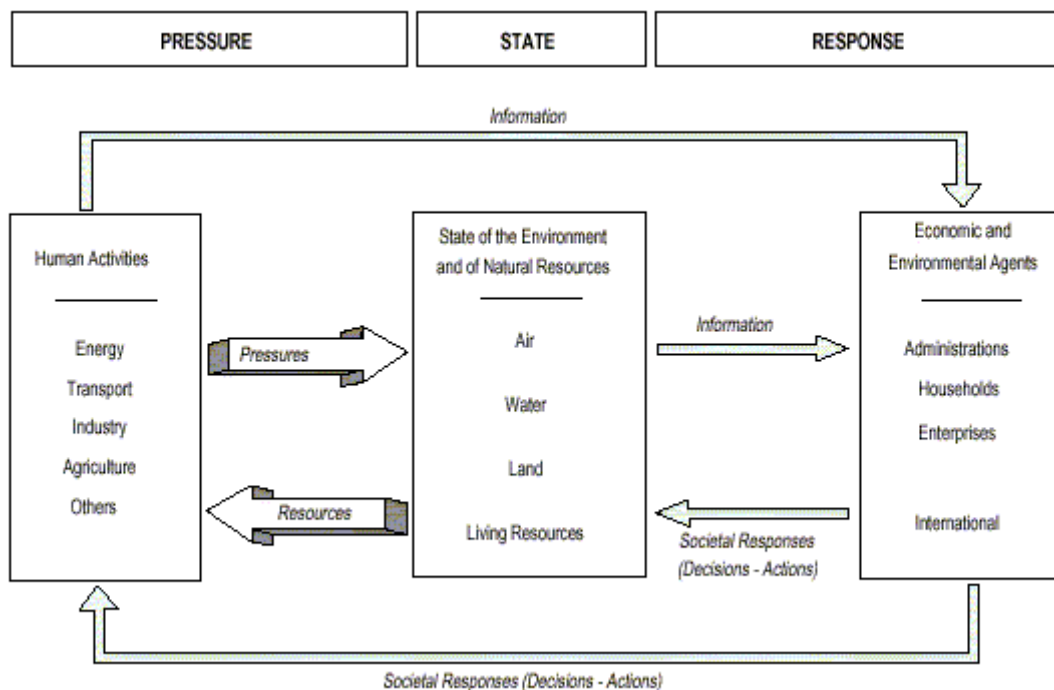
3. A policy approach

In one of its final reports, the Sustainable Development Commission has suggested a definition of 'environmental limits' which combines environmental, social and economic considerations:⁶

"Actions that breach environmental limits cannot be sustainable, but neither can initiatives which respect those limits but are socially divisive or economically unviable. An essential step in responding to environmental change is to understand the limits that exist within the environmental system and therefore when and how to take action. The SDC defines an environmental limit as:

The critical point(s) at which pressure on a natural resource or system creates unreasonable or irreversible change to the resource or system itself, to the detriment of the humans and other organisms to which it provides a service."

This approach is embedded in the policy and decision-making process, and draws on the Pressure-State-Response model developed by the OECD in 1993 *"initially...to structure its work on environmental policies and reporting."*⁷



⁶ Know your environmental limits: A local leaders' guide, page 5, available from here: <http://www.sd-commission.org.uk/publications.php?id=1149>

⁷ See Annex II on page 21 of the document entitled *OECD Environmental Indicators: Development, Measurement and Use* (2003), available here <http://www.oecd.org/dataoecd/7/47/24993546.pdf>.

The Parliamentary Office for Science and Technology has also offered its understanding, in its March 2011 report on 'Environmental Limits', citing the Defra study referred to at the opening of section 2 above:⁸

"An environmental limit is usually interpreted as the point or range of conditions beyond which there is a significant risk of thresholds being exceeded and unacceptable changes occurring."

This understanding also implies consideration of social and economic impacts. This is made clear by POST later in that report, which as a whole is very much focused on how 'natural capital accounting' and the valuation of 'ecosystem services' might be implemented, in the face of a frequent lack of data and difficulties in monetarising the natural world:⁹

"Agreeing environmental limits also requires definition of unacceptable social and economic impacts arising from environmental degradation, a means of mitigating or reducing drivers/pressures of environmental change and a legislative framework within which they can be addressed, such as the UK Climate Change Act".

But, as the POST report points out:

"The evidence base is not yet sufficient to determine the most effective ways to maintain benefit provision [from ecosystems] within environmental limits".

In other words, according to this approach, 'environmental limits' does not suggest a purely scientific or biophysical reality, but involves a negotiated critical point or threshold beyond which serious¹⁰ change could occur, and the process of negotiating the critical point necessarily involves economic and social considerations. This would seem to be behind the Royal Commission on Environmental Pollution's recently-expressed view favouring instead the term 'environmental constraints':¹¹

"4.40 The Commission has used the language of environmental constraints as opposed to the now more widely used language of environmental limits. This is

⁸ Summary, page 1 (footnote omitted). The full 159-page report is available here:

http://www.parliament.uk/documents/post/POSTLongReport_370-Environmental-Limits.pdf

⁹ Section 2.2 on page 9 of the full POST report 370 (159 pages), which is available here:

http://www.parliament.uk/documents/post/POSTLongReport_370-Environmental-Limits.pdf. The still-to-be-published UK National Ecosystem Assessment is expected to go further down this road of seeking to put a monetary value on "ecosystem services".

¹⁰ I am aware of the risk of bringing too much of a lawyer's approach to bear here, but I have deliberately used this adjective (serious), as it helps, for now, to gloss over some of the apparent ambiguities in the SDC's definition, which refers to "unreasonable or irreversible" change. It is not clear why the SDC definition does not refer to "abrupt" change, which is the adjective used in the POST Table's definition of "thresholds, tipping points and regime shift", and which, apparently, might be reversible or irreversible. Equally, it does not seem that non-linear change is a particular focus.

¹¹ RCEP Twenty-ninth Report, Demographic Change and the Environment, 16th February 2011, accessible from here: <http://www.rcep.org.uk/reports/index.htm>

because the language of limits suggests something which is fixed and absolute, whereas the Commission believes that an assessment of how much environmental damage a group or society is prepared to accept is often a matter of political judgement. This is not to suggest that science, economics and law cannot assist in exercising this judgement, but merely that they cannot be relied upon to provide unequivocal 'right answers'."

4. A scientific approach

A different approach was taken by 29 scientists from Sweden, the US and six other countries, when, in a remarkable intellectual effort, they set out an apparently novel concept of 'planetary boundaries' (PB) in a feature published in the journal *Nature* in September 2009.¹²

Noting that the unusually stable state of the Earth's environment over the last 10,000 years may now be under threat, the authors propose a framework of planetary boundaries that would define a safe operating space for humanity, associated with the planet's biophysical subsystems and processes. They write:

"Although Earth's complex systems sometimes respond smoothly to changing pressures, it seems that this will prove to be the exception rather than the rule. Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables. If these thresholds are crossed, then important subsystems, such as a monsoon system, could shift into a new state, often with deleterious or potentially even disastrous consequences for humans (footnotes omitted)..."

We have tried to identify the Earth-system processes and associated thresholds which, if crossed, could generate unacceptable environmental change. We have found nine such processes for which we believe it is necessary to define planetary boundaries: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorous cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading...Our analysis suggests that three of the earth-system processes – climate change, rate of biodiversity loss and interference with the nitrogen cycle – have already transgressed their boundaries."

In the Annex to this paper, Table A.1 is reproduced from the *Nature* feature sets out these nine processes, the suggested numerical parameters and the proposed boundary for seven of them, along with quantification of their current status and pre-industrial value.

¹² Rockström, J, et al, 2009, *Nature* **461**: 472-475 (A safe operating space for humanity). The fuller scientific paper on which this feature is based, along with Supplementary Information, can be accessed from the 'Relevant Info' box on this web page: <http://www.stockholmresilience.org/planetary-boundaries>

In considering Table A.1, a number of additional comments by the authors should also be borne in mind:

- *“Determining a safe distance involves normative judgements of how societies choose to deal with risk and uncertainty. We have taken a conservative, risk averse approach to quantifying our planetary boundaries, taking into account the large uncertainties that surround the true position of many thresholds”*
- They found setting a boundary for biodiversity *“difficult. Although it is now accepted that a rich mix of species underpins the resilience of ecosystems, little is known quantitatively about how much and what kinds of biodiversity can be lost before this resilience is eroded”* (footnotes omitted). The PB for biodiversity is therefore *“only a very preliminary estimate”*.
- Interactions between the processes, such as large-scale deforestation in the northern Amazon influencing surface temperature and precipitation in Tibet, which in turn affect much of Asia’s water resources, have not been analyzed but *“many of these interactions will reduce rather than extend the boundary levels we propose, thereby shrinking the safe operating space for humanity. This suggests the need for extreme caution in approaching or transgressing any individual planetary boundaries.”*

Table A.2 in the Annex summarises expert commentaries on the concept that were published at the same time as the *Nature* feature. The commentaries show a variety of responses:

- the concept itself is welcomed by some commentators - e.g., *“a sound idea...[with]...profound implications for future governance systems.”*; a *“very interesting and useful concept”*;
- though its usefulness is questioned – e.g., *“is it truly useful to create a list of environmental limits without serious plans for how they may be achieved?”*;
- and sole reliance on it is cautioned against - e.g., *“Setting boundaries is fine, but waiting to act until we approach these limits merely allows us to continue with our bad habits until it’s too late to change them”*;
- some of the chosen parameters are questioned - e.g., the climate change CO₂ concentration parameter *“misses the point”*; a single biodiversity boundary *“may not be useful”*; soil degradation or soil loss might be preferable to percentage cropland cover;

- some of the proposed boundaries are questioned - e.g., the nitrogen boundary “*seems arbitrary*”; the ozone boundary is “*reasonable but a bit arbitrary*”; the ocean acidification boundary “*seems reasonable*”, but other limits might be necessary; and
- one commentator suggests that “[r]ather than get bogged down in detailed arguments about the weaknesses of the approach or the methods of analysis, we now have a tool we can use to help us think more deeply – and urgently – about planetary limits and the critical actions we have to take.”

In light of the policy approach discussed in section 3, and one of the comments (“*is it truly useful to create a list of environmental limits without serious plans for how they may be achieved*”), three points of apparent difference are worth noting:

- economic and social considerations do not appear to play a part, or at least not an acknowledged part, in the PB concept. In a Supplementary Information paper, and in the context of comparing the PB concept with the ‘Tolerable Windows Approach’ and ‘impact guardrails’ developed in the climate change context by the German Advisory Council on Global Change, the authors state:
“the planetary boundaries approach does not propose economic boundaries to be given equal weight, but that the ecological and biophysical boundaries should be non-negotiable, and that social and economic develop (should) [sic] occur within the safe operating space provided by planetary boundaries.”;

It is not entirely clear to me, though, how this statement relates to the first quotation in the preceding list of bullet points, which refers to societies making normative judgments about risk, and the authors taking a risk-averse approach.

- the PB concept is not, in itself, and at least for now, an action plan. In the Supplementary Paper, the authors write:
“the planetary boundaries approach as of yet focuses on boundary definitions only and not as a design tool of compatible action strategies.”;
- the PB concept is focused on the planetary scale (though regional or continental scales are also acknowledged, at least for aerosol loading). The policy approach appears to be capable of application at any scale. That is not to say, though, that the PB concept has no potential relevance at a sub-global or sub-regional scale (far from it) – or even at the local scale.

Differences between the PB concept and other similar concepts are also described in the Supplementary Information paper, such as ‘critical loads’ and ‘safe minimum standards’. These latter concepts are regarded (correctly in my view) as involving what the authors call ‘normative’ (for this paper’s purposes, political) judgements in areas of uncertainty and risk. On risk, they state:

“The planetary boundaries approach explicitly focuses on the Earth’s regulatory services, which even though directly linked to human welfare, are not easily captured in conventional risk assessment methodologies. Another potential problem with using quantitative risk assessment methods in the context of global environmental change is that it would be more difficult to construct reliable probability distributions”.

The PB concept seems to be hindered at present, in its readiness for immediate comprehensive application, by a similar lack of data to that suffered by natural capital accounting and ecosystem valuation approaches: as the commentaries suggest, and as the authors state, *“some of the figures are merely our first best guesses”*. The concept appears, however, to have been taken up, for example, by:

- the **UN Secretary-General’s High-level Panel on Global Sustainability** in February 2011, in the overall goal for its report later this year and input into Rio+20:¹³

“To eradicate poverty and reduce inequality, make growth inclusive, and production and consumption more sustainable while combating climate change and respecting the range of other planetary boundaries.”

The report of that meeting reflects many of the concerns that have led to the recent formation in the UK of the Alliance for Future Generations:

“8. A discussion of the inadequate level of implementation of the sustainable development agenda in the last 20-25 years pointed to the lack of a long term vision. “Short-termism”, the failure to properly price natural resource use and the market’s inability to tackle inequity, were mentioned as major impediments.

9. Panel Members strongly emphasized the need for intra- and inter-generational equity and social justice as key ingredient to sustainable development.

10. Panel members spoke of the need to broaden the understanding of growth and to develop a new approach to managing the global commons.

11. Some Panel members stressed the need for an innovative paradigm based on low carbon green growth to solve global challenges, while other members felt that it had yet to be proven that this approach was evenly beneficial for developing and developed countries.”

The potential for the PB concept to play a part in the development of a new approach to managing the global commons is clear.

¹³ High-level Panel on Global Sustainability, Second meeting of the Panel, Cape Town, 24-25 February 2011, Meeting Report, available here: <http://www.un.org/wcm/webdav/site/climatechange/shared/gsp/docs/GSP2%20meeting%20report.pdf>

- the **UK's Institution of Civil Engineers** in its *Engineering to live within planetary boundaries* report, in its view that:¹⁴
"the concept is clear and sufficiently intuitive that we can begin to explore ways in which society can stay within such boundaries."

5. A legal approach

Whilst the first two strands might be characterised as policy and science driven, a distinctively legal approach has emerged, known as 'legacy planning'. Though not using the environmental limits idea explicitly, legacy planning is clearly motivated by the same concerns. It focuses instead on the quality of the environment that present generations wish future generations to inherit, and may have particular relevance at the local level.

The idea appears to have emerged from the Center for Progressive Reform in the US, which describes itself on its website as *"a network of university-affiliated Member Scholars with expertise in legal, economic, and scientific fields"*.¹⁵ In its report *Squandering Public Resources*, the Center listed common reasons why US environmental laws or their implementation fell short: inadequate or unenforceable legal standards, inadequate monitoring and enforcement, limits on public participation, exemptions, inadequate funding, and inadequately justified subsidies for degradation or depletion of resources – a list that is not unfamiliar to UK public interest environmental lawyers (though we would also add, at least, the cost of citizens' access to the courts).

In an article in 2008, Professor Alyson C. Flournoy reviewed the Center's findings, and considered how to design progressive conservation laws to better incorporate scientific insights into legal regimes, in particular by enacting a National Environmental Legacy Act to remedy:

"the lack of meaningful long-term conservation goals for public natural resources and the lack of associated enforceable constraints on our depletion and degradation of these resources. Its core objective is therefore to complement existing laws with a mandate that is enforceable and achieves clear conservation objectives."

Her discussion of a key problem with a US statute aimed at ensuring multiple use of land illustrates the nature of the problem from a legal perspective - with wider relevance, for example, in relation to the multiple uses of the aquatic environment:

¹⁴ *Engineering to live within planetary boundaries: Civil engineering research needs*, Institution of Civil Engineers, October 2010, available here:

<http://www.ice.org.uk/Information-resources/Document-Library/Engineering-to-live-within-planetary-boundaries>

¹⁵ <http://www.progressivereform.org/aboutCPR.cfm>

“The lack of a strong, unambiguous statutory mandate, when coupled with well-funded pressure from industries that have an economic incentive to exploit resources for profit, has led agencies to make decisions that produce degradation and depletion of resources clearly in conflict with the general mandates for multiple use and sustained yield [footnote omitted].

The shortcomings of the statutes could have been overcome by agency interpretations and regulations that imposed enforceable constraints to ensure that public and private actions do not impair the resources' sustainability”.

A Legacy Act would define public natural resources that must be preserved for future generations, and would prohibit all actions that would degrade or deplete them. Public natural resources would include forests, wetlands, grasslands, uplands on public lands, all species found in these ecosystems, as well as fisheries under federal protection or control, hard-rock minerals as well as oil, gas, and other energy resources.

The statute would designate a fixed period of years (such as 20-50 years) - the legacy period - over which the resources must be conserved. It would set out clearly and enforceably the maximum degree of degradation or depletion of resources, if any, that would be permitted over the course of the period. Metrics of resource quality and quantity would be developed, supported by collection of baseline data, which would be used to produce enforceable standards. Each resource would be under the auspices and monitoring of a public stewardship agency, which would be obliged to produce and update a ‘no degradation or depletion plan’ in excess of permissible limits. Agencies and citizens would have enforcement powers, including a citizen suit provision with fee-shifting.

A (supposedly) narrow exception to the prohibition on degradation or depletion would be permitted in two circumstances: if it can be shown by clear and convincing evidence that (i) foreseeable technological advances or the availability of substitute resources will obviate the need for and value of the resource in question (*sic*); or (ii) impermissible degradation or depletion is clearly in the public interest, no acceptable alternative that will not cause impermissible degradation or depletion exists that will serve the public interest adequately, and the impacts to all services and values to be impaired can and will be mitigated.

The legacy planning approach has also been suggested as a way of protecting the environment at a local level. In its response to the Natural England White Paper in October 2010, the Environmental Law Foundation has written (footnotes omitted):

“3.24. Legacy planning could be a first step in the process whereby a local authority in conjunction with its local community set both values and limits upon the use and depletion of their local natural environment – one such mechanism could be to use models such as those adopted in the Philippines towards setting eco budgets.

3.25. A legacy plan could be a way in which to engage local communities to participate in the decision making process around biodiversity valuation. Such plans can also be a mechanism for taking an ecosystem approach to the natural environment over the longer term thereby capturing public benefits from changing landscapes as a result of climate change.

3.26. One aim of legacy planning is to capture those biodiversity values (cultural, public) that are often invisible when planners determine whether the development of our natural environment is unlikely to have significant environmental impacts.

3.27. A legacy plan could be incorporated into the current planning system through existing Sustainable Community Strategies. Local communities would be fully involved in the provision of such plans that could look at a set legacy period and take into account climate change scenarios over the legacy period (say 2010-2050)."

The reference in the above extract to the ecoBUDGET approach in the Philippines is a reference to an environmental management system developed for and by local authorities by ICLEI-Local Governments for Sustainability, which defines locally-set key short-term and long-term (generally 8-20 year) targets.¹⁶ This would appear to link well with the focus of the SDC's March 2011 publication, *Know your environmental limits: A local leaders' guide*.¹⁷

To summarise sections 3, 4 and 5: there are policy, scientific and legally-driven ways of approaching this question, including in the context of local government. The policy way reviewed in this paper is very much linked to government and public decision-making, to the thinking of politicians and bureaucrats, and to the current monetization *zeitgeist*. The scientific way, the PB concept, is concerned with biophysical reality, is not an action plan, and requires more development. The legal approach evolves from asking what natural resources do we want to leave for those who come after us? The challenge is to draw the lessons from these different approaches to inform possible legislation by the Westminster Parliament.

It might seem odd not to have included the Climate Change Act as an example of the legal approach, but the reasons for that will become clear in the next section.

¹⁶ <http://www.ecobudget.org/index.php?id=6975>

¹⁷ *Know your environmental limits: A local leaders' guide*, available from here: <http://www.sd-commission.org.uk/publications.php?id=1149>

6. The Climate Change Act 2008 and its lessons

The Climate Change Act was passed in 2008. The Sustainable Development Commission described it in December 2010 as a “*robust and world-leading approach*”.¹⁸ On 31st March 2011, the government announced that the UK’s greenhouse gas emissions for 2010 are provisionally estimated to have *increased* by 2.8% over 2009.¹⁹

Hubris aside, juxtaposing these three pieces of information gives pause for thought. It’s much too early to tell, but might it be, as seems so often the case with environmental laws, that the best argument in favour of the Climate Change Act is that its effectiveness lies in slowing down the descent into dangerous climate change, rather than in helping to secure a safe climate? Maybe that’s too big ‘an ask’ for any single piece of legislation? The jury’s still out.

That said though, there are clear features of the Climate Change Act (CCA) that have lessons for environmental limits legislation.

The CCA is often cited as an example of legislation that respects – or at least reflects – environmental limits. This is correct, in the sense that acceptance of the limit of atmospheric carbon is implied in the Act’s concept of ‘carbon budgets’, though the provisions of the Act are focused on capping emissions – i.e., on the activities that affect that atmospheric limit. It does seem, however, to differ fundamentally from the planetary boundaries concept, for example, in that it is an ‘effects-based’ approach, obviously negotiated, with a number of gaps – though at the same time motivated by the concerns lying behind, if not designed in accordance with, the planetary boundaries concept. It seems, rather, by implication – it is the product of a political process – to be nearer to the policy approach.

The Act is summarized in the Box below. Its legal duties on the government to keep within carbon budgets, an expert committee to advise on their levels, duties to report and to reason against the committee’s recommendations, stepped duties and medium- and long-term targets, are all features of the CCA that merit consideration for other forms of environmental limits legislation.

The Climate Change Act 2008 in a nutshell

- The Climate Change Act places on the executive the duty to ensure that “the net UK carbon account” in 2050 will be at least 80% lower than “the 1990 baseline” for carbon dioxide and other greenhouse gases.

¹⁸ NEWP Discussion Document, An Invitation to Shape the Nature of England, SDC Consultation Response, December 2010, page 4, available here: http://www.sd-commission.org.uk/publications/downloads/SDC%20Response%20to%20NEWP_Discussion%20paper.pdf

¹⁹ http://www.decc.gov.uk/en/content/cms/news/pn11_033/pn11_033.aspx

- To aid fulfilment of this duty, amounts of that account must be fixed every five years ('carbon budgets') from 2008; the executive must ensure that those amounts are not exceeded; and the annual amount in 2020 must be at least 26% lower than the 1990 baseline.
- Carbon budgets must be set by an order of the Secretary of State in a statutory instrument, and he or she must take into account the advice of the Committee on Climate Change and any representations from other national authorities.
- In appointing the Committee, the national authorities must consider the desirability of it having experience in or knowledge of business competitiveness; climate change policy, especially its social impacts; climate science, and other branches of environmental science; differences in circumstances between England, Wales, Scotland and Northern Ireland and the capacity of national authorities to take action in relation to climate change; economic analysis and forecasting; emissions trading; energy production and supply; financial investment; and technology development and diffusion.
- The Secretary of State must prepare proposals and policies to enable carbon budgets to be met, with a view to meeting the 2050 target, and the "proposals and policies, taken as a whole, must be such as to contribute to sustainable development".
- It is the legal duty of the Committee to advise the Secretary of State on whether the 2050 percentage reduction should be amended, and on the level of the carbon budget for each five-year period. If the order sets the carbon budget at a level different from that recommended by the Committee, the Secretary of State must set out the reasons for that.
- The Committee must make an annual report to Parliament (and the devolved legislatures) on progress made towards meeting the five-yearly budgets and the 2050 target; on further progress needed; and on whether they are likely to be met. The Secretary of State must respond to that report.
- The Secretary of State has power to issue guidance and directions to the Committee, and the Committee must take into account that guidance and comply with those directions.
- There are also duties relating to adaptation, including the duty on the executive to lay before Parliament programmes setting out objectives, proposals, policies and time-scales addressing the risks for the UK of the current and predicted impact of climate change. The "objectives, proposals and policies must be such as to contribute to sustainable development".

In considering how replicable some or all of these features might be, three factors seem to be particularly relevant.

First, it is important to recall that there is an internationally-agreed, binding, qualitatively-expressed ultimate objective on climate change, accepted, in effect, by all

States, contained in Article 2 of the United Nations Framework Convention on Climate Change 1992:²⁰

“The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”

And developed countries have accepted legally-binding emission limits in the 1997 Kyoto Protocol *“with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.”*²¹ Although this is far below what is needed to prevent dangerous climate change, and was known to be such in 1997, it amounts in effect to a ‘cap and share’ between the developed countries.

Second, there is an international scientific consensus developed over 20+ years, since the Intergovernmental Panel on Climate Change was set up in 1988, that provides a sound basis both for taking the legal measures already taken, and for having to take much deeper measures beyond 2012.

Third, as well as the very significant international legal and scientific contexts, a political consensus has developed²² around the need to limit global average temperature to

²⁰ The Convention can be accessed from here:

http://unfccc.int/essential_background/convention/items/2627.php

²¹ “The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.” Kyoto Protocol, Article 3.1, which can be accessed from here:

http://unfccc.int/kyoto_protocol/items/2830.php

²² For example, section I of The Cancun Agreements, 2010, “1. Affirms that climate change is one of the greatest challenges of our time and that all Parties share a vision for long-term cooperative action in order to achieve the objective of the Convention under its Article 2, including through the achievement of a global goal, on the basis of equity and in accordance with common but differentiated responsibilities and respective capabilities; according to science, and as documented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2 °C above preindustrial levels, and that Parties should take urgent action to meet this long-term goal, consistent with science and on the basis of equity; also recognizes the need to consider, in the context of the first review, as referred to in paragraph 138 below, strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5 °C;...5. Agrees, in the context of the long-term goal and the ultimate objective of the Convention and the Bali Action Plan, to work towards identifying a global goal for substantially reducing global emissions by 2050, and to consider it at the seventeenth session of the Conference of the Parties; [Decision 1/CP.16, The Cancun Agreements:

below 2° C above pre-industrial levels – even though this might be too high to protect many countries sufficiently,²³ and even though it has not been reflected in a legally-binding agreement for deeper emission cuts beyond 2012. Frustration at the lack of political progress and the adequacy of the limit aside, in legal terms the limit can be construed as a political interpretation of what is needed to meet the ultimate objective to prevent dangerous climate change.

Given the coalescing of the legal, scientific and political contexts – and recalling also the EU emissions trading scheme,²⁴ as evidence of the widespread acceptance of a limit – it will be appreciated that there was fertile ground for the initiative led by Friends of the Earth which resulted in the CCA.

In summary it seems to be reasonable to say that:

- the CCA was enacted as a result of significant campaigning in a favourable legal, scientific and political context;
- it is an example of legislation that *implicitly* recognises environmental limits, more in the policy than in the scientific sense, but it is not framed by reference to environmental limits in the ‘natural world sense’;
- the legal ‘cap and share’ principle, such as agreed in the Kyoto Protocol, is an important element in environmental limits legislation that seeks to impose a particular limit on a particular activity affecting an aspect of the environment beyond national jurisdiction involving multiple international participants;

Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, available here: <http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2>. It has been in place at the EU level at least since, for example, the (now outdated) 6th Environment Action Programme adopted in 2002: “The Programme aims at: — emphasising climate change as an outstanding challenge of the next 10 years and beyond and contributing to the long term objective of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Thus a long term objective of a maximum global temperature increase of 2 °Celsius over pre-industrial levels and a CO₂ concentration below 550 ppm shall guide the Programme. In the longer term this is likely to require a global reduction in emissions of greenhouse gases by 70 % as compared to 1990 as identified by the Intergovernmental Panel on Climate Change (IPCC);” [DECISION No 1600/2002/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 July 2002 laying down the Sixth Community Environment Action Programme, Article 2.2, available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:242:0001:0015:EN:PDF>]

²³ “A 2 degrees temperature rise can no longer be considered “safe”; even 1.5 degrees carries with it major risks.”, *Reckless gamblers: How politicians’ inaction is ramping up the risk of dangerous climate change*, Friends of the Earth England, Wales & Northern Ireland, December 2010, available here: http://www.foe.co.uk/resource/reports/reckless_gamblers.pdf

²⁴ http://ec.europa.eu/clima/policies/ets/index_en.htm

- even if there is no comparable legal, scientific and political contexts in other environmental areas, some of the Act's features might still be replicable, and this is discussed further in section 8.

Before that discussion, however, it is helpful to consider how other legal regimes might relate to environmental limits.

7. Other legal regimes and environmental limits

During the research so far, I have sought to find another legal regime where there is a broad objective that hints at an environmental limit (maybe even with some kind of collective cap), a scientific consensus supporting the need for further action, a political consensus on the need to take it, and a clear vision for what the Westminster Parliament might enact. Perhaps unsurprisingly, I have not, so far, found one meeting all criteria. There is of course a limit on what one person can do across such a broad canvas, so perhaps with further consideration and discussion one or more will emerge.

Some regimes might meet one or more of the criteria. Almost all regimes have international and EU law contexts. The feasibility of UK legislation therefore has to be considered in those contexts, and that raises additional issues.

In the Box below, some good, bad and indifferent examples of objectives in international agreements, from the point of view of the above criteria, are set out.

Objectives of relevant international agreements

2001 Stockholm Convention on Persistent Organic Pollutants, Article 1:²⁵

"Mindful of the precautionary approach as set forth in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Convention is to protect human health and the environment from persistent organic pollutants."

1979 UNECE Convention on Long Range Transboundary Air Pollution, Article 2 (Fundamental Principles):²⁶

"The Contracting Parties, taking due account of the facts and problems involved, are determined to protect man and his environment against air pollution and shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution."

1998 Aarhus Protocol on Persistent Organic Pollutants, Article 2:²⁷

"The objective of the present Protocol is to control, reduce or eliminate discharges, emissions and losses of persistent organic pollutants."

²⁵ <http://chm.pops.int/Convention/tabid/54/language/en-GB/Default.aspx>

²⁶ http://www.unece.org/env/lrtap/lrtap_h1.htm

²⁷ http://www.unece.org/env/lrtap/pops_h1.htm

1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, Article 2:²⁸

“The objective of the present Protocol is to control and reduce emissions of sulphur, nitrogen oxides, ammonia and volatile organic compounds that are caused by anthropogenic activities and are likely to cause adverse effects on human health, natural ecosystems, materials and crops, due to acidification, eutrophication or ground-level ozone as a result of long-range transboundary atmospheric transport, and to ensure, as far as possible, that in the long term and in a stepwise approach, taking into account advances in scientific knowledge, atmospheric depositions or concentrations do not exceed [specified critical loads of acidity and of nutrient nitrogen, and (save in the US and Canada) specified critical levels for ozone].”

1992 Convention on Biodiversity, Article 1:²⁹

“The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.”

2010 Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity 2010, Article 1:³⁰

“The objective of this Protocol is the fair and equitable sharing of the benefits arising from the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components.”

A decent broad **objective** is contained, for example, in the 2001 Stockholm Convention on Persistent Organic Pollutants. The Convention requires Parties to prohibit and/or eliminate production and use of listed chemicals, and generally their import and export, and to restrict production and use of other listed chemicals. There is no collective cap on these chemicals, understandably, though it is perhaps an open question whether keeping within a planetary boundary for chemical pollution would require one.

The 1998 UNECE Aarhus Protocol on Persistent Organic Pollutants, however, has no such objective, focusing instead on the activity addressed in the instrument rather than the human health and environmental goals. This is perhaps not surprising, particularly bearing in mind the 1979 UNECE Convention on Long Range Transboundary Air Pollution,³¹ of which it is a Protocol, which contains no objective at all. It has a provision

²⁸ http://www.unece.org/env/lrtap/multi_h1.htm

²⁹ <http://www.cbd.int/convention/text/>

³⁰ <http://www.cbd.int/abs/text/>

³¹ <http://www.unece.org/env/lrtap/welcome.html>. This is the international legal context for EU air quality legislation: http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm; and for domestic laws: <http://www.defra.gov.uk/environment/quality/air/air-quality/>. The UNECE Convention regime applies to States across the northern hemisphere (“from Vancouver to Vladivostok”), and mainly via national emissions ceilings and source controls, reductions emissions of air pollutants such as sulphur,

entitled “Fundamental Principles”, which reads more like preamble text, plus a weak form of obligation. It is hardly surprising that there is ***strong scientific consensus***, which is officially admitted, supporting the need for further action under the auspices of this Convention as critical loads for the environment and human health are being exceeded. Despite improvements, a significant proportion of Europe’s urban population still live in cities where certain EU air quality limits are exceeded, reducing human life expectancy by more than two years in the most polluted cities and regions.³² The European Environment Agency reports critical loads continuing to be exceeded for sensitive ecosystem areas in terms of eutrophication (40% of areas), acidification (10% of areas) and ozone damage to crops.³³ The European Nitrogen Assessment published on 11th April 2011 after five years of study, has estimated that the annual cost of damage caused by nitrogen across Europe is £60 - £280 billion (€70 -320 billion), more than double the extra income gained from using nitrogen fertilizers in European agriculture.³⁴

Nearly all the Earth-system processes identified in the planetary boundaries concept are affected by the UNECE Convention regime, yet a gap between critical loads and the regime’s delivery of them is, in effect, designed into the regime (and the EU regime flowing from it), through a combination of no or misdirected objectives and weak obligations. In December 2010, the Parties acknowledged this gap, and seem to imply that the gap will continue until at least 2050:

(e) Building further on its core expertise, the Parties to the Convention will regularly reassess the Gothenburg Protocol in terms of its correspondence with the updated scientific effects assessment and the degree to which it has achieved its long-term effects oriented goals. Stepwise improvements and revisions of the multi-pollutant/multi-effects Protocol will reduce the gap between the impacts on the environment and on human health and critical loads, critical levels and health-oriented air quality targets. Such revisions will take account of new and emerging findings of relevance to this Protocol, including intercontinental transport of air pollution, reactive nitrogen and the interlinkages between air pollution and climate change. Parties to the Convention aim at these long-term objectives and at achieving ecosystem recovery as far as possible in 2050.

At the EU level, the Commission admitted in March 2011 that “*current [air quality] policy efforts, at EU and national level, have not fully delivered the expected results*”, and announced that “*a comprehensive review of the EU air quality policies should be*

nitrogen oxides, volatile organic compounds, ammonia, cadmium, lead, mercury and 23 persistent organic compounds are agreed. Particulates and black carbon (as particulates) may be added in a revision to the Convention’s 1999 Gothenburg Protocol later this year.

³² According to the EU Commissioner for the Environment, see here:

<http://www.eea.europa.eu/themes/air/about-air-pollution> . The European Environment Agency’s 2009 status report on the National Emissions Ceiling Directive is here:

<http://www.eea.europa.eu/publications/nec-directive-status-report-2009>

³³ <http://www.eea.europa.eu/themes/air/about-air-pollution>

³⁴ http://www.ceh.ac.uk/news/news_archive/EuropeanNitrogenAssessment.html

*launched soon and completed by 2013 at the latest.*³⁵ Might now be the time to consider a collective cap and even air pollutant budgets, along the lines of carbon budgets, at both the EU and UNECE levels?

Another area where there appears to be **strong scientific consensus** is in relation to the EU Common Fisheries Policy. The EU and its Member States have managed over the years to allow a frightening decline in fish stocks. In the words of the Commissioner in 2008:³⁶

"In 2007, independent fisheries scientists assessed the condition of 33 of Europe's most important commercial fish stocks, and concluded that 29 (some 88 % of them) were overfished. This compares with the situation outside the EU as reported by the FAO, where the global average is 25% of stocks being overfished."

Academic commentators considering the science/policy tension in the EU fisheries policy have opined that *"advice from scientists, based on observations of the status of stocks, is not being implemented, either officially in terms of regulations, or actually in terms of mortality on the fish, with serious consequences for the sustainability of the resource"*.³⁷ They considered one of the problems to be that:

"[a]lthough the policy is widely recognised as a failure, change is resisted by EU Member States who benefit from the status quo represented by politicians interested in short term popularity with their electorates."

The policy is currently being reviewed, but the Westminster Parliament is not able to enact legislation that will affect its sustainability.

From an environmental limits point of view, and particularly considering the PB concept, the three **objectives** of the 1992 Convention on Biological Diversity, and the objective of its 2010 Nagoya Protocol, are not very promising. They do not focus on biophysical reality. Indeed, the fact that the former Convention has three, seemingly equal, objectives (conservation, use and sharing of benefits) is a perfect example of not accepting that without biodiversity being conserved, there is no use or benefits to share.

In passing, an example of a definition of 'conservation and management', from US domestic fisheries law, more closely captures how a PB-related objective might perhaps

³⁵ Brussels, 14.03.2011, SEC(2011) 342 final, Commission Staff Working Paper on the implementation of EU Air Quality Policy and preparing for its comprehensive review, available here: http://ec.europa.eu/environment/air/pdf/sec_2011_342.pdf

³⁶ Common Fisheries Policy: A User's Guide, pages 4-5, available here: http://ec.europa.eu/fisheries/documentation/publications/pcp2008_en.pdf

³⁷ Fisheries science and sustainability in international policy: a study of failure in the European Union's Common Fisheries Policy, Tim Daw and Tim Gray, Marine Policy 29 (2005) 189–197, available here: <http://www.uea.ac.uk/dev/People/staffresearch/tdawresearch/TDaw-2005-fisheriesscience-cfp>

read in a biodiversity context, as it embeds use and benefits within conservation and management.³⁸

- (5) The term "conservation and management" refers to all of the rules, regulations, conditions, methods, and other measures*
(A) which are required to rebuild, restore, or maintain, and which are useful in rebuilding, restoring, or maintaining, any fishery resource and the marine environment; and
(B) which are designed to assure that—
(i) a supply of food and other products may be taken, and that recreational benefits may be obtained, on a continuing basis;
(ii) irreversible or long-term adverse effects on fishery resources and the marine environment are avoided; and
(iii) there will be a multiplicity of options available with respect to future uses of these resources.

On the positive side, the 2010 Nagoya Protocol contains a very interesting provision in the context of the long-continuing debate about the ability of international and domestic environmental laws to be trumped by trade rules. Nothing that is suggested in the following section could be so trumped, by any stretch of the imagination, but it is worth pointing out that Article 4.1 of the Protocol should help biodiversity rules be respected in the face of competing trade rules. It provides:

"The provisions of this Protocol shall not affect the rights and obligations of any Party deriving from any existing international agreement, except where the exercise of those rights and obligations would cause a serious damage or threat to biological diversity. This paragraph is not intended to create a hierarchy between this Protocol and other international instruments."

It appears that one of the effects of this provision, for example, is that a State seeking to rely on trade rules to override measures to protect biodiversity under the Nagoya Protocol would not be able to do so if application of those trade rules would cause serious damage or threat to biological diversity. This is very welcome, and an example of the kind of provision that is consistent with respecting environmental limits.

This section ends with a brief consideration of three issues that will feed through into the discussion on feasible legislation in section 8.

(1) The precautionary principle

The precautionary principle has been a feature of international environmental law since its emergence in the mid-1980s. The first treaty which referred to the term was the

³⁸ Magnuson-Stevens Fishery Conservation and Management Act, Public Law 94-265, as amended by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (P.L. 109-479), Sec. 3(5), available here: http://www.nmfs.noaa.gov/msa2005/docs/MSA_amended_msa%2020070112_FINAL.pdf

1985 Vienna Convention (as 'precautionary measures'), and this fed through to the 1987 Montreal Protocol and its amendments. This legal regime is generally regarded as having been successful, largely because of production bans on the depleting substances, though still there has been "unprecedented" ozone depletion over the Arctic this spring.³⁹

The principle has been evident in treaties to protect the marine environment. A particularly strong expression of it appears in Article 2.2 of the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention):

"The Contracting Parties shall apply:

(a) the precautionary principle, by virtue of which preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship between the inputs and the effects;"

Such strong expressions of the principle, which are very much in keeping with its initial comprehensive elaboration,⁴⁰ do not incorporate economic or cost-effective considerations. On the other hand, the principle never made it into the operative provisions of the 1992 Convention on Biodiversity (only the preamble), and it was significantly downgraded in the UNFCCC.⁴¹

³⁹ "Depletion of the ozone layer - the shield that protects life on Earth from harmful levels of ultraviolet rays - has reached an unprecedented level over the Arctic this spring because of the continuing presence of ozone-depleting substances in the atmosphere and a very cold winter in the stratosphere", according to the World Meteorological Organization. See its press release of 5th April 2011, here: http://www.wmo.int/pages/mediacentre/press_releases/pr_912_en.html

⁴⁰ See The 1990 Bergen Ministerial Declaration on Sustainable Development in the ECE Region, 16th May 1990, paragraph 7, which stated as follows: *"In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."* Document reference A/CONF.151/PC/10.

⁴¹ "In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, *inter alia*, by the following:... 3. The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors...", UNFCCC, Article 3, Principles.

Bearing in mind the differences between the policy and scientific approaches discussed in this paper, and the absence of a legislative provision in UK law requiring application of the principle, is environmental limits legislation the place to resurrect something along the lines of the OSPAR and initial formulations of the precautionary principle?

(2) The aquatic environment

Given the continuing problems with eutrophication, and to an extent acidification, it might seem strange to consider that higher expectations, perhaps, are held for implementation of the EU Water Framework Directive (and of the Marine Strategy Directive). In many ways, it is an admirable instrument, and the product of a great effort to address the water issue in its many manifestations. Its river basin management approach and its legal framework for achieving ‘good ecological status’ demonstrate a clearly evolved approach to securing water quality and quantity. But it remains to be seen how it will be implemented: according to the POST report:⁴²

“Current statistics suggest that only 22% of rivers and 25% of all water bodies met the WFD’s “good ecological status” target in 2009 and this figure is likely to increase only to 30% by 2015.”

There are significant potential “let-outs” in the Directive, a lot of discretion is given to Member States, and there is plenty of legalese for economic pressures to be able to have their way – which motivates much of the natural capital accounting and ecosystem valuation approaches. A “real live example” in the Box below helps to illustrate the concerns.

Protection of the Pembrokeshire Marine Special Area of Conservation

Achieving good ecological status by 2015 for the Milford Haven Inner and Outer water bodies, a substantial part of the Pembrokeshire Marine Special Area of Conservation under the Habitats Directive, is stated in the Western Wales River Basin Management Plan to be “disproportionately expensive”, and not to be achieved until 2027, with favourable conservation status for the SAC not to be achieved until 2021.

Despite the Countryside Council for Wales’ advice that it will adversely affect the integrity of the SAC, the Environment Agency is about to grant a permit for a new gas-fired power station that will abstract its cooling water from, and discharge its (often bleached) heated water at 8⁰ C above ambient temperature into, the SAC at Milford Haven at a scale equivalent to three times the combined average flow of the two main

⁴² At page 58: http://www.parliament.uk/documents/post/POSTLongReport_370-Environmental-Limits.pdf

rivers draining into the Haven, whilst the waste heat would represent an energy loss equal to about 40% of Wales' current electricity demand.⁴³

If the Water Framework Directive, here in combination with the Habitats Directive – which should have the concerted effect of ensuring protection of the Haven – cannot prevent this kind of development in the face of politicians' will to the contrary, then it is difficult to be optimistic about the Directive's long-term effect.

Another area of aquatic concern is the problem of nitrogen pollution. Over 60% of England is covered by Nitrate Vulnerable Zones under the Nitrates Directive,⁴⁴ and in a European Commission report in 2010⁴⁵ England was singled out (with Flanders and Brittany) for “high values above 40 mg/l” in fresh surface waters, with increasing trends in more than 30% of monitoring stations, and the west of England was identified as one of many EU regions “with a relatively large fraction of strongly increasing nitrate concentrations”.

According to the website of the Centre for Ecology and Hydrology, key messages of the the European Nitrogen Assessment published on 11th April 2011 include:⁴⁶

- *“At least ten million people in Europe are potentially exposed to drinking water with nitrate concentrations above recommended levels.*
- *Nitrates cause toxic algal blooms and dead zones in the sea, especially in the North, Adriatic and Baltic seas and along the coast of Brittany.*
- *Nitrogen-based air pollution from agriculture, industry and traffic in urban areas contributes to particulate matter air pollution, which is reducing life expectancy by several months across much of central Europe.*
- *In the forests atmospheric nitrogen deposition has caused at least 10% loss of plant diversity over two-thirds of Europe.”*

⁴³ References for this paragraph can be found here:

http://www.foe.co.uk/resource/submissions/pembroke_power_station_com.pdf

⁴⁴ COUNCIL DIRECTIVE of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC) (OJ L 375, 31.12.1991, p. 1), as amended, available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1991L0676:20081211:EN:PDF>. The preamble of the 2009 Commission Decision granting England, Scotland and Wales derogations from the Directive's annual limitation on livestock manure applied to land to 170 kg nitrogen (up to 250 kg), gave the figure for England of 68%: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:141:0048:0051:EN:PDF>. According to the Environment Agency's website, “NVZs now cover 62 per cent of England”: <http://www.environment-agency.gov.uk/business/sectors/54714.aspx>

⁴⁵ Brussels, 9.2.2010, COM(2010)47 final, REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT On implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2004-2007 SEC(2010)118, available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0047:FIN:EN:PDF>

⁴⁶ http://www.ceh.ac.uk/news/news_archive/EuropeanNitrogenAssessment.html

Bearing in mind, especially, that the authors of the planetary boundaries concept consider the nitrogen cycle boundary already to have been crossed, how might this be reflected in legislation relevant to water quality and quantity?

(3) Environmental assessment

The planning system has become increasingly distinctive in the different parts of the UK since devolution, and the coalition government's localism agenda will add to this. For example, regional spatial strategies are to be abolished in England, Scotland's first Land Use Strategy was laid before the Scottish Parliament on 17th March 2011, and Wales retains its Spatial Plan.

That said, however, there are several kinds of what can broadly be termed 'environmental assessments' which are to a large extent common, and which extend beyond the traditional land use planning sphere (e.g., to river basin management plans under the Water Framework Directive, and to marine plans under the Marine and Coastal Access Act 2009), in particular:

- Environmental impact assessments for projects, under domestic legislation transposing the EIA Directive;⁴⁷
- Strategic environmental assessments (SEAs) of plans and programmes for agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use which set the framework for future development consent of projects listed in the Environmental Impact Assessment Directive, or which, in view of the likely effect on sites, have been determined to require an "appropriate assessment" under Article 6 of the Habitats Directive. This requirement is set out in the various UK laws transposing the EU SEA Directive.⁴⁸

In addition to SEAs of plans and programmes, under Article 8 of the UNECE Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context (SEA Protocol),⁴⁹ which came into effect in July 2010, and which the UK signed in 2003 but has still not yet ratified, the Parties:

⁴⁷ Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, as amended by Council Directive 97/11/EC. Available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1985L0337:20090625:EN:PDF>

⁴⁸ DIRECTIVE 2001/42/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, available here: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:197:0030:0037:EN:PDF>. Excluded from this Directive are financial and budget plans and programmes, those solely serving national defence or civil emergency purposes, and those with certain minor effects.

⁴⁹ http://www.unece.org/env/eia/sea_protocol/contents.htm

*“shall endeavour to ensure that environmental, including health, concerns are considered and integrated to the extent appropriate in the preparation of its proposals for **policies and legislation** that are likely to have significant effects on the environment, including health”(emphasis added)*

- Sustainability appraisals of national policy statements must be carried out by the Secretary of State under section 5 of the Planning Act 2008; of a marine policy statement by the policy authorities under section 44 of the Marine and Coastal Access Act 2009; and the Planning and Compulsory Purchase Act 2004 includes provisions requiring sustainability appraisal of local development documents and plans in England and Wales
- Appropriate assessments under the Habitats Directive, where a “plan or project” is likely to have a significant effect on a site protected under the Directive.

Recent statements by the RCEP, and in the POST report, are worth noting.

In its 29th report on the RCEP has emphasised the importance of strategic environmental assessment, at multiple levels:⁵⁰

“We conclude that environmental assessment at the strategic level should be an important part of medium- to long-term planning whether plans are being considered at national, regional or local level.”

The POST report points out how project EIAs do not, for example, integrate the ecosystem approach, or apply to changes in agricultural use of uncultivated and semi-natural land that affect less than 2 hectares, less than 4km of field boundaries or movements of 10,000m³ or less of earth and rock – which has led to criticisms that there is continued loss of valuable habitat fragments in landscapes, which are often in patches of less than 2 hectares.⁵¹ It also makes some interesting observations about SEAs and environmental limits:

“The SEA Directive includes a requirement to provide information about measures “envisaged” to prevent, reduce or offset significant effects on the environment, but no specific mention is made of ecosystem services or biodiversity. SEA of policies, plans and programmes, at national and local government levels is a possible existing regulatory mechanism for taking account of environmental limits, but the lack of clearly defined environmental limits is a major impediment to their incorporation. Theoretically, environmental limits

⁵⁰ RCEP Twenty-ninth Report, Demographic Change and the Environment, February 2011
<http://www.rcep.org.uk/reports/index.htm> Unfortunately, the abolition of the RCEP at the end of March 2011 appears to have reduced the web access to its reports, at least after 18th January 2011. Hopefully this is just a temporary matter, or perhaps I have just failed to find this report, which I found online in March, online during April.

⁵¹ <http://www.grasslands-trust.org/campaign.php?campaignid=4>

should be a key part of defining an environmental baseline for an SEA, but there needs to be a clearly agreed basis for defining these in any given relevant situation.”

Is it feasible now to amend environmental assessment and sustainability appraisal legislation to reflect more precisely the importance of environmental limits? And could the devolved legislatures act now to apply SEAs to policies and legislation, ahead of the UK's ratification of the SEA Protocol?

8. Feasible legislation on environmental limits

So, are there any laws, taking the long view, that the Westminster Parliament could pass which would address the question of environmental limits? The short answer is, emphatically, yes. The longer answer is the purpose of this section.

First, though, what is not feasible at this point?

I am not yet sure that it is feasible to propose domestic legislation that would impose now a specified actual (tougher) limit on particular 'resource' use or consumption, or require a specified higher degree of quality (e.g. for air or water) than might be specified in current legislation, on the ground that a critical tipping point has been reached. I should emphasise that this is not because it could not be done on environmental limits grounds, and the overwhelming general impression is that it *must* be done, but I have not (yet) seen a particular area in which there is sufficiently detailed evidence.

Having said that, I have considered whether it might be possible for the Westminster Parliament to legislate for adherence to critical loads in relation to air pollution. In principle, this *would* be feasible, but at the moment, subject to what I say in the next paragraph, it would not be so much on an environmental limits (tipping point) basis, but simply because it was a necessary measure for protection of the environment and human health. Even though the UK's air quality legislation has been based on agreements at the UNECE and EU levels, Article 193 of the Treaty on the Functioning of the European Union provides that Member States are not prevented from maintaining or introducing more stringent protective measures. It would be a departure from the usual practice of dealing with this at the EU level, the Westminster Parliament would probably only be able to do so in relation to England, and because, presumably, transboundary (and localised?) pollution (and maybe other factors) would prevent the critical loads being met, legislation might not be immediately effective. But it seems feasible to do so, on environmental protection grounds.

In addition, because air pollution appears to be implicated in almost all the planetary boundaries, if it could be shown, as appears to be the case, that a planetary boundary

parameter to which air pollution contributed had already been crossed (e.g., the nitrogen cycle), or might soon be transgressed as a result of further contributions from air pollution, then this would in my view make legislation feasible on environmental limits grounds, subject to the particular boundary being sufficiently robust and a reasonable estimate of the contribution was also possible.

Before setting out suggestions for feasible legislation on environmental limits grounds, it should be borne in mind that most UK environmental law is derived from EU law. No laws passed in any UK legislature should conflict with those, but UK laws can provide more stringent protection than EU laws (as just stated). At the same time, environment is a devolved matter, and so what is written below in relation to the Westminster Parliament would also apply in principle to the Scottish Parliament, to the Northern Ireland Assembly and, since the referendum result in Wales last month, to the National Assembly for Wales.

Legislation containing procedural, substantive and institutional provisions relating to environmental limits could be passed.

(1) Procedural obligations at local and national levels, on public authorities and the Environment Agency

Recognition of the existence of planetary boundaries could be incorporated into the laws on strategic environmental assessment, sustainability appraisal, appropriate assessments and project EIAs. Although it appears that the concept has probably not, yet, formed into a widespread international consensus as far as its proposed boundaries, and as far as some of the parameters, are concerned, there seems to be little doubt that climate change, biodiversity, the nitrogen and phosphorus cycle, stratospheric ozone depletion, ocean acidification, freshwater use, change in land use, chemical pollution, and atmospheric aerosol loading are all crucial Earth-system processes (or effects) that are capable of at least being considered during decision-making where these assessments and appraisals are undertaken.

Legislation could also go further, and require consideration of these processes in the development of policies, in addition to those policies that are already covered, such as national policy statements and the marine policy statement,⁵² and also in proposed legislation, in line with the unratified SEA Protocol.

Much of the information on Earth-system processes is already available, and should be provided in some form or other already in these instruments, but one of the points of such legislation would be to organise collation of the information within a planetary

⁵² The UK Marine Policy Statement, under section 44 of the Marine and Coastal Access Act 2009, was published in March 2011: <http://archive.defra.gov.uk/environment/marine/documents/interim2/marine-policy-statement.pdf>

boundaries framework, and to systematise consideration of the effect of the relevant decision on each planetary boundary. In this (modest) way, a developing understanding that there are biophysical realities that operate at a quite different level to economic and social realities would be facilitated. Assuming this would make scientific sense, as the PB concept developed, in time a Resilience Impact Assessment could be required (though the risk of this becoming a box-ticking nature would militate against this).

The legislation could also require a 'certified statement' to be made by the relevant authority, at the same time as making the decision in question, providing its quantified estimate of the effect of the decision on each planetary boundary. Judgmental statements such as 'minimal or insignificant effect' on a given planetary boundary (or indeed 'significant effects' thereon) would not be permitted.

It would also make sense in this context, depending on scientific advice, to consider expanding the parameters for each planetary boundary – at least until it might be said that there is sufficient scientific consensus on each parameter - to include other activities and effects that obviously bear on the relevant Earth system processes, such as nitrogen deposited on land, soil loss and greenhouse gas emissions.

Because of a common tendency on public authorities to 'divide and pollute' - to minimise the environmental impact of particular decisions by excluding effects not immediately connected to the nature of the bureaucratic decision - such as excluding from an SEA the assessment of oil and gas licensing rounds the emissions that result from oil and gas use; or excluding from a project EIA for fertiliser production the effects of the use of that fertiliser; or excluding from the EIA of a road the extra emissions of the traffic using that road - the legislation could make clear that all effects that can be reasonably foreseen from the decision must be accounted for, so that 'the official world' and 'the real world' would not be so far apart.

The Environment Agency grants permits to industrial processes that contribute to effects on the Earth-system processes recognised in the PB concept. In the same way as for assessments and appraisals, a similar requirement can be placed on the Agency as well.

Some advantages and disadvantages of legislation along these lines

Some advantages:

- Relatively easy
- Wide application
- Respects the limitations of the science - doesn't require agreement on parameters or proposed boundaries
- Would build a base for further action
- Would benefit from current information gathering systems

- “UK World First”

Some disadvantages:

- Weak – doesn’t prevent planetary boundaries being further threatened
- Risks box ticking

(2) Substantive and institutional obligations at national level

At central government level, it would be feasible to place on the Secretary of State – e.g., in a Planetary Boundaries Framework Bill - a duty to consider each of the nine Earth system processes that are part of the PB concept, with a view to coming forward with proposals for how they could be implemented in the country.

He or she would be assisted in this task by a Planetary Boundaries Commission which could be established in a similar way to the Committee on Climate Change under the Climate Change Act, and which would have a wide ranging advice and research role, with a duty to make recommendations on how to proceed that the Secretary of State would be legally obliged to follow or alternatively to provide a reasons for not following. In Wales, for example, these duties could be undertaken by a strengthened Commissioner for Sustainable Futures. One of the Commission’s tasks could be to consider how the mechanism of a carbon budget might be extended, for example, to a nitrogen budget, phosphorous budget, air pollutant budget or other possible Earth-system process-relevant budgets, at least notionally to begin with (in the absence of internationally agreed limits). This is already done, in effect, for climate change, and in a sense also under the 2001 National Emission Ceilings Directive.⁵³ It could also be required to suggest how the country’s own ‘national Earth-system boundaries’ should look like, both from the point of view of the resilience of the national (*sic*) environment, and as regards our “fair share”.

The Bill would also require the Secretary of State to monitor, and to report to Parliament, on the country’s effects on each of the nine Earth system processes, both in absolute terms and relative to other countries. The Commission would also be able to assist with this.

It would also be possible in the same Bill to require the Secretary of State to adopt policies, strategies, plans and programmes which sought to reduce the country’s impact on each of the processes. This could be done in response to recommendations from the Commission. The Bill could be structured in such a way flexibly so as to allow different mechanisms and measures to be applied to each planetary boundary individually, and in combination. This would probably be best done (for flexibility) by statutory instrument,

⁵³ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:309:0022:0030:EN:PDF> [text and footnote inserted 24th June 2011]

but as this gives a lot of power to the executive, who could be expected to dilute the Bill as far as possible, a “super-affirmative resolution” type of procedure could be provided for, along the lines of that set out in section 18 of the Legislative and Regulatory Reform Act 2006.⁵⁴

In addition, where a public authority has a statutory duty to contribute to sustainable development (putting aside for now the problems with the weakness of that duty) the Bill could expressly include reference to (and a definition of) planetary boundaries. In this way, a public authority would be obliged to contribute to sustainable development in a manner which did not threaten planetary boundaries. A start could be made, or an alternative adopted, by taking the Nagoya Protocol language and, in statutes where a duty to contribute to sustainable development existed, an obligation could be inserted not, in the exercise of that duty, to cause serious damage or threat to biodiversity.

In this Bill, it would be possible to require the Secretary of State to apply a strongly worded form of the precautionary principle, along the lines of the OSPAR Convention, and excluding economic or cost effective considerations requirements, when carrying out functions under the Bill.

Some advantages and one disadvantage of legislation along these lines

Some advantages:

- Stronger than merely procedural duties
- Takes the science as far as it can go, without over-stretching it
- Climate Change Act precedent – “taking politics out of the biophysical”, to parody Prime Minister David Cameron’s remarks in 2008 on the setting up of the Committee on Climate Change (*“An independent body should set and enforce these targets and be able to adjust them in the light of circumstances. That would take the politics out of climate change”*)⁵⁵
- Flexible
- Provides a framework for development
- Possible in all 4 UK legislatures
- The precautionary principle in UK domestic law at last
- “UK World First”

⁵⁴ Under this section, a Minister must consider recommendations from a Committee of either House charged with reporting on a draft order made within 60 days of the draft order having been laid before Parliament. If the Minister still wishes to make the order as set out in the draft, he or she must lay before Parliament a statement setting out the existence and details of representations made. If a Committee then recommends that no further proceedings be taken in relation to the draft order, then the order cannot proceed, unless the recommendation is, in the same session, rejected by a resolution of the House.

⁵⁵ http://www.foe.co.uk/campaigns/climate/press_for_change/help_break_carbon_silence_27316.html

One disadvantage is that legislation would not involve an immediate requirement to reduce impacts.

A more direct, but quite different, way of dealing with this issue in legislation would be to enact something like a National Environment Legacy Act, along the lines discussed in section 5. This would make explicit the concerns behind the environmental limits idea, namely the quality of the environment that will be inherited by future generations. As already discussed, a bill along these lines would set out the maximum degree of degradation or depletion of resources, if any, that would be permitted over the course of a specified period of several decades, with metrics of resource quality and quantity being used to produce enforceable standards. The supposedly narrow two exceptions though, discussed in section 5, would seem to be, in fact, capable of easy application.

Some advantages and disadvantages of legislation along these lines

Some advantages:

- Expressly recognises future generations
- Starts with a clear objective
- Confronts the present v. future tension head-on
- Good link with local level
- Practical and focused

Some disadvantages:

- No precedent
- Exceptions too loose
- Still needs a lot of data

If the ideas of natural capital accounting and placing a monetary value on ecosystem services were considered worth pursuing, then it would be possible in legislation, for example, to require the UK system of national accounts to cover 'natural capital accounting'. Subject to scientific advice, the ecosystem approach could also be expressly required in assessments and appraisals (as for planetary boundaries), but more thought would need to be given to how the two would relate to each other. This would not be my preferred approach.

(3) Obligations at the local level

How the idea of environmental limits is understood and applied at a local level, with the genuine participation of local people is crucially important. There is much merit in the

‘legacy planning’ approach at the local level, as put forward by the Environmental Law Foundation, and discussed in section 5, and this could be achieved within sustainable community strategies, required under section 4 of the Local Government Act, and which are supposed to feed into the local development framework.

Possible legislation discussed in (1) and (2) above would impact at the local level, e.g., because section 4 of the Local Government expressly requires the strategies to contribute to sustainable development, and through legacy planning legislation, but additional changes might be needed to implement the legacy approach at the local level. Equally, it seems perfectly feasible to require the strategies to include express reference to planetary boundaries.

Although it is outside this paper’s remit to consider international or EU law (as such), given the nature of the issue this section cannot end without offering some comments in this regard.

(4) The European level

As regards the EU, the 6th Environmental Action Programme, covering period from 2002-2012, expires in July next year. According to its website, the Commission is currently working on the final assessment which is due in “mid-2011”.⁵⁶ It has still not been announced if there will be a 7th version. If there will be a 7th version, then recognition of the planetary boundaries concept should certainly be included in it.

More widely, the failings of the UNECE Convention and its Protocols, and EU legislation, to protect human health and the environment, as discussed in section 7, suggests that this regime would benefit from (at least) consideration of the planetary boundaries concept. In particular, the discussion in paragraph (3) above has suggested the possibility of UK air pollutant budgets, along the lines of carbon budgets. From the climate lessons, the possibility of this idea working is helped enormously by the coalescing of legal, scientific and political contexts. So far, there certainly seems to be a legal and political consensus around non-adherence to critical loads, and seemingly a scientific consensus on the need to achieve them. The planetary boundaries concept should be a wake-up call to strengthen the legal framework and to jolt the politicians and bureaucrats out of their informal and flexible ways of working, which have been recognised as affecting the effectiveness of the Convention regime.

A comprehensive review of EU air quality policies, and requiring adherence to critical loads and recognition of planetary boundaries should be included in this review as well.

⁵⁶ <http://ec.europa.eu/environment/newprg/final.htm>

(5) The international level

Justice can best be done to the PB concept at the international level. Although it is not (at least yet) an action plan, it is, as discussed above, feasible to recognise it now in national legislation, and also to recognise it within the contexts of current international legal regimes. But in my view it is the kind of cohering concept that is capable of express recognition in international law, and deserves to be.

A United Nations Framework Convention on Planetary Boundaries, which could begin with a simple recognition by States that certain Earth-system processes exist and that policies and strategies across the board need to recognise and respect them, and to cooperate in so doing, including in research and policy development, would certainly seem feasible. In the short-term, at least, negotiations dealing with human activities that affect the boundaries, including, for example, the World Trade Organization and the World Bank, will continue within the already-established international processes and agreements. It would therefore be appropriate to consider how these processes should recognise the boundaries within their legal frameworks.

Given that air pollution is implicated in almost all of the earth-system processes in the planetary boundaries concept, but that there is no global international treaty on air pollution, attention should be given to how best to ensure that global air pollution does not push humanity further across the nitrogen cycle and other thresholds.

In 2012, governments will be meeting in Rio de Janeiro to mark twenty years since the UN Conference on Environment and Development. This would seem to be an imminent opportunity for taking the planetary boundaries concept forward, for example by the adoption of a Rio Declaration on Planetary Boundaries, as a fore-runner of a possible Convention.

9. Next steps

The next steps will depend on what legislative options are considered worth pursuing. This in itself depends on further discussion, including further discussion of the scientific and policy backgrounds, with other organisations, and on the further work that would be needed to take the options forward. The current political feasibilities in the different parts of the UK would also be a part of the discussions, though it is also important to take the longer view.

On the assumption that further discussion results in deciding to go forward with proposed legislation, work could be undertaken to draft a proposed Bill, and a plan adopted for pursuing it.

Consideration can also be given to how this issue might be pursued at EU and international levels.

Annex – Planetary Boundaries

This Annex contains two Tables.

Table A.1, on the following page, is reproduced from the *Nature* feature which presented the planetary boundary concept in 2009.⁵⁷ It sets out:

- the nine Earth-system processes, although this does not seem to be an accurate description of each of them;
- the suggested numerical parameters and the proposed boundary for seven of them; and
- a quantification of their current status and pre-industrial value.

Table A.2, on pages 38-39, contains a summary of the seven short expert commentaries on the planetary boundary concept that were published at the same time as the *Nature* feature,⁵⁸ with one addition.

The commentators are: Myles Allen, a physicist specialising in climate at University of Oxford; Cristián Samper, Director of the Smithsonian National Museum of Natural History, Washington DC; William H. Schlesinger, President of the Cary Institute of Ecosystem Studies in Millbrook, New York; Mario J. Molina, Director of the Mario Molina Center for Strategic Studies in Energy and the Environment, Mexico City; Peter Brewer, Ocean Chemist and Senior Scientist, Monterey Bay Aquarium Research Institute, Moss Landing, California; David Molden, Deputy Director General for Research, International Water Management Institute, Colombo, Sri Lanka; and Steve Bass, Senior Fellow at the International Institute for Environment and Development.

(No commentaries were published on the two processes for which boundaries were not proposed, atmospheric aerosol loading and chemical pollution.)

The addition is the inclusion in the Table of text from a paper by Stephen Carpenter (Center of Limnology, University of Wisconsin) and Elena Bennett (McGill University),⁵⁹ relating to the phosphorus cycle.

⁵⁷ Rockström, J, *et al*, 2009, *Nature* **461**: 472-475 (*A safe operating space for humanity*). The fuller scientific paper on which this feature is based, along with Supplementary Information, can be accessed from the 'Relevant Info' box on this web page: <http://www.stockholmresilience.org/planetary-boundaries>

⁵⁸ The commentaries are available here: Nature reports, Climate Change, Vol. 3, October 2009, pages 112-119, <http://www.anu.edu.au/climatechange/wp-content/uploads/2009/09/climate-commentary-october-2009.pdf>.

⁵⁹ The paper is entitled '*Reconsideration of the planetary boundary for phosphorus*', which was published in February 2011 in Environmental Research letters and is available here: http://iopscience.iop.org/1748-9326/6/1/014009/pdf/1748-9326_6_1_014009.pdf


Table A.1 – 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 the Earth system thereof	To be determined		

Table A.2 - COMMENTARIES ON PLANETARY BOUNDARIES

Earth system process <i>parameters & proposed boundary</i>	Commentaries
Climate change <i>(i) Atmospheric carbon dioxide concentration (parts per million by volume) - 350</i> <i>(ii) Change in radiative forcing (watts per metre squared) - 1</i>	<p>“defin[ing] a ‘climate boundary’ in terms of long-term CO₂ concentrations [is] an unnecessary distraction... it misses the point...The actions required over the next couple of decades to avoid dangerous climate change are the same regardless of the long-term concentration we decide to aim for.” Even if we keep to 2⁰C, “it will probably be many centuries, and possibly millennia, before concentrations return naturally to 350 ppm”. “There is, however, one important respect in which aiming for 350 ppm, even without a date attached, may be a helpful target – it implies that we limit net anthropogenic carbon emissions to less than one trillion tonnes...this is simply what we need to do to keep the most likely peak CO₂-induced warming below 2⁰C”. Allen</p>
Rate of biodiversity loss <i>Extinction rate (number of species per million species per year) - 10</i>	<p>Boundaries for individual physical & chemical variables are more amendable to measurement than extraordinarily complex interactions between species & ecosystems. Limited data on species abundance & distribution. Good data (e.g.) on bird extinctions, but not on insects or most marine invertebrates. Extinction rates almost certainly higher than proposed boundary in the past. A single biodiversity boundary across all taxa and habitats “may not be useful” (e.g., as rates of extinction and speciation vary across different organisms and habitats). Alternatives might be “a measure of how population size, distribution and threat levels are changing for specific groups....[or] express species extinction as a probability based on evolutionary history and the tree of life, instead of a range of values”. Samper</p>
Nitrogen cycle (part of a boundary with the phosphorus cycle) <i>Amount of N₂ removed from the atmosphere for human use (millions of tonnes per year) - 35</i>	<p>The nitrogen threshold “seems arbitrary” and “waiting to cross the threshold allows much needless environmental degradation”. In areas of excess nitrogen deposition from the atmosphere, e.g. in pastures in Great Britain, species decline linearly as a function of increasing nitrogen inputs to land. “Unfortunately, policymakers face difficult decisions, and management based on thresholds, although attractive in its simplicity, allows pernicious, slow and diffuse degradation to persist nearly indefinitely...Setting boundaries is fine, but waiting to act until we approach these limits merely allows us to continue with our bad habits until it’s too late to change them.” Schlesinger</p>
Phosphorus cycle (part of a boundary with the nitrogen cycle) <i>Quantity of P flowing into the oceans (millions of tonnes per year) - 11</i>	<p>“[A] lenient limit”. Schlesinger “The planetary boundary for freshwater eutrophication has been crossed while potential boundaries for ocean anoxic events and depletion of phosphate rock reserves loom in the future.” Carpenter & Benett (February 2011)</p>
Stratospheric ozone depletion <i>Concentration of ozone (Dobson unit) - 276</i>	<p>“[a] very interesting and useful concept”. The boundary is “reasonable, but a bit arbitrary”. The tipping point for ozone depletion is 30 ppb of atmospheric concentration of effective equivalent stratospheric chlorine (EESC), so 10 or 20 ppb would maintain a safe distance. 10 ppb would lead to a 15 % stratospheric ozone loss. The Montreal Protocol limited EESC to about 4 ppb, leading to ozone loss of about 5-6%. “[T]he [PB] concept is a very important one, and its proposal should now be followed by discussions of the connections between the various boundaries and of their association with other concepts such as the ‘limits to growth’. Molina</p>

Ocean acidification <i>Global mean saturation state of aragonite in surface sea water – 2.75</i>	The limit of 3.44 “seems reasonable”, but other boundaries might also be necessary because of impacts other than changes in pH. “But is it truly useful to create a list of environmental limits without serious plans for how they may be achieved?” Brewer
Global freshwater use <i>Consumption of freshwater by humans (km³ per year) – 4,000</i>	“[A] welcome new approach in the ‘limits to growth’ debate.” “As a scientific organizing principle, the concept has many strengths”. The 4,000 km ³ value “may well be too high”, because “the concept of a global limit overlooks the importance of local conditions and the role of management in magnifying or ameliorating problems”. “[T]he [PB] concept and its first estimate of numeric values give us an important warning call that must be heeded. Rather than get bogged down in detailed arguments about the weaknesses of the approach or the methods of analysis, we now have a tool we can use to help us think more deeply – and urgently – about planetary limits and the critical actions we have to take.” Molden
Change in land use <i>Percentage of global land cover converted to cropland - 15</i>	“[A] sound idea”. “Their paper has profound implications for future governance systems.” “That said, there is much work to be done before the concept can be used practically”. The 15% limit is based on “a sensible – though apparently arbitrary – expansion factor” – why not 10 or 20%? “[S]ustainability of land use depends less on percentages and more on other factors”, such as intensively farmed cropland in large blocks. 15% is “a premature policy guideline that dilutes the authors’ overall scientific proposition”. Might want to consider a limit on soil degradation or soil loss – “a more valid and useful indicator of the state of terrestrial health”. Bass

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