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Chapter 1 : Ecology and Society: Safe operating space for humanity at a regional scale

RockstrÃ¶m, J. et al. "Planetary Boundaries: Exploring the Safe Operating Space for Humanity." Ecology and Society Vol. 14, no. 2, art. This article provides an expanded version of the argument presented in the paper in Nature.

Subsequent assessments concluded that impacts exceed most delineated boundaries. Societal responses to these results have been insufficient to restore safety. One factor impeding effective action is differences in scale between planetary boundaries and national, regional, or local scales where many impacts and solutions originate. I have contributed toward a resolution by developing a regional scale framework and an approach to translate boundaries across spatial scales. I developed the framework for a county and river basin in the Pacific Northwest. The framework includes six state variables related to planetary scale analogues. Boundary translation can be achieved by aggregating hydrologic processes across scales. Because of greater process certainty and lower spatial heterogeneity at the regional scale, regional boundaries can be defined with more precision than global analogues. The region has exceeded five boundaries and is close to the remaining one. Effects of existing and proposed policies will be to exceed boundaries further. Likely consequences include irreversible degradation in river functions, severe water shortages, impaired water quality, human health impacts, and extinctions of iconic salmonids. In most cases, policy and enforcement mechanisms to restore conditions within regional boundaries are in place, but they have been ignored or misapplied. New initiatives with potential to restore safety are being pursued by indigenous peoples, who also are most directly affected by boundary transgression. By clearly delineating regional boundaries and identifying consequences of boundary transgression, this framework may complement indigenous efforts with policy imperatives for other stakeholders in the region. The framework identifies 11 biophysical processes that determine environmental function at a planetary scale and that have been affected severely by human activities. For each process, it determines boundaries beyond which the Earth system could shift to a state incompatible with human civilization and persistence of many species Barnosky et al. The latest assessment concluded that the Earth system remains within boundaries of 3 processes, but that humanity has driven the Earth system beyond a safe operating space for 5 processes Steffen et al. Sufficient data are lacking to determine the status of the 3 remaining processes. These results should compel rapid and comprehensive responses in societies around the planet. To date, such responses have been inadequate, although there are several regional exceptions Jones et al. Many factors underlie the discrepancy between planetary boundary analysis and societal responses. First, international environmental treaties are difficult to enact, implement, and enforce Feldman , Foster Second, responses are impeded by differences between the global scale of planetary boundaries and the national, regional, and local scales where policy decisions are made Nykvist et al. These policies and decisions would be informed by local or regional analogues to planetary boundaries. Heterogeneity in resource distribution and human impacts further compel regional boundary identification. Regional state shifts may occur earliest where resource use is excessive, even though processes at the planetary scale may remain within global boundaries Brook et al. Heterogeneity in biophysical circulation and transport processes can cause systemic impacts to cascade through the Earth system. For example, interactions between atmospheric circulation patterns and forest clearing in the Amazon basin can alter precipitation in distant continents Badger and Dirmeyer Deforestation can alter circulation patterns themselves in ways that differ among regions McGuffie et al. Regional boundaries also are needed for critical regions where impacts can cause global consequences even though global variables may remain within safe limits Nykvist et al. Establishing regional boundaries would contribute to the planetary boundary approach, because six global boundaries involve processes that aggregate from regional to planetary scales Nykvist et al. For those processes, remaining within regional boundaries is a prerequisite for respecting planetary limits Nykvist et al. Regional-scale boundaries need delineation because resource management and land use often do not consider limits or thresholds. Many policy analysis frameworks implicitly devalue safe operating space for future generations by applying economic discounting: In Washington State USA , many resource and land-use decisions are determined through comprehensive planning, which requires counties and cities to accommodate population growth within a year planning

horizon without consideration of biophysical process boundaries Washington State Legislature Planning laws in most other U. Regional boundaries need to be delineated even if policy mandates to minimize environmental impacts are in place. Environmental responses that warn of approaching thresholds may not be evident Hastings and Wysham , Boettiger and Hastings or provide sufficient lead time to mount effective policy and management responses Biggs et al. These concerns become magnified when impacts beyond boundaries are irreversible Scheffer et al. When the time required to change policy and practice exceeds the latency between environmental warnings and threshold transgression, proactive mechanisms to maintain safety margins are required Lindenmayer et al. Boundary delineation supports these mechanisms. Three studies identified national analogues for each planetary variable and determined relevant limits for the focal nations Nykvist et al. For processes characterized by well-mixed stressors, such as climate change, ocean acidification, and stratospheric ozone depletion, these analyses applied linear downscaling from global limits to determine per capita shares. Then they aggregated per capita shares to national levels and compared observed national impacts with downscaled planetary boundaries. Two analyses Nykvist et al. In contrast, Cole et al. They adjusted planetary boundaries to reflect regional conditions and data available for land use, freshwater use, nutrient cycles, and biodiversity loss. They applied three methods: They found the first method inadequately addressed regional heterogeneity for the same reasons that limit accuracy in downscaling from planetary to national scales. They delineated regional boundaries and current status for five processes: They analyzed time series data for soil erosion, air quality, and water quality to detect changes in environmental dynamics indicative of approaching state transitions. Their results have strong implications for social and environmental management in those regions, although connections to planetary boundaries are less clear. Finally, safe operating spaces have been developed for ecosystem components, including wetlands Green et al. If the priority is to maintain local environmental functions within desirable bounds, consistency is unnecessary. Consistency and cross-scale translation are required, however, if regional and national boundary delineations are to support the planetary framework. Interregional consistency could be achieved using linear downscaling from planetary boundaries, but spatial heterogeneity and scale dependency of most processes render this approach inadequate Cole et al. This problem also occurs when data at the national scale are downscaled to a regional scale Cole et al. The heterogeneous and local nature of most drivers of environmental change Cole et al. Nevertheless, regional boundaries lead to conceptual challenges of reconciling interregional differences and translating up to national and global levels. I address two linked goals: To simplify boundary delineation, the focal region consists of an independent basin that discharges directly into the sea. Future analyses should address scale translation within and among large basins. It is bounded on the north by the U. Most of the human population of , Washington State Office of Financial Management resides in the western third of the county. The county is within the traditional territories of the Lummi Indian Nation and the Nooksack Tribe, who retain reservations and trust lands in the western third of the county. During the following century, most of the forested land of the main-stem Nooksack subbasin was cleared and converted to agricultural uses NWIFC Since , some agricultural land and remaining forest land have been converted to residential, commercial, and industrial uses. Approximately half of the county population obtains domestic water from Lake Whatcom, which is augmented by diversion from the Middle Fork of the Nooksack River. The other half obtains water from the Nooksack River or groundwater wells. All Nooksack subbasins are closed to further water withdrawal year-round or during the summer dry season Water Resources Program, Washington State Department of Ecology Boundaries determined for one scale can be translated to another scale using methods appropriate to the kind of process involved. Three of the 11 global processes, i. These processes occur at a global scale, with regional limits that can be determined by linear downscaling Nykvist et al. Alternative downscaling approaches to national or regional allocations have been proposed using socioeconomic, efficiency, or equity criteria. These approaches include perpetuating current allocations in stressor production, shifting to equal per capita allocation, considering national or regional capacity for stressor adjustments, and accounting for historical responsibility in stressor production Gignac and Matthews I will not consider boundaries for well-mixed stressors any further, although per capita driver emissions from the focal region are similar to U. Two global processes, production of novel entities and

atmospheric aerosol loading, have not been quantified at a global level Steffen et al. Both processes are partially measured within the focal region, but in the absence of national or global boundaries and mechanisms to link them, I will not consider them. The remaining six global processes, i. Translating boundaries for these processes across scales is the key challenge in efforts to relate regional impacts to global processes and, conversely, to determine regional limits consistent with global boundaries. Cross-scale interactions have received extensive study e. This literature can be summarized simplistically as follows: These principles provide insight that can be applied to boundary translation across scales. In most regions, ecosystem states relevant to boundary processes are constrained by precipitation regimes. Precipitation quantity and timing strongly influence biogeochemical flows, freshwater availability, potential terrestrial vegetation types and land uses, and biodiversity composition and functions. Conversely, mechanisms determining these properties often involve hydrologic processes. Hydrologic processes also provide connectivity within and between subbasins that may confer local resilience to local perturbations. In basins with abundant anadromous fish, return of spawning adults also provides upstream connectivity. Strong spatial connectivity also may lead to catastrophic state change when stressors exceed critical levels Scheffer et al. These considerations suggest that effective boundary translation across scales could involve hydrologic processes Perveen , which are more amenable to cross-scale modeling than terrestrial phenomena Giorgi and Avissar Accordingly, this regional boundary analysis includes hydrologic processes where relevant, in variable selection, boundary delineation, or impact identification. First, I resolved regional systems into causal chains linking human activities to resultant impacts. At each scale, Earth-system processes function in a web of interactions among anthropogenic and nonanthropogenic stressors, diverse system components, feedbacks, and affected entities. Effective societal interventions must act on stressors rather than impacts Hughes et al. Intervention design, including selecting indicator variables and identifying policy options, is clarified by delineating causal pathways connecting drivers to impacts. I applied a driver-pressure-state-impact-response DPSIR framework for these purposes, similar to other subglobal analyses Nykvist et al. DPSIR frameworks outline causal chains linking anthropogenic stressors or drivers, system fluxes or pressures, system states affected by fluxes, impacts resulting from state changes, and societal responses to modify drivers or pressures. Boundaries identify states at the limit of safety Dao et al. The state criterion caused some discontinuity with the planetary boundary framework Steffen et al.

Chapter 2 : A safe operating space for humanity.

A safe oper ating space for humanity Identifying and quantifying planetary boundaries that must not be transgressed could help pr event human activities from causing unacceptable envir onmental.

From the Stockholm Memorandum Science indicates that we are transgressing planetary boundaries that have kept civilization safe for the past 10, years. Humans are now the most significant driver of global change , propelling the planet into a new geological epoch, the Anthropocene. We can no longer exclude the possibility that our collective actions will trigger tipping points, risking abrupt and irreversible consequences for human communities and ecological systems. Overall, this is an impressive attempt to define a safety zone. The notion of a single boundary is just devoid of serious content. In what way is an extinction rate 10 times the background rate acceptable? He thinks waiting until we near some suggested limit will just permit us to continue to a point where it is too late. They also provide benchmarks and direction for science. As we improve our understanding of Earth processes and complex inter-relationships, these benchmarks can and will be updated Disruption of the global nitrogen cycle is one clear example: How can such ethical and economic issues be matched with a simple call to set limits? We need to know how to live within the unusually stable conditions of our present Holocene period and not do anything that causes irreversible environmental change The planetary boundaries concept should enable policymakers to understand more clearly that, like human rights and representative government, environmental change knows no borders. Importantly, this novel concept highlights the risk of reaching thresholds or tipping points for non-linear or abrupt changes in Earth-system processes. As such, it can help society to reach the agreements required for dealing effectively with existing global environmental threats, such as climate change. A future worth choosing", The High-level Panel on Global Sustainability called for bold global efforts, "including launching a major global scientific initiative, to strengthen the interface between science and policy. We must define, through science, what scientists refer to as "planetary boundaries", "environmental thresholds" and "tipping points". This language is unacceptable to most of the developing countries as they fear that an emphasis on boundaries would place unacceptable brakes on poor countries. Red bars show temperatures above and blue bars show temperatures below the average temperature. Positive radiative forcing results in warming. From the start of the industrial revolution in to , the increase in atmospheric carbon dioxide has led to a positive radiative forcing, averaging about 1. She puts emphasis in choosing policies that minimize costs and preserve consensus. She favors a system of green-house gas emissions tax , and emissions trading , as ways to prevent global warming. She thinks that too-ambitious objectives, like the boundary limit on CO2, may discourage such actions. The challenge is to make conservation attractiveâ€”from economic and cultural perspectives. We cannot go on treating nature like an all-you-can-eat buffet. We depend on nature for food security, clean water, climate stability, seafood, timber, and other biological and physical services. The Costa Rican government is paying landowners for ecosystem services from tropical forests, including carbon offsets, hydropower production, biodiversity conservation and scenic beauty. The country is also creating "ecosystem function conservation areas" that make up 18 percent of its land area. Colombia and South Africa have made dramatic policy changes, too. Three advances would help the rest of the world scale such models of success. Much of this new reactive nitrogen pollutes waterways and coastal zones, is emitted back to the atmosphere in changed forms, or accumulates in the terrestrial biosphere. Most of the nitrogen and phosphorus ends up in rivers, lakes and the sea, where excess amounts stress aquatic ecosystems. For example, fertilizer which discharges from rivers into the Gulf of Mexico has damaged shrimp fisheries because of hypoxia. He says the boundary suggested for phosphorus is not sustainable, and would exhaust the known phosphorus reserves in less than years. The single largest contributor is fertilizer use. But the burning of fossil fuels actually dominates the problem in some regions, such as the northeastern U. The solution in that case is to conserve energy and use it more efficiently. Hybrid vehicles are another excellent fix; their nitrogen emissions are significantly less than traditional vehicles because their engines turn off while the vehicle is stopped. Emissions from conventional vehicles actually rise when the engine is idling. Nitrogen emissions from U. In agriculture, many farmers could use less

fertilizer, and the reductions in crop yields would be small or nonexistent. In addition, nitrogen losses can be reduced by 30 percent or more if farmers plant winter cover crops, such as rye or wheat, which can help the soil hold nitrogen. These crops also increase carbon sequestration in soils, mitigating climate change. Better yet is to grow perennial plants such as grasses rather than corn; nitrogen losses are many times lower. Nitrogen pollution from concentrated animal feeding operations CAFOs is a huge problem. Require CAFO owners to treat their wastes, just as municipalities must do with human wastes. Further, if we ate less meat, less waste would be generated and less synthetic fertilizer would be needed to grow animal feed. Eating meat from animals that are range-fed on perennial grasses would be ideal. The explosive growth in the production of ethanol as a biofuel is greatly aggravating nitrogen pollution. Several studies have suggested that if mandated U. The best alternative would be to forgo the production of ethanol from corn. If the country wants to rely on biofuels, it should instead grow grasses and trees and burn these to co-generate heat and electricity; nitrogen pollution and greenhouse gas emissions would be much lower. Peak phosphorus With regard to phosphorus, the ocean engineer David Vaccari says that the most sustainable environmental flow of phosphorus "would be the natural flux: Phosphorus is a scarce finite resource on earth and means of production other than mining are unavailable because of its non-gaseous environmental cycle. About one quarter of the additional carbon dioxide generated by humans is dissolved in the oceans, where it forms carbonic acid. This acidity inhibits the ability of corals, shellfish and plankton to build shells and skeletons. Knock-on effects could have serious consequences for fish stocks. This boundary is clearly interconnected with the climate change boundaries, since the concentration of carbon dioxide in the atmosphere is also the underlying control variable for the ocean acidification boundary. Regionally, nutrient runoff to coastal waters not only creates dead zones but also amplifies acidification. The excess nutrients cause more phytoplankton to grow, and as they die the added CO2 from their decay acidifies the water. We have to be smarter about how we fertilize fields and lawns and treat livestock manure and sewage Locally, acidic water could be buffered with limestone or chemical bases produced electrochemically from seawater and rocks. More practical may be protecting specific shellfish beds and aquaculture fisheries. Larval mollusks such as clams and oysters appear to be more susceptible to acidification than adults, and recycling old clamshells into the mud may help buffer pH and provide better substrate for larval attachment. The drop in ocean pH is expected to accelerate in coming decades, so marine ecosystems will have to adapt. We can enhance their chances for success by reducing other insults such as water pollution and overfishing, making them better able to withstand some acidification while we transition away from a fossil-fuel energy economy. Human land uses include arable farmland yellow and pasture light green Across the planet, forests, wetlands and other vegetation types are being converted to agricultural and other land uses , impacting freshwater, carbon and other cycles, and reducing biodiversity. For example, the environmental impact of 15 per cent coverage by intensively farmed cropland in large blocks will be significantly different from that of 15 per cent of land farmed in more sustainable ways, integrated into the landscape. Instead, the authors might want to consider a limit on soil degradation or soil loss. This would be a more valid and useful indicator of the state of terrestrial health. We can avoid losing the best agricultural land by controlling land degradation, freshwater depletion and urban sprawl. This step will require zoning and the adoption of more efficient agricultural practices, especially in developing countries. The need for farmland can be lessened, too, by decreasing waste along the food distribution chain, encouraging slower population growth, ensuring more equitable food distribution worldwide and significantly reducing meat consumption in rich countries. The freshwater cycle is another boundary significantly affected by climate change. Overexploitation occurs if a water resource is mined or extracted at a rate that exceeds the recharge rate. Recharge usually comes from area streams, rivers and lakes. Forests enhance the recharge of aquifers in some locales, although generally forests are a major source of aquifer depletion. A modified Hubbert curve applies to any resource that can be harvested faster than it can be replaced. More controversial is defining where those limits are or what steps to take to constrain ourselves within them. Another way to describe these boundaries is the concept of peak water. Three different ideas are useful. Although it is difficult to quantify this point accurately, we have clearly passed the point of peak ecological water in many basins around the world where huge damage has occurred The good news is that the potential for savings, without hurting human health or

economic productivity, is vast. Improvements in water-use efficiency are possible in every sector. More food can be grown with less water and less water contamination by shifting from conventional flood irrigation to drip and precision sprinklers, along with more accurately monitoring and managing soil moisture. Conventional power plants can change from water cooling to dry cooling, and more energy can be generated by sources that use extremely little water, such as photovoltaics and wind. Ozone depletion During 21â€”30 September the average area of the Antarctic ozone hole was the largest ever observed The stratospheric ozone layer protectively filters ultraviolet radiation UV from the Sun , which would otherwise damage biological systems. The actions taken after the Montreal Protocol appeared to be keeping the planet within a safe boundary. The gain has relied, in part, on intermediate substitutes, notably hydrochlorofluorocarbons HCFCs , and the growing use of compounds that cause no depletion, such as hydrofluorocarbons HFCs. Ongoing success depends on several steps: Ensure that nations adhere to regulations; for example, the HCFC phaseout will not be complete until It attributes causes of changes in the ozone layer and evaluates new chemicals for their potential to destroy ozone and contribute to climate change. It provides information on technologies and substitute compounds that helps nations assess how the demand for applications such as refrigeration, air-conditioning and foam insulation can be met while protecting the ozone layer. Climate change affects ozone abundance by altering the chemical composition and dynamics of the stratosphere, and compounds such as HCFCs and HFCs are greenhouse gases. For example, the large projected demand for HFCs could significantly contribute to climate change. Some aerosols produce clouds which cool the Earth by reflecting sunlight back to space, while others, like soot, produce thin clouds in the upper stratosphere which behave like a greenhouse, warming the Earth. On balance, anthropogenic aerosols probably produce a net negative radiative forcing cooling influence. Aerosol loading is sufficiently important to be included among the planetary boundaries, but it is not yet clear whether an appropriate safe threshold measure can be identified.

Chapter 3 : Planetary boundaries - Wikipedia

A Safe and Just Space for Humanity Oxfam Discussion Paper, February 3 Author's note Oxfam's GROW campaign is committed to growing a better future - and as a priority that.

The wedges represent an estimate of the current position for each variable. The boundaries in three systems rate of biodiversity loss, climate change, and human interference with the nitrogen cycle have already been exceeded. The environmentâ€"our life-support systemâ€"is changing rapidly from the stable Holocene state of the last 12, years, during which we developed agriculture, villages, cities, and contemporary civilizations, to an unknown future state of significantly different conditions. Key Concepts In the last years, humanity has transitioned into a new geological eraâ€"termed the Anthropoceneâ€"which is defined by an accelerating departure from the stable environmental conditions of the past 12, years into a new, unknown state of Earth. We must return to the long-term stable global environment that nurtured human development. The nine areas that are most in need of planetary boundaries are climate change, biodiversity loss, excess nitrogen and phosphorus production, stratospheric ozone depletion, ocean acidification, global consumption of freshwater, change in land use for agriculture, air pollution, and chemical pollution. We estimate that humanity has already transgressed three of these boundaries: Several steps can be taken to establish and enforce these boundaries, and they are suggested here. See these papers for a complete description of the planetary boundaries. Here, we present the underlying concepts and suggest ways to limit continued growth of the material economy on a finite planet. The Challenge Over the past half century, we have become adept at dealing with environmental problems on a local and global scale. The worst excesses of the Industrial Revolution have, in many cases, been ameliorated. Rivers, such as the Thames in London, have been cleaned up and the air quality in major cities, such as Los Angeles, is better. Synthetic pesticides once sprayed on our crops, such as DDT, have been banned in most developed countries, and lead has been removed from petroleum-based fuels. For them, many of the local and regional environmental problems still exist and, in many cases, are worsening. Second, the environmentâ€"our life-support systemâ€"is under increasing threat from a wide range of human pressures, many of them emanating from consumption in the wealthy countries. The deterioration of the global environment puts even more pressure on the poorest countries to limit growth, even as they struggle to bring their populations out of poverty. This is an entirely new situation for humanity. In the past when we fouled our local environment, we could move to someplace else. As human population has grown, these short-term solutions are no longer viable. Furthermore, the impacts of our presence were not usually felt beyond our immediate surroundings. This is also no longer the case. The global environment has provided an especially accommodating environment over the past 12, years for humanity to develop and thrive. Does our planet have boundaries regarding the amount of growth it can absorb? We believe it does and that certain preconditions must be set that acknowledge and respect those boundaries. This new situation is captured in the concept of the Anthropocene, a newly defined geological era beginning around the s, with the Industrial Revolution. The term was introduced and popularized by Nobel Laureate Paul Crutzen,5 who felt the recent influence of human activity on the Earth was significant enough as to constitute the naming of a new epoch. The past 12, years or so is a period defined by geologists as the Holocene, an epoch in which global average temperature has been remarkably stable and during which time agriculture developed, followed by the appearance of ever larger settlements and the development of complex civilizations in Africa, Asia, South and Central America, and the Mediterranean region. Since the Industrial Revolution, the human enterprise has expanded so rapidly that we are now overwhelming the capacity of the Earth system to absorb our wastes and to sustainably provide the services we require. In the period since the Second World War, the acceleration of development has become particularly dramatic. So what is the solution to this dilemma? Humanity needs to change course, but in what direction and what principles should guide the journey? The problem has been recognized for several decades, and many attempts have been undertaken to define or inform solutionsâ€"limits to growth,9 safe minimum standards,10 the precautionary approach,11 and tolerable windows,12 for example. These provide an excellent knowledge base from which to work toward a more

sustainable future. The Concept of Planetary Boundaries How do we begin to identify what aspects of our planet need boundaries and what those boundaries are? The concept of planetary boundaries,1,2 while building on earlier efforts, takes a rather different approach. It does not focus so directly on the human enterprise, as do most of these earlier approaches, but rather emphasizes the Earth as a complex system. Here we identify nine areas that are most in need of set planetary boundaries: This refers to a specific point related to a global-scale environmental process beyond which humanity should not go. The position of the boundary is a normative judgment, informed by science but largely based on human perceptions of risk. Our planet can undergo abrupt changes naturally. An example is the sudden switch in North Atlantic ocean circulation when a critical level of freshwater input is reached. But these thresholds and abrupt changes are intrinsic features of the Earth system and cannot be eliminated or modified by human actions, such as the development of new technologies. We have to learn to live with thresholds and respect them. An abrupt change is a hardwired feature of the Earth system independent of human existence, while violation of a boundary is a subjective judgment by humanity about how close we wish to approach dangerous or potentially catastrophic thresholds in our own life-support system. Climate change, biodiversity loss, and phosphorus and nitrogen production are just three areas in which boundaries can be determined and measured, and we will use these as examples. Human-provoked climate change is no longer disputed. Scientists can measure climate change by studying the levels of CO2 in our atmosphere. Transgressing these boundaries could lead to the melting of ice sheets, rising sea level, abrupt shifts in forest and agricultural land, and increasing intensity and frequency of extreme events like floods, wildfires, and heat waves. A second example is biodiversity loss, which does occur naturally and would continue to some degree without human interference. However, the rate of animal extinction has skyrocketed in the postindustrial age. Compared with fossil records, today the rate of extinction per species is â€”1, times more than what could be considered natural. Human activities are to blame: We believe another 30 percent of wildlife will come under the threat of extinction this century if change is not made. The dangers of biodiversity loss go beyond nostalgia for certain animals: Setting a planetary boundary for biodiversity is difficult because there is so little known about the way in which species are interwoven and how they connect to the broader environment. However, we propose beginning by using the extinction rate as a flawed but acceptable indicator. Our suggested planetary boundary is that of ten times the background rate of extinction. More research may change this boundary. In our third example, we propose that no more than 11 million tonnes of phosphorous should be allowed to flow into the ocean each yearâ€”which is ten times the natural background state. Excessive production of phosphorus, along with nitrogen, is a by-product of our agricultural system. Excessive phosphorous and nitrogen production pollutes waterways and coastal areas and adds harmful gases to the atmosphere. Current levels already exceed critical thresholds for many estuaries and freshwater sites, and so further research may reduce the current phosphorus and nitrogen boundaries. We propose that a boundary be set for each of the nine areas and that it be respected globally, in order for humans to continue along a healthy, productive path for an indefinite amount of time table 2. Thus, we need to define a zone within which we are reasonably sure the threshold lies or beyond which we are reasonably sure that a significant degree of resilience will be lost. Implementing the concept of planetary boundaries presents huge challenges for global governance and institutions. Critical Features of the Planetary Boundaries Concept Several features of the planetary boundaries conceptual framework are critical to understanding how the approach works. First, planetary boundaries are explicitly designed for the global scale and are aimed at keeping the Earth within safe ranges that existed prior to the Industrial Revolution. Although some Earth-system processes, such as ocean acidification, are intrinsically global in scale, others become global only when they aggregate from much smaller scales. In no way does this mean that local or regional environmental issues, which have largely been the focus of policy and management for decades, have become less important. Efforts to reduce pollution and limit and reverse ecosystem degradation at local and regional scales continue to be very important and in fact have become even more important because of their larger-scale implications. However, we must now also focus on the global scale explicitlyâ€”in addition to and not at the expense of the many environmental issues we still need to solve at smaller scales. A global solution to the sustainability challenge is thus a prerequisite for living sustainably at local and regional scales. This is

not at all surprising given that the Earth behaves as a single, complex system at the global scale, but it does complicate the formulation and implementation of planetary boundaries. There are cascading impacts, in which transgressing one boundary can have implications for other boundaries. For example, converting the Amazon rainforest to a grassland or savanna could influence atmospheric circulation globally and ultimately affect water resources in East Asia through changes in rainfall. To see how humanity is faring with respect to the boundaries, we have listed the current and preindustrial values of the control variable along with the proposed boundary. Even small changes can have a synergistic effect when linked to other small changes. For example, conversion of forest to cropland, increased use of nitrogen and phosphorus fertilizers, and increased extraction of freshwater for irrigation could all act together to reduce biodiversity more than if each of these variables acted independently. Many changes feed back into each other. The processes involving ocean acidity and atmospheric CO2 concentration are an example of a reinforcing feedback loop. These are part of the trade-offs that allow humanity to continue to pursue increased well-being. The boundaries simply define the regions of global environment space that, if human activities push the Earth system into that space, would lead to unacceptably deleterious consequences for humanity as a whole. These two socioeconomic states, however, would deliver vastly different outcomes for human well-being. Thus, remaining within the planetary boundaries is a necessaryâ€”but not sufficientâ€”condition for a bright future for humanity. The Implications for Governance As a practical solution for living sustainably in the modern era, the planetary boundaries approach raises important questions and opportunities for governance and institutions, even to the point of challenging the concept of national sovereignty. We have identified four specific challenges for governance: Indeed, the planetary boundaries approach is based directly on this feature of the Earth system. An early-warning system is a prerequisite for being able to recognize and steer away from such thresholds. Each of the planetary boundaries is placed within a zone of uncertainty, some much larger than others. Although further scientific research will reduce these uncertainties in many cases, they will never be completely eliminated. In a poisonous political environment, uncertainties can be exploited as reasons for inaction, but scientists must be able to address uncertainty without being attacked. A global governance system will need to live with a certain level of uncertainty, emphasizing the need for a precautionary approach when determining the position of boundaries. Interacting with the traditional institutions that currently exist at national, subnational, and local levels will be necessary, and probably will be complex and challenging to implement. Creating effective multilevel governance systems will be especially important for those planetary boundaries that are based on aggregates of many local and regional actions. Capacity to assimilate new information. In addition to reducing the zone of uncertainty for some boundaries, scientific research will continue to uncover more insights into the dynamics of the Earth system itself. This could lead to the need for additional planetary boundaries or the reformulation of existing ones. The increasing flow of new scientific information will undoubtedly put pressure on any institutional framework to keep up with the pace of new knowledge.

Chapter 4 : How Defining Planetary Boundaries Can Transform Our Approach to Growth - The Solutions Jo

These are estimates of how the different control variables for seven planetary boundaries have changed from to present. The green shaded polygon represents the safe operating space.

Chapter 5 : Planetary Boundaries: A Safe Operating Space for Humanity

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Chapter 6 : Planetary Boundaries: A Safe Operating Space for Humanity â€” PIK Research Portal

Planetary Boundaries: Exploring the Safe Operating Space for Humanity Johan RockstrÃ¶m 1,2, Will Steffen 1,3, Kevin Noone 1,4, Ã…sa Persson 1,2, F. Stuart III Chapin 5, Eric Lambin 6, Timothy M. Lenton 7, Marten Scheffer 8, Carl Folke

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Chapter 7 : Scientists identify â€œsafe operating space for humanityâ€• in seminal Nature study | Grist

Although we have not analyzed the interactions among planetary boundaries, the examples we present suggest that many of these interactions will reduce rather than expand the boundary levels we propose, thereby shrinking the safe operating space for humanity.

Chapter 8 : A Safe and Just Space for Humanity | Oxfam International

A safe operating space for humanity. RockstrÃ¶m J(1), Steffen W, Noone K, Persson A, Chapin FS 3rd, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber.

Chapter 9 : Ecology and Society: Planetary Boundaries: Exploring the Safe Operating Space for Humanity

The group wanted to define a "safe operating space for humanity" for the international community, including governments at all levels, international organizations, civil society, the scientific community and the private sector, as a precondition for sustainable development.