3rd Nobel Laureate Symposium on Global Sustainability

Transforming the World in an Era of Global Change

Stockholm, Sweden, May 16-19 2011

EXECUTIVE SUMMARY

OF SCIENTIFIC BACKGROUND REPORTS

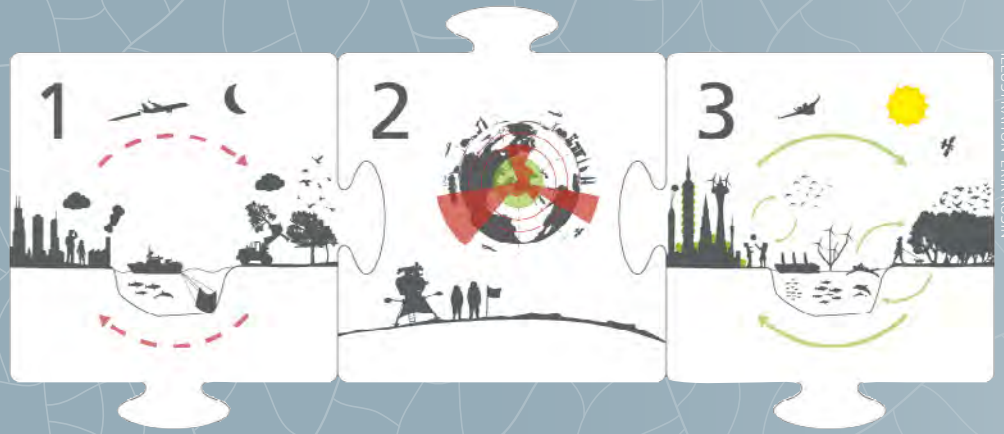

ILLUSTRATION ERIK ROSIN

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Introduction

This Executive Summary provides an overview of the three scientific background reports prepared for the 3rd Nobel Laureate Symposium on Global Sustainability: Transforming the World in an Era of Global Change, to be held in Stockholm on 16–19 May 2011. The Symposium is being organised jointly by the Stockholm Resilience Centre at Stockholm University, the Royal Swedish Academy of Sciences, the Stockholm Environment Institute, the Beijer Institute of Ecological Economics and the Potsdam Institute for Climate Impact Research.

The Symposium gathers Nobel Laureates, high-level representatives of politics, business and civil society and renowned experts on sustainability and development to discuss the challenges the world is facing.

The sessions during the Symposium will revolve around three themes, which also reflect the scientific background reports:

1. RECONNECTING TO THE BIOSPHERE: Dealing with the role of *natural capital* and the life-supporting environment as the foundation for societal development and provider of services for human well-being.
2. THE HUMAN DOMINATED PLANET: Focusing on the advent of the *Anthropocene* – the new geological epoch dominated by humanity – and on recent attempts to identify the safe operating space for humanity to continue to develop within a stable planet Earth.
3. TIPPING TOWARDS SUSTAINABILITY: Exploring the links between crisis, opportunity and innovation for navigating shifts and large-scale *transformations* towards global sustainability.

The work on the three scientific background reports has engaged a number of the scientists invited to the Symposium. In essence, the scientific evidence provided clearly indicates that we are in a critical period. This is a new situation for humanity, with unprecedented challenges of solving interrelated issues such as poverty, inequality, hunger and environmental degradation. The capacity and ingenuity to deal with these challenges exist if we channel our creativity in a way that reconnects human development with the biosphere (the global ecological system) and continue to develop within *planetary boundaries*.

The three background reports present a mix of necessary actions and exciting planetary opportunities. They also illustrate how we can use the growing insights of the multiple global challenges facing humanity to support real transformative changes.

In this Executive Summary we describe these challenges and planetary opportunities in the same order as the background reports, and conclude with five key messages for each chapter.

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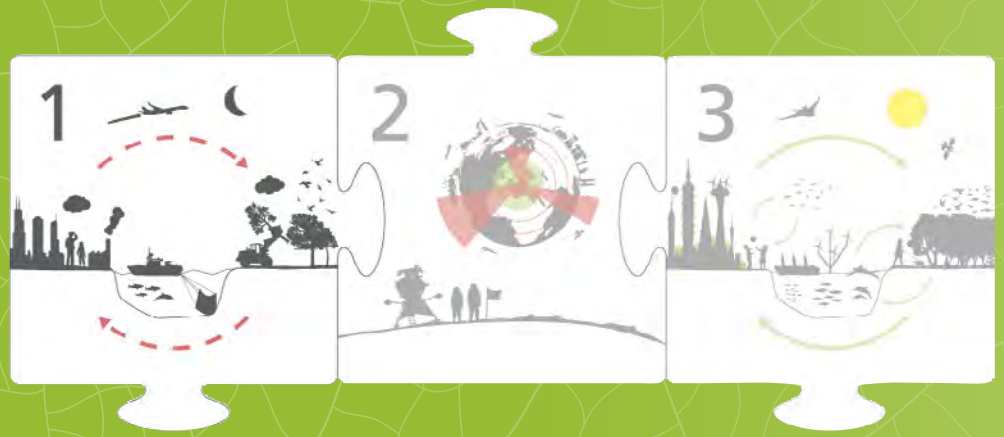

Reconnecting to the Biosphere

1. Linking people and ecosystems

In our globalised society, there are virtually no ecosystems that are not shaped by people and no people without the need for ecosystems and the services they provide. The problem is that too many of us seem to have disconnected ourselves from nature and forgotten that our economies and societies are fundamentally integrated with the planet and the life-supporting ecosystems that provide us with a hospitable climate, clean water, food, fibres and numerous other goods and services. It is high time we reconnect and start accounting for and governing the capacity of natural capital to sustain development.

SINCE EARLY 1800 the human population has increased massively from one billion to the current (still increasing but at a slower rate) figure of seven billion people. During these last 200 years, and particularly after World War II, economic development, international collaboration, technical and *social innovation*, improved health and wealth have all contributed to boost the standard of living of most people, although the world still hosts one billion of the absolute poor and three billion people living on less than 2.5 USD a day.

Within the same period of time, the Earth's *ecosystems* have started to show serious signs of fatigue. In 2005, the UN *Millennium Ecosystem Assessment* (MA) published the first 'global health control' of the world's ecosystems. The diagnosis was clear: the rapidly growing human demands for food, freshwater, timber, fibre and fuel have changed the Earth's ecosystems faster and more extensively in the past 50 years than ever before. The MA shows that some 60 percent of the *ecosystem services* that support human well-being are being degraded or used unsustainably. This ecosystem degradation could grow significantly worse during the first half of this century and is a barrier to reducing global poverty and achieving the Millennium Development Goals.

Everything is connected

Amidst gloomy forecasts, the MA also brought with it some good news. The assessment represented a major shift towards a better understanding of the relationship between human progress, economic development and governance of the world's ecosystems. Rather than separating human progress from environmental governance, the MA has helped clarify that people and societies are indeed inseparable parts of what we call the *biosphere* – the global ecological system that embraces all living beings on Earth and in the atmosphere. The MA emphasises the importance of extending the economic notion of financial value to include nature's goods and services. The bottom line is that poverty alleviation and future economic development can only be achieved with a stronger emphasis on management and governance of ecosystems and their capacity to generate essential services.

A striking example is the Goulburn-Broken catchment in the Murray-Darling Basin, which has become one of the principal income providers for the State of Victoria, Australia. Thanks to widespread and seemingly well-adapted dryland cropping, grazing and fruit production, the region has apparently thrived. However, if the analysis is broadened to include the capacity or *resilience* of the landscape to sustain these activities, the picture looks different. Widespread replacement of deep-rooted native trees with crop and pasture plants that need less water, in combination with irrigation, have resulted in rising watertables. This in turn has brought salt normally held deep within the soil profile to the surface and is causing severe salinisation problems in the region.

Another example of the delicate interactions between social and ecological systems is the global market demand for palm oil and tropical timber, which has changed large parts of Borneo from *biodiversity*-rich tropical rainforests to a simplified oil palm landscape. The situation becomes critical when the role of El Niño is included in the equation. The reproduction of trees in the Dipterocarp family, which dominate the rainforests, is tightly linked with this climate phenomenon. Up to 90 per cent of Dipterocarp species synchronise

PHOTOGRAPHY MAX TROELL/AZOTE

their flowering with the onset of dry weather conditions, which traditionally occur on a roughly four-year basis. The mass blooming and subsequent fruiting involve thousands of species across millions of hectares and represent a strategy that intermittently starves and swamps seed predators, so that at least some seeds survive to germination. This dynamic relationship between Dipterocarp trees and El Niño has lasted for millennia, but the growing global thirst for palm oil is now breaking the system down. Intensive logging of the trees has reduced the local density and biomass of mature trees below a critical threshold that limits masting. In addition, the introduction of fires in a region that had no prior fire regime has exacerbated drought stress and caused a radical *transformation* in forest ecology, which has made El Niño a destructive rather than a regenerative force. In the process, Borneo has turned from being a carbon sink into becoming a carbon source, with fires releasing massive amounts of carbon dioxide, making Indonesia one of the largest greenhouse gas polluters in the world.

Resilience thinking

One increasingly relevant scientific approach to deal with analysis of such interwoven systems of humans and nature is through the concept of resilience. This concept is not only being used as a framework for research, but is now being applied in practice. Examples range from city planning in developed regions to small-scale water innovations to combat poverty in drought-prone areas in the developing world (see case study map, page16). Resilience is the long-term capacity of a system to deal with change and continue to develop. For an ecosystem, such as a forest, this can involve dealing with storms, fires and pollution, while for a society it can involve an ability to deal with events such as political unrest and natural disasters in a way that is sustainable in the long-term. Low resilience may lead to undesired shifts in a system. Examples include savannah systems that turn into shrub-deserts, coral reefs that turn into algae-covered rubble and lakes that become over-enriched with nutrients and shift into a state with blooms of toxic algae and fish kills. The outcome tends to be biodiversity-poor ecosystems that are vulnerable to change and generate fewer ecosystem services to human societies.

Increased knowledge of how we can strengthen resilience in both society and nature, or rather interconnected *social-ecological systems*, is becoming increasingly important when grappling with climate change and other environmental impacts. Investing in resilience can be seen as insurance against future shocks. By safeguarding critical resources, the chances of 'riding through' shocks – such as extreme events – increase. This is of critical importance considering future uncertainty and limited understanding of the vulnerability generated by anthropogenic change. In essence, resilience theory argues that the nub and kernel of the problem is that many of the serious, recurring problems in natural resource management stem from a lack of recognition that ecosystems and social systems are dynamic and inextricably linked.

Accounting for nature's capital

A substantial challenge is to ensure that the provisioning of ecosystem services becomes more visible in the market. Putting a price on ecosystem services is gaining increasing interest among researchers and policy makers. Although the scientific basis and financial and political mechanisms are still under development, there are several promising efforts. For instance, The Economics of Ecosystems and Biodiversity (TEEB) report calls for wider recognition of nature's contribution to human livelihoods, health, security and culture by decision makers at all levels (local, regional and national policy makers, business leaders and private citizens). The report concluded that in 2008 the annual costs of forest losses alone (2–5 trillion USD) dwarfed the ongoing financial crisis. In other words, the world was losing more money from the disappearance of forest ecosystem services alone than through the banking crisis that year. The TEEB report has helped place biodiversity management on the high end of the political agenda, showcasing the enormous economic value of forests, fresh-water, soils and coral reefs, to name but a few.

Acknowledging the key demands of the TEEB report, India has already announced plans to implement a new set of accounts, which track the country's natural capital and include the value of nature's services alongside GDP in decision-making. China is another country where natural capital investments and payments for ecosystem services are now being integrated into governance on a remarkable scale (see case study map, page 16). The TEEB report also emphasises the message that failure of business to account for the value of natural capital, particularly in sectors such as mining, can pose significant economic and social risks. Estimates show that the negative environmental impacts of the world's top 3,000 listed companies amount to around 2.2 trillion USD annually.

The nub and kernel of the problem is that many of the serious, recurring problems in natural resource management stem from a lack of recognition that ecosystems and social systems are dynamic and inextricably linked.

One example of better integration of ecosystems and their services into business activities is the Corporate Ecosystem Services Review (ESR), developed by the World Resources Institute and others. This is a five-step methodology for corporate managers to proactively develop strategies for managing business risks and opportunities arising from their company's dependence and impact on ecosystems. The ESR has been translated into five languages and over 200 businesses have put it to use. For instance, the international paper and packaging company Mondi conducted an ESR for three of its South Africa tree plantations.

This resulted in new strategies to use invasive species cleared from its plantations for power and heat generation, a decision to co-finance water efficiency improvements of upstream landowners, and promotion of coppiced woodlots for biomass fuel that provide additional revenue for villagers.

Another example is the Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme. In terms of dollars per ton of carbon, it is an economically attractive option for reducing CO_2 emissions. REDD+ expands the scope of previous REDD programmes beyond avoided deforestation and degradation activities to include e.g. rehabilitation, planting of trees, sustainable management and an explicit aim to ensure the full and effective participation of indigenous peoples and local communities. Although by no means a perfect solution, estimates show that financial flows for greenhouse gas emission reductions from REDD+ could reach up to 30 billion USD a year. In addition to climate change mitigation, REDD+ can also generate a number of other benefits, including biodiversity conservation and a multitude of ecosystem services. Such ecosystem services are essential for the livelihoods of many millions of people and include erosion control, stabilisation of water supply and many wood and non-wood forest products.

The governance of global dynamics

Raising awareness about the dynamic interactions between social and ecological systems is one challenge, coming up with new ways to govern them is quite another. Governing complex systems, such as social-ecological systems, requires an institutional ability and zeal to cope with, adapt to and shape sudden changes. A move from rigid sector-based resource management to more adaptive *ecosystem-based management* is slowly gaining momentum, e.g. through the 'ecosystem approach', which is the primary framework for action under the UN Convention on Biological Diversity. Ecosystem-based management is an adaptive management approach that does not simply seek to manage human impacts on ecosystems. It also recognises that the capacity of an ecosystem to generate goods and services is shaped by humans and acknowledges the importance of their actions, including collaboration among individuals, networks, organisations, agencies, researchers and local resource users. Research suggests that flexible social networks and organisations built on adaptive learning are in a better position to sustain and manage ecological systems. *Adaptive governance* approaches must be able to coordinate relevant actors at multiple scales, but also to achieve meaningful collaborations and collective action before essential ecosystem services are depleted or critical thresholds are transcended. Key individuals provide trust and visions, while bridging organisations lower the costs of collaboration and conflict resolution. They also connect groups that would otherwise not be connected and enhance learning among stakeholders.

Such adaptive governance systems have emerged locally around the world, but are also increasingly appearing at regional and global level. The wetland area of Kristianstad in southern Sweden is one such case where ecosystem-based management structures have been successfully implemented. This wetland, which provides important ecosystem services such as flood control, cultural and recreational values and flooded meadows for grazing and haymaking, was increasingly degraded until the Ecomuseum Kristianstads Vattenrike (EKV) organisation was established in 1989. Although it has no authority to make or enforce legal rules, EKV has brought about changes in management and is playing a highly active and influential role in managing the wetlands. In June 2005, the wetlands were formally designated a Biosphere Reserve under the UNESCO Man and Biosphere scheme.

Examples of adaptive governance have also appeared on an international level, with measures taken to curb illegal and unregulated fisheries in Antarctic waters. Effective international collaboration between states was initially hampered by political sensitivity, but non-state actors (NGOs and the fishing industry itself) and their engagement in the Commission for the Conservation of Antarctic Marine Living Resources enabled the emergence of new ways to address the problem. A small number of key individuals living in countries remote from Antarctica mobilised personal networks and produced reports, which in turn raised political awareness, produced voluntary monitoring schemes and imposed informal pressure on states and industries involved in the industry. Although illegal and unregulated fishing has not completely disappeared, it has been considerably reduced through the complementary roles filled by state and non-state actors.

Key messages:

1. In spite of immense technological development and progress, our economies and societies still fundamentally depend on ecosystems to provide us with a hospitable climate, clean water, food, fibres and numerous other goods and services.
2. It is time to fully realise that our societies and economies are integral parts of the biosphere, and to start accounting for and governing natural capital. Poverty alleviation and future human development cannot take place without such a wider recognition of nature's contribution to human livelihoods, health, security and culture.
3. The issue at stake extends beyond climate change to a whole spectrum of global environmental changes that interplay with interdependent and rapidly globalising human societies. Science has a great responsibility in this respect to provide a better understanding of the multiple challenges facing humanity and to explore solutions for sustainable development in an increasingly unpredictable world.
4. Resilience thinking is an important part of the solution, as it strives at building flexibility and adaptive capacity rather than attempting to achieve stable optimal production and short-term economic gains.
5. It is time for a new social contract for global sustainability rooted in a shift of perception – from people and nature seen as separate parts to interdependent social-ecological systems. This provides exciting opportunities for societal development in collaboration with the biosphere; a global sustainability agenda for humanity.

The human dominated planet

2. From hunter-gatherers to planetary stewards

Believe it or not, for most of human history we have existed as hunter-gatherers. Now, thanks to the dramatic fossil fuel-driven expansion since the 1800s, our imprint on the global environment is so large that we risk triggering a number of abrupt or even irreversible global environmental changes. The big question is how we can become planetary stewards instead, and strike a long-term balance between human well-being and sustainable use of the Earth's ecosystems.

WE HAVE HAD a good run, but business-as-usual cannot continue. Humanity has begun to emit more than nature can absorb and acquire more than the Earth's resources can provide. In other words, we are beginning to live off the Earth's capital, rather than the interest.

The good news in all this is that we are the first generation with the knowledge of how our activities influence the Earth System. We are also the first generation with the power and responsibility to change our relationship with the planet.

21st century crossroads

The evidence that the Earth is warming and that human emissions of greenhouse gases have been responsible for most of this warming since the middle of the 20th century is unequivocal. However, just as disturbing as climate change is the increasing erosion of the Earth's goods and services. There is a growing acknowledgement that humans must be seen as part of and not apart from nature, and that the delineation between social and ecological systems is artificial and arbitrary (see Chapter 1 for more details).

A further realisation of the strong correlations between human actions and the Earth's life-supporting system is reflected in the term Anthropocene. This indicates that the human imprint on the planet is now so great that the Earth may have entered a new geological epoch. It is leaving the *Holocene*, the remarkably stable period within which human societies as we know them have developed, and it is entering a stage where humanity itself has become a global geophysical force. In other words, we have gone from being primitive hunter-gatherers to a force that can tip the Earth's future into the unknown. In the worst case scenario this new state of the Earth is much warmer, with more sea and less land, impoverished ecosystems, mass extinction of species and a number of severe socio-economic consequences.

The Great (fossil fuel-driven) Acceleration

About 10,000 years ago, agriculture was developed roughly simultaneously in four different parts of the world. This set humanity on a trajectory that led to a more sedentary lifestyle, the development of villages and cities and the creation of complex civilisations that eventually spanned large regions. Around 1800 AD, however, something dramatic happened. Our ancestors at that time learned to access and exploit fossil fuels as a new energy source and dramatic changes came about at a pace never experienced before: fossil fuel-based agricultural and manufacturing systems enhanced the production of foodstuffs and other goods, and consumption began to grow along with an increasingly healthy and expanding population. Little did they know that the rapid expansion of fossil fuel usage was slowly raising the CO_2 concentration in the atmosphere above the limits of the Holocene. The exit door from the Holocene had been opened.

The increased pace of just about everything after World War II marked a further threshold in humanity's history called the *Great Acceleration*. While the human population tripled, consumption in the global economy grew many times faster. With foreign direct investments, international tourism, cars, telephones and above all the internet, the connectivity of humanity has grown at an astounding rate since 1950. Not surprisingly, the acquisition and use

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of natural resources – as well as the pressure on our climate and ecosystems – has also risen dramatically during this period.

It is clear that the Great Acceleration has not been an environmentally benign phenomenon. It has driven large changes to the Earth System and human activities are eroding the Earth's resilience. This is due to overfishing, extensive (tropical) deforestation, a dramatic increase in domesticated land, increasing nitrogen fluxes and a profound loss of biodiversity, to name a few. However, one other aspect deserves particular attention.

The forgotten sea

Being terrestrial creatures, much of human concern about changes in the planetary environment is focused on the land, the coasts or the atmosphere. In reality, the ocean is more important than both land and atmosphere in the functioning of the Earth as a whole.

The ocean, particularly the coastal seas, provides an important supporting Earth System service by absorbing and recycling human-generated waste products. Much of the nitrogen and phosphorus waste produced by human societies from e.g. agricultural fertilisers and animal and human excrement ultimately ends up in the coastal oceans, where it is metabolised. Problems occur when the compounds produced exceed nature's capacity to absorb them. Excess nutrients can generate a number of negative environmental effects. Furthermore, many of the chemicals, including medicines and manufactured products (e.g. plastics), that are produced and used by humans end up in the ocean, where they are not easily metabolised and accumulate to very high concentrations.

The ocean's ability to absorb carbon dioxide also slows the rate of climate change and consequently acts as a climate regulator. However, the most important regulating service the ocean provides for humanity is probably its global distribution patterns of heat and moisture via ocean circulation. For example, most of the rainfall over land that supports agriculture and cities originates through evaporation from the ocean. Humans are crucially dependent upon access to this fresh water and any changes to these climate conditions will have knock-on effects for human societies.

Another example is ocean acidification via increasing amounts of atmospheric CO_2 reacting with the ocean water to form carbonic acid. The resulting higher acidity, mainly near the surface, has been proven to inhibit shell and skeleton growth in many marine animals and is suspected to cause reproductive disorders in some fish. Ultimately, this renders ocean ecosystems less resilient to extreme events and human pressure. This can have drastic consequences on coral reefs

We know the Earth's resilience and resource base cannot be stretched infinitely and we are uncomfortably aware that we are heading in the wrong direction. The question that remains is how we can better manage our relationship with nature.

and other marine life, with cascading impacts on the fishing and tourism industries.

Understanding the human trajectory, from hunter-gatherers to the drivers of the Great Acceleration and beyond, is an essential element in the process of transforming our role on Earth from resource exploiters to resource stewards.

Working within planetary boundaries

So, here we are. We know the problem, we know the Earth's resilience and resource base cannot be stretched infinitely and we are uncomfortably aware that we are heading in the wrong direction. The question that remains is how we can better manage our relationship with nature. We are not only the first generation with the knowledge of how our activities influence the Earth System, we are also the first generation with the actual power and responsibility to change our relationship with the planet on a global scale.

Clearly, we have an uneven distribution of power and responsibility, which means that developed countries that were the engines of the Anthropocene, and especially the Great Acceleration, need to demonstrate leadership in bearing the cost of transformation.

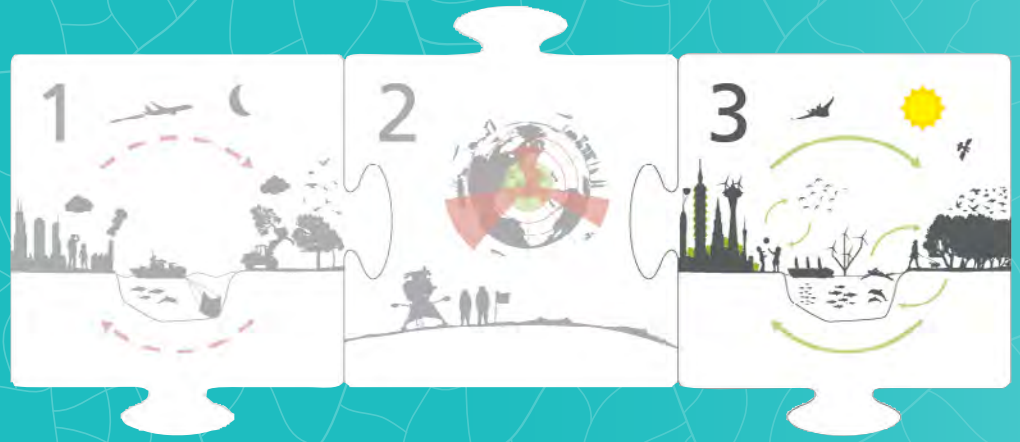
On a general level, what is needed is a number of fair and equitable local-to-global solutions that transcend national boundaries and cultural divides. One of the most recent and most significant attempts to provide scientific guidelines for such improved stewardship came in 2009 with the so-called Planetary Boundaries approach, published in Nature. It attempted to define a 'safe operating space' for humanity and suggested boundaries within which humanity could continue to develop, but beyond which humans should not cross. Nine planetary boundaries were suggested, seven of which had specific quantitative boundaries. These were: climate change, stratospheric ozone, ocean acidification, the nitrogen and phosphorus cycles, biodiversity loss, land use change and freshwater use. There was insufficient knowledge to suggest quantitative boundaries for two other processes – aerosol loading (airborne particles such as sulphur and soot) and chemical pollution (e.g. mercury, flame retardants and dioxins).

The 28 scientists behind the Planetary Boundaries approach estimated that three of the boundaries – those for climate change, the nitrogen cycle and biodiversity loss – have already been transgressed. Several others are in the danger zone. The approach does not offer a complete roadmap for sustainable development, but provides an important element of sustainability. Within these boundaries, humanity has the flexibility to choose pathways for future development and well-being.

In addition, the Planetary Boundaries approach helps shift the focus from the slightly one-sided emphasis on climate change to a complex systems perspective acknowledging that the desired stability of the Earth systems is dependent on a variety of factors, including addressing overfishing, deforestation, loss of biodiversity, etc. A more holistic approach in dealing with climate change can also entail other synergistic effects. For example, actions that reduce greenhouse gas emissions globally can also improve air quality in metropolitan areas.

Key messages:

1. The human imprint on the planet's environment is now so vast that the current geological period should be labelled the 'Anthropocene' – the Age of Man.
2. Human pressure has reached a scale where the possibility of abrupt or irreversible global change – challenging our own well-being – can no longer be excluded.
3. The challenges of the 21st century – resource constraints, financial instability, inequalities, environmental degradation – are a clear signal that 'business-as-usual' cannot continue.
4. We are the first generation with the knowledge of how our activities influence the Earth as a system, and thus the first generation with the power and the responsibility to change our relationship with the planet.
5. Effective global stewardship can be built around the 'planetary boundaries' concept, which aims to create a scientifically defined safe operating space within which humanity can continue to evolve and develop.



Tipping towards sustainability

3. Social-ecological innovations for planetary opportunities

There are ample examples out there to demonstrate the tremendous capacity we humans have in finding innovative solutions to improve our lives. However, innovation is not always for the better. Aspects of innovation may be driving the world in the wrong direction, directly opposed to a sustainable future. The challenge we face is to use this innovative capacity to reconnect ourselves with the biosphere (Chapter 1) and stay within the safe boundaries of the planet (Chapter 2) in order to safeguard human development in the long term. It is time to introduce innovations that are sensitive to the fundamental bonds between social and ecological systems.

IT IS A FASCINATING paradox that the same innovative capacity that has put us in the current environmental predicament is actually what can be used to push us out of it. History has shown that humanity has managed to adapt to a wide range of complex challenges. However, the current predicament might just be the greatest ever. For decades, concerned scientists and environmental NGOs have been calling for urgent changes (or transitions) that are large enough to transform our current way of living. Politics, the corporate world and civil society are increasingly getting the message and there are indeed an immense number of ideas on how to shift to more sustainable trajectories (green urbanism, renewable energy, agroecological farming and ecosystem-based fisheries, to name but a few). The problem is that we not only have to collectively speed up our efforts, but must also look at ways to solve several problems at the same time. An ambitious plan admittedly, but nonetheless necessary and by all means possible.

Halting a steam-powered train of thought

Despite decades of calls for change, a clear understanding of the mechanisms and patterns under which global transformations can actually happen is still lacking. The growing concern about this has led to an increased focus on the role of innovation, but the question remains: Can we innovate sufficiently rapidly and intelligently to tip our system out of the current paradigm and into a more sustainable one?

Historically, humanity has placed great faith in technological innovation to help transform societies and improve the quality of life. The most obvious example is the industrial revolution, while the most recent example is the fast-changing way we communicate across the world. There are good reasons why we place faith in our capacity to innovate, because it has traditionally been associated with a better quality of life. Questioning innovation therefore goes against the grain of our world view and the governance structures that rule our lives. There are thus good reasons not to question our innovative ability, but we cannot deny that the last five decades or so of high innovation have also caused some serious damage to the planet. Moreover, we appear to be locked on a technological path that is not only accelerating tremendously rapidly, but also carries with it unintended and undesired consequences. In other words, we have a decreasing degree of control over the future impact of our innovations.

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Mind the ingenuity gap

The problems we are facing are so complex that some argue that we are caught in an 'ingenuity gap', where the world's problems have become so difficult to solve that we lack the ingenuity required to solve them. Along the same lines is the argument that the 'technosphere', the innovative engine that has driven our modern economy, is organised along lines that are very different, if not downright contrary, to the functioning of the world's ecosystems. Ecosystems are based on non-linear mutual interdependency and one part cannot be separated from another, while the technosphere, whether in terms of machines or structures, is based on a linear, means-to-an-end logic. Putting it bluntly, most current economic and technological solutions are ecologically illiterate and too linear and single problem-orientated. There is a need for a change of mindset.

The private sector is in many respects one of the main suppliers of innovative thinking and is consequently fundamental in carving out new directions for more sustainable innovations. However, relying on businesses alone to address issues such as climate change and biodiversity conservation is somewhat risky,

PHOTOGRAPHY TOM HERMANSSON SNICKARS/AZOTE

because they are unlikely to introduce a new strategy unless it simultaneously increases their competitive advantage. Businesses can make a huge difference, but governments or societal stakeholders must also enforce standards with which the market must comply. In order for business and the market to play a truly innovative role in sustainable development, governments must enforce standards on the market that work both as carrot and stick. Non-compliant companies must be penalised, while innovative and proactive companies must be favoured and above all rewarded. This would create a level playing field, making sustainable innovative investments worthwhile for companies.

The essence of social-ecological innovation

The outlook need not be too gloomy. Ongoing large-scale transformations in e.g. information technology, biotechnology and energy systems have huge potential to significantly improve our lives in a sustainable way. However, this can only happen if we 'incorporate the capacity of the biosphere in framing development', i.e. start working with, instead of against, nature. However, in order to boost our capacity to innovate in the interests of a more sustainable lifestyle, there needs to be support and incentives for social-ecological innovation, particularly in the private sector. The transformation needed must include the creativity and ingenuity of users, workers, consumers, citizens, activists, farmers and small businesses alike.

Multi-level adaptive governance, tax incentives and sponsored experiments are needed to spur private sector ingenuity. Examples of sponsored experiments include the Big Green Challenge in the UK issued by the National Endowment for Science, Technology and the Arts (NESTA). In this, communities were invited to come up with community-led responses to climate change. In early 2008, 355 groups came forward with a wide range of imaginative and practical ideas for reducing CO_2 emissions in their communities. Of the proposals submitted, 100 received support to be developed into detailed plans. From this group, a final 10 were shortlisted to compete for the £1 million prize.

Law also plays its part. Law is traditionally characterised by 'thou shalts' rather than opening doors for new approaches. As a reaction to this, the concept of reflexive law has emerged. Reflexive law is less rule-bound and recognises that as long as certain basic procedures and organisational norms are respected, participants can arrive at positive outcomes and correct their projects along the way, basically learning by doing. In response to growing complexity, detailed rules are replaced by procedures for regulated entities to follow. Reflexive law is a social innovation which seeks to promote multi-level governance and preserve diversity and experimentation at local level.

Bottom-up responses to crises are a central element in all of this. There are enormous reservoirs for learning and innovation that are often revealed in moments of crises. In fact, some of the best and most constructive innovations often come from disaster-hit (or disaster-prone) communities. Studies on innovative responses to social and natural disasters increasingly stress the need for governments and institutional aid mechanisms to take a step back and 'listen and engage' with communities rather than 'orchestrate and

plan' on their behalf. This involves listening to local communities for ideas, informing local populations of resources and possibilities available, trusting them and allowing a diversity of innovative responses to emerge, as opposed to insisting on a top-down planning process.

Studies in north-eastern Honduras after the powerful Hurricane Mitch in 1998 showed how the disaster led to substantial changes in land management. However, it was not established aid organisations that facilitated the change, but household-to-household, viral-like initiatives that resulted in a shift to more equitable land distribution, protected forests and overall an increased resilience to cope with similar floods in the future.

There are enormous reservoirs for learning and innovation that are often revealed in moments of crises. In fact, some of the best and most constructive innovations often come from disaster-hit (or disaster-prone) communities.

Resilience scholars have also focused on the role of informal shadow networks – groups of stakeholders that work outside the fray of regulation and implementation in places where more formal networks and structures fail. One of the most celebrated examples comes from Chile, where a combination of fisheries collapse and the move to democracy provided the opportunity to try out some new arrangements for managing fisheries. The experiments were based on informal partnerships and trust between fishers, scientists and managers. There was a general recognition that Chile's fish stocks were in trouble, things were turbulent and people were looking for answers, all of which made them open to new approaches. There was also a good scientific understanding of coastal ecosystems in the region on which to base a new management plan. All this eventually led to the testing of new co-operative models for fishery management, based on the latest science concerning fish stocks and the surrounding marine ecosystem. The end result was a revolutionary national system of marine tenure that allocates exclusive ocean territories to local and small-scale fisheries. The system excludes the major industrial fishing fleets, which have their own exclusive fishing zone. By cutting the number of large vessels in distinct territories, fishing pressure has been reduced.

Planetary opportunities

Tapping shadow networks such as those in Chile is a key challenge to governance. Traditional, expert-driven, top-down approaches to problem solving are not nimble enough to effectively address convergent, non-linear and rapidly changing problems. There are also lessons to be learned from innovation studies in the domain of business, technology and organisational behaviour. These have long established the importance of approaching innovation from a top-down and bottom-up perspective, sometimes referred to as 'management up-down' (MUD). This basically refers to a company's ability to efficiently connect those drawing up company strategy with the sources of innovation, most commonly taking place at the front line, on the shop floor or in small designated teams. This in turn produces the cascade of resources required to bring innovation to markets and scale up the innovation itself. Key individuals in this process are the so-called connectors, who are able to understand the overall strategic direction the company wants to take, frame that to those working on the 'front line', identify promising innovations and sell these back to the strategic apex of the company.

Overall, economic and technological solutions must become more ecologically literate and see the numerous planetary opportunities in investing in sustainable use of ecosystems and their services. This requires us to organise innovation and technology development in new ways that are more networked, open-sourced and inclusive, while working more directly for social justice, poverty alleviation and environmental sustainability. The planetary risks we are facing are so large that business-as-usual is not an option.

Emerging social innovations and technological transformations involve enormous opportunities with huge potential to improve our lives in a sustainable way, but only if we incorporate knowledge of social-ecological systems and planetary boundaries in framing their future development.

Key messages:

1. An immense number of sustainability initiatives are emerging (transition towns, clean energy, agroecological farming, ecosystem-based fisheries management, etc.). Such initiatives need to be upscaled through e.g. innovation funds, seed money, structural adjustment funds and other incentives in order to have a global impact. Social media and associated advances in information and communication technologies can play a role in this process.
2. Ongoing large-scale transformations in e.g. information technology, biotechnology and energy systems have the potential to significantly improve our lives in a sustainable way, but only if we incorporate knowledge of social-ecological systems and planetary boundaries in risk assessments and development strategies.
3. Most current economic and technological solutions are ecologically illiterate and too linear and single problem-orientated. What is needed is financial and political support for safe-fail experiments in communities around the world, using diverse technologies, organisations and ideas, for instance in 'Policy Laboratories' or 'Change Labs'.
4. Policy makers around the world need to adopt a new systems thinking that pays much more attention to the negative side-effects of quick fixes and recognises the numerous possibilities in investing in sustainable use of ecosystems and their services.
5. We need a new type of 'social-ecological' innovations and technologies that work more directly for social justice, poverty alleviation, environmental sustainability and democracy, while including the creativity and ingenuity of users, workers, consumers, citizens, activists, farmers and small businesses alike.

The three scientific background reports all discuss issues of global concern, but with local and regional implications and solutions. The world map features twelve local/regional case studies presented in the respective reports.

CASE 1: THE GULF OF MAINE LOBSTER FISHERIES, USA

This case illustrates a failure to see the full integration of socio-economic and ecological systems. In the Gulf of Maine the American lobster comprises over 80 per cent of the total marine resource value, but this economic success does not equal ecosystem success. Rather, the long-term sequential depletion of cod, hake, haddock, halibut and sea urchins has resulted in a vulnerable near monoculture of lobsters. Elsewhere, such high lobster densities have preceded an outbreak of shell disease. A similar collapse in Maine would be devastating for the over 7,000 lobstermen and their support industries.

PHOTOGRAPHY OSKAR HENRIKSSON/AZOTE

CASE 2: EL NIÑO AND RAINFOREST RENEWAL, BORNEO

Global market demand for palm oil has led to an expansion of monoculture plantations and an increasingly fragmented forest landscape in the rainforests of Borneo. This has altered the resilience to droughts induced by the recurring weather phenomenon El Niño, which previously triggered

Twelve local and regional case studies featured in the three scientific background reports

mast reproduction among trees, regenerating forest biodiversity. In the new situation, El Niño events disrupt fruiting, interrupt wildlife reproduction and trigger wildfires that contribute significantly to global carbon emissions.
PHOTOGRAPHY RAINFOREST ACTION NETWORK/ FLICKR.COM

CASE 3: ECOSYSTEM SERVICES OFFSETTING IN THE 'SATOYAMA' CULTURAL LANDSCAPE, JAPAN

In the Japanese city of Nagoya, urban sprawl is challenging the traditional agricultural 'Satoyama' landscape. Under a new system of tradable development rights, developers that exceed existing limits on high-rise buildings can offset their impacts by investing in the conservation of Satoyama areas threatened by urban exploitation. Favourable bank loans are also offered for building projects scoring high on a green certification system.
PHOTOGRAPHY MOOKE/FLICKR.COM

CASE 4: MELTING OF THE GREENLAND ICE SHEET APPROACHING A THRESHOLD

The Greenland ice sheet, which has melted at an increasing rate during the past 30 years, is an example of how the Earth's subsystems risk moving outside their stable Holocene state. As the planet warms the ice melts, leaving more water and land exposed to the sun. Those surfaces in turn absorb more of the sun's heat, leading to a self-enforced process with accelerated melting of snow and ice. There are fears that melting of the entire sheet could raise sea levels globally by about 7 m.
PHOTOGRAPHY BENT CHRISTENSEN/AZOTE

CASE 5: LARGE-SCALE SHIFTS IN THE AMAZON RAIN FOREST

We are approaching serious thresholds, or tipping points, in major ecosystems. One example is the projected changes in the vegetation of the Amazon Basin, from tropical forest to dry savannah or grassland, due to climate change and deforestation. The concern is that the Amazon might be caught in a vicious circle – with altered rainfall patterns and increased wildfires – that could bring it to the point of no return, with massive impacts on the world's biodiversity and climate.
PHOTOGRAPHY NICOLAS DESAGHER/AZOTE

CASE 6: ACIDIFICATION AND OTHER THREATS FACING INDONESIAN CORAL REEFS

The world's oceans are steadily becoming more acidic due to increasing amounts of atmospheric CO_2. Ocean acidification in combination with global warming, declining water quality and overexploitation of key species is predicted to drive coral reefs increasingly toward the tipping point for functional collapse. This will involve cascading impacts on local livelihoods as well as the fishing and tourism industries, not least in Indonesia, which has the largest area of threatened reefs in the world.
PHOTOGRAPHY TONY HOLM/AZOTE

CASE 7: TRANSFORMATION OF CHILEAN FISHERIES

New *transformational* changes in governance are urgently required to cope with overfishing, pollution, climate change and other drivers of degradation in the marine environment. One example arose when fisheries collapses and the move to democracy in Chile after a 17-year dictatorship, quite by chance, opened the way for reforms and new laws that excluded large industrial fishing fleets and gave exclusive ocean territories to local 'artisanal' fishers. Scientists and the small fishers then worked out a shared vision and voluntary agreements on how to manage these territories.
PHOTOGRAPHY CLAUDIUS PRÖßER/FLICKR.COM

CASE 8: INNOVATION IN LAND MANAGEMENT IN HONDURAS AFTER HURRICANE MITCH

Innovation often comes as a result of crisis and sustainable solutions often from community level. Studies in north-eastern Honduras after the powerful Hurricane Mitch hit the country in 1998 showed how the disaster led to substantial changes in land management. These changes were facilitated not by established aid organisations, but by initiatives that spread almost 'virally' from household to household. This resulted in a shift to a more equitable land distribution and protected forests that helped the community cope with similar flooding 10 years later.
PHOTOGRAPHY APES_ABROAD/FLICKR.COM

CASE 9: RENEWABLE ENERGY DEVELOPMENT IN DENMARK

What does it take to transform a country's energy system and move it onto a more sustainable track? A study comparing Denmark, Costa Rica, Ecuador and Canada revealed that Denmark, with economic resources to invest in government renewables programmes and a small oil industry, had the highest potential for wind power development. However, project-specific factors (e.g. cost of electricity generation, wind resources, grid access and 'weak ties' between local champions and outsiders), as well as informal institutional factors (e.g. green culture, the role of visionary leaders, perception of a climate change crisis), were also important.
PHOTOGRAPHY DANISHWINDINDUSTRYASSOCIATION/ FLICKR.COM

CASE 10: NATURAL CAPITAL INVESTMENTS IN CHINA

Ecosystem service investments in China today are remarkable in their goals, scale, duration and innovation. Following severe droughts in 1997 and massive flooding in 1998, China implemented several national forestry and conservation initiatives, exceeding 100 billion USD over the current decade. Targeted investments aim to secure natural capital and alleviate poverty through wealth transfer from coastal provinces to inland regions, where many ecosystem services originate. Over 120 million farmers are directly involved in programmes with the intention to reduce the loss of soil, reduce desertification and protect biodiversity and ecosystems for e.g. flood control, more productive agriculture and ecotourism.
PHOTOGRAPHY UNITED NATIONS PHOTO/FLICKR.COM

CASE 11: THE NATURAL CAPITAL PROJECT (NATCAP)

A movement that started off on the west coast of the US is today an international effort to motivate greater investments in ecosystems and human well-being by helping decision makers visualise the impacts of potential policies (e.g. InVEST toolkit, which will soon be on Google's new Earth Engine platform). NatCap is also helping to build evidence and policy innovation through a shared programme of research and policy support. In addition, it is magnifying the impact of these demonstrations by engaging key *institutions* and thought leaders, disseminating tools and lessons and creating an informed community of leaders and practitioners.
PHOTOGRAPHY ÅSA GALLEGOS TORELL/AZOTE

CASE 12: SMALL-SCALE WATER INNOVATIONS BREAK DRYLAND POVERTY TRAPS IN TANZANIA

Improved water management in rainfed agriculture can build resilience to cope with water-related risks and uncertainties. Conventional solutions have been to develop large-scale irrigation systems, but recent studies in e.g. Makanya, Tanzania, have shown that small-scale innovations, such as rainwater harvesting and conservation tillage, have enormous potential for increasing on-farm productivity and ecosystem services output in areas where people live in poverty and are vulnerable to climate change.
PHOTOGRAPHY JERKER LOKRANTZ/AZOTE

Glossary

ADAPTIVE GOVERNANCE: Governance approaches that are collaborative, flexible and learning-based and rely on networks of people and organisations at multiple levels.

ANTHROPOCENE: The Age of Man, a new name for the present geological epoch defined by our own massive impact on the planet's climate and ecosystems. Coined in 2000 by Nobel Laureate Paul Crutzen.

BIODIVERSITY: Short for biological diversity – the variety of all forms of life on earth, including the variability within and between species and within and between ecosystems.

BIOSPHERE: The sphere of all air, water and land on the planet in which all life is found; the global ecological system integrating all living beings and their relationships.

ECOSYSTEM: All the organisms in a given area, along with the physical environment with which they interact (e.g. a forest, a coral reef or a rock-pool).

ECOSYSTEM-BASED MANAGEMENT: A management approach that recognises the full array of interactions within an ecosystem, including humans, rather than considering single issues, species or ecosystem services in isolation.

ECOSYSTEM SERVICES: The benefits people obtain from ecosystems, e.g. provision of clean water, regulation of climate, pollination of crops and fulfilment of people's cultural needs.

GREAT ACCELERATION: Refers to the dramatic acceleration of human enterprise after World War II and the resulting pressure on the global environment.

HOLOCENE: The postglacial geological period, which began approximately 9600 BC and continues to the present.

INSTITUTIONS: A central concept within the social science of natural resource management whereby institutions are defined as the norms and rules governing human interactions. These can be formal, such as rules and laws, but also informal (unwritten), such as norms and conventions of society.

MILLENNIUM ECOSYSTEM ASSESSMENT: Global review launched by the UN and carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being.

NATURAL CAPITAL: An extension of the traditional economic notion of capital, coined to represent the natural assets that economists, governments and corporations tend to leave off the balance sheets. It can be divided into non-renewable resources (e.g. fossil fuels), renewable resources (e.g. fish) and services (e.g. pollination).

PLANETARY BOUNDARIES: A concept developed by a group of researchers in 2009 to describe nine safe biophysical boundaries outside which the Earth System cannot be pushed without disastrous consequences.

RESILIENCE: The capacity of a system – be it a forest, city or economy – to deal with change and continue to develop; withstanding shocks and disturbances (such as climate change or financial crises) and using such events to catalyse renewal and innovation.

SOCIAL-ECOLOGICAL SYSTEM: An integrated system of people and nature with reciprocal feedback and interdependence. The concept emphasises the humans-in-nature perspective and that delineation between the social and ecological is artificial and arbitrary.

SOCIAL INNOVATION: An initiative, product, process or programme that profoundly changes the basic routines, resource and authority flows or beliefs of any social system.

TRANSFORMATION: The creation of a fundamentally new system when ecological, economic or social conditions make the continuation of the existing system untenable.

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About the Symposium

This Executive Summary provides an overview of the three scientific background reports prepared for the 3rd Nobel Laureate Symposium on Global Sustainability: Transforming the World in an Era of Global Change. The Symposium is being jointly organised by the Stockholm Resilience Centre at Stockholm University, the Royal Swedish Academy of Sciences, the Stockholm Environment Institute, the Beijer Institute of Ecological Economics and the Potsdam Institute for Climate Impact Research.

The Symposium gathers some 50 of the world's most renowned thinkers and experts on global sustainability – almost half of them Nobel Laureates – and other top-level leaders within science and society in Stockholm on 16-19 May 2011 to explore the most pressing challenge of the 21st century, the quest for global sustainability.

Sponsors of the 3rd Nobel Laureate Symposium

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