

Annual report 2019/2020



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The Beijer institute of Ecological Economics is an international research institute under the auspices of the Royal Swedish Academy of Sciences. Since 1991, the Beijer Institute has been an institute of ecological economics. The major objectives of the Beijer Institute are to carry out research and stimulate scientific cooperation to promote a deeper understanding of the interplay between ecological systems and social and economic development.

The Beijer Institute of
Ecological Economics

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Director's column

THE WORLD IS in the midst of the Covid-19 pandemic, an extreme event rapidly spreading across societies and nations. The pandemic has exposed fragility in several dimensions of the tightly coupled and interconnected globalised world. At the same time, the climate change challenge is becoming real and urgent. Our future on our planet will be strongly influenced by our ability to keep global warming below 2°C and foster the resilience of the living biosphere.

These are turbulent times, where science is needed more than ever. Young people are demanding that we listen to scientists! Science provides informed consensus on the facts and trade-offs in times of misinformation and polemics. The planetary challenges that confront humanity need governance that mobilises the best that science has to offer, with shared visions for sustainable futures. Political will and competence are required to implement choices that will sustain humanity and the rest of the living world for long into the future.

It is in this context that the Beijer Institute operates. Our interdisciplinary work, often curiosity driven, aims at generating evidence-based understanding as a foundation for actions towards sustainability. Much of the science that we perform is at the interface of ecology and economics and related disciplines. It is now proving to be highly relevant for dealing with current issues and uncertainties, extreme events, tensions and turmoil, and for helping guide societies towards sustainable futures.

For example, we have shown that all economies, societies and civilisations are embedded in the biosphere, and that people and nature

are intertwined in social-ecological systems, now coevolving and shaping the operation of the planet as a whole. Insights have been gained on the complex dynamic behaviour of ecological and economic interactions, including non-linear change, tipping points and regime shifts. Finally, we have long been investigating how slower and deeper changes

“These are turbulent times, where science is needed more than ever. Young people are demanding that we listen to scientists!”

es interplay with abrupt and rapid changes, how seemingly unrelated shocks influence economic performance, societal development and sustainability, and what this means for resilient futures.

In addition to ongoing work that the Covid-19 pandemic has triggered, in the past year we have published new findings on these issues in leading journals like *Nature*, *Proceedings of*

the National Academy of Sciences, *European Review of Agricultural Economics*, *Science Advances*, *Nature Sustainability*, *Nature Ecology & Evolution*, *Global Environmental Change* and *Environmental Research Letters*.

It is rewarding to note that we are highly in demand, not only in science but also by society in its diverse dimensions. At the exciting Svenskt Tenn exhibition ‘Welcome to the Biosphere’, artists interpreted the findings of several of our recent publications, which was very inspiring! During the year, we actively interacted with practice, policy and business in various ways, as presented in more detail in this report.

The collaboration with internationally leading researchers and institutions and the close interactions with the Global Economic Dynamics and the Biosphere (GEDB) Academy Programme and Stockholm Resilience Centre make our research cluster a very special node in the world. Being part of the Royal Swedish Academy of Sciences is essential, and its professional and friendly support is most appreciated.

There are many to thank for a Beijer Institute in good shape. First and foremost, and very sadly, two giants of our legacy have passed away: Karl-Göran Mäler, the father of environmental economics and the founding director of the Beijer Institute of Ecological Economics, at the age of 81 years, and CS ‘Buzz’ Holling, the father of resilience thinking, at the age of 88 years. Karl-Göran’s deep insights and wonderful personality shaped the Beijer Institute and its activities. Buzz’s contributions to the Beijer Institute Board and Beijer research programmes brought complex systems and resilience thinking to the forefront at the Beijer

Institute. We will sincerely miss and always remember Karl-Göran and his visions, curiosity and leadership and Buzz’s deep friendship and amazing novel thinking and systems understanding. They will always remain in the hearts and minds of all at the Beijer Institute!



The year has been unusual in other respects. In late autumn, we moved into the Academy Villa, due to the much needed and very welcome renovation of the Academy main building. This move has been pleasant in many respects. It brought Beijer and GEDB staff even closer and inspired to new research constellations and the premises have increased the feeling of being at home. The Villa is particularly well suited for social activities and we have taken the opportunity to organise events to increase cohesion in the group and stimulate creativity and innovation.

Then the Covid-19 close-down hit us and shifted our activities to Zoom meetings and working from home. Although we miss the daily interactions, overall the changes have worked quite well. Later, when the pandemic has faded and the renovations to the Academy main building are completed, we will move back and start to use those premises again. It will be most exciting, with the upgrading of the Beijer Hall and the opportunities it will provide for new types and forms of meetings, thanks to generous funding from the Beijer Foundation, which has supported us over decades with core funding. We are most grateful for the continuous support of the Beijer Foundation, which makes it possible to operate, discover, shape and influence.

A handwritten signature in dark ink, appearing to read 'Carl Folke'.

Carl Folke
Director of the Beijer Institute
Stockholm, July 2020

Karl-Göran Mäler

1939–2020

PROFESSOR EMERITUS KARL-GÖRAN MÄLER passed away on 20 May 2020, at the age of 81. He was one of the founders and the first director of the Beijer Institute of Ecological Economics and a pioneering, world-leading environmental economist. He was an intellectual giant, mentor and dear friend to colleagues at the Beijer Institute and around the world.

Karl-Göran's curiosity and continuous desire to understand matters at a deeper level were key ingredients for the success of the Beijer Institute's early endeavour to build bridges between disciplines that were not accustomed to collaborating. The journey of the Beijer Institute with Karl-Göran was inspiring, searching for new understandings and always with the problems in focus, exploring and investigating with an open mind and deep commitment.

Career

Karl-Göran Mäler initially studied mathematics, statistics and economics at Stockholm University, followed by studies in economics at MIT, Stanford University and Stockholm University. 1972, he earned a PhD in economics at Stockholm University. He was Professor of Economics at the Stockholm School of Economics 1975–2002.

In 1981, Karl-Göran was elected member of the Royal Swedish Academy of Sciences, where he was a member of the Committee on the Prize in Economic Sciences in Memory of Alfred Nobel 1981–1994 (and chaired the committee in 1986–1987).

Together with fellow economist Sir Partha Dasgupta, he founded the Beijer Institute of Ecological Economics in 1992, with funding from the Beijer Foundation. He was the institute's director until his retirement in 2002.

Under Karl-Göran Mäler's leadership, the Beijer Institute established several regional networks of environmental economists, as well as the journal *Environment and Development Economics* (EDE), which encourages submissions from researchers in the field in both developed and developing countries.

The networks and the journal have had a great impact on research and policy in developing countries and have been very important to many researchers in the network regions, where the Beijer Institute also organised a series of teaching and training workshops. This work was mainly led together with Partha Dasgupta, while other world-leading ecologists and economists were part of the teaching teams. Karl-Göran regarded this work as one of the most important accomplishments of his career. It was in one of the teaching workshops, in Jamaica, that he met his beloved wife Sara Aniyar.

Together, Karl-Göran Mäler and Partha Dasgupta received the Volvo Environmental Prize in 2002.

Scientific accomplishments

Karl-Göran Mäler's PhD thesis from 1972 was published internationally in 1974 (*Environmental Economics: A Theoretical Inquiry*). It has been widely read and cited, probably because it was very innovative in using economic theory to analyse serious environmental issues. The thesis covered an astonishingly broad set of topics, such as a general equilibrium model of environmental quality, economic growth and the quality of the environment, basic consumption theory and welfare economics, and estimation of the demand for environmental services.

During his career, Karl-Göran continued to address diverse issues related to economics and the environment. He pioneered the field of international environmental agreements with the 'acid rain games', where he depicted strategic interactions between countries emitting and receiving pollution by sulphuric acid, painting a landscape of the problem in order to get countries to cooperate on a critical transboundary environmental problem.

He was instrumental in starting up the study of the economics of regime shifts with the shallow lake model, where the lake could flip from clear to turbid even in response to an optimal policy intervention. He also made fundamental contributions to accounting and

the notion of inclusive wealth. However, these were just a few topics among the wide set of issues with which he engaged.

Karl-Göran had a brilliant mind and excelled in all the essential qualities of a good researcher. He was extremely curious, which was a great advantage when starting discussions with the natural scientists in the early days of the Beijer Institute. He was rigorous and tenacious and would not rest until issues were properly solved.

Karl-Göran's huge experience and knowledge was highly valued, which is reflected by his legacy in shaping the field of environmental economics, his many roles within the Royal Swedish Academy of Sciences and, not least, in his role as advisor to policy makers, nationally and internationally.

Teacher, mentor and friend

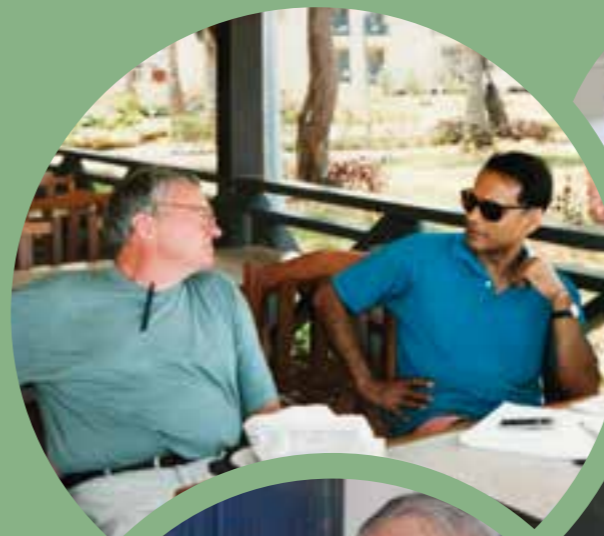
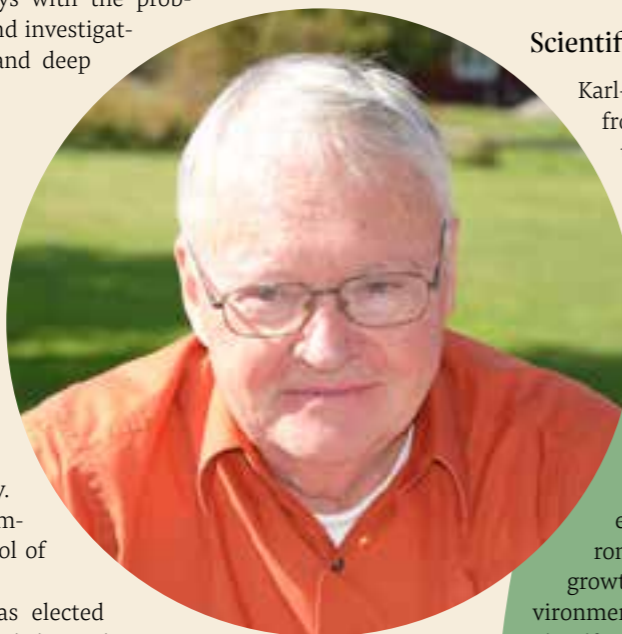
Many of Karl-Göran Mäler's former students, whether PhD students or workshop attendees, can testify to his genuine interest in sharing his knowledge and in learning from his pupils. The current deputy director of the Beijer Institute, Anne-Sophie Crépin, is among them: "Karl-Göran would set everything aside to spend a couple of hours helping out with a problem that had

emerged. He did so in a relaxed way, often joking, but also generously sharing his huge experience and knowledge of the field and methods."

Christina Leijonhufvud, office manager at the Beijer Institute, organised the teaching workshops and courses and often travelled with Karl-Göran:

"Karl-Göran was very much appreciated among the participants with his straightforwardness, patience and support. He showed such interest in people and ideas and loved to discuss things from different angles. He shared his wisdom and encouraged everyone to think, dig deeper and never give up. His broad and deep knowledge about the most diverse matters was impressive and his love for nature was remarkable. He was an enjoyer of life; he loved to travel, he loved to be creative with close friends and colleagues, he loved opera music, good food and wine."

Above all, Karl-Göran was kind, as he demonstrated many times in difficult moments. He was an inspiring role model and father figure and he will be deeply missed, not least by those of us who had the privilege of working under his leadership for many years.



Top left: Karl-Göran with Partha Dasgupta during a workshop in Malaysia 1996.
Top right: With Carl Folke and Christina Leijonhufvud at Askö.
Bottom left: With wife Sara Aniyar



C.S. Buzz Holling

1930–2019

CRAWFORD STANLEY “BUZZ” HOLLING, the father of resilience research and long-time colleague and friend of the Beijer Institute, passed away in August 2019, aged 88. Pioneers break new ground and leave an empty space when they move on.

Buzz Holling was a pivotal figure in the development of the Beijer Institute, the Resilience Alliance and Stockholm Resilience Centre. He was a pioneer in efforts to understand complex systems, inspired by thinkers emerging at that time. Buzz strongly emphasised that understanding, not knowledge in a narrow sense, is essential in navigating the dynamic, connected and evolving challenges of our rich, unequal and beautiful world. He encouraged creative and fun experimental research that bridges science, practice and art, which has inspired the research culture at the Beijer Institute and Stockholm Resilience Centre.

From insects to adaptive management

Buzz Holling grew up in the forests of Northern Ontario, where he developed a deep interest in the living world. An early interest in forest insects led him to study insects, first at the University of Toronto and then at the University of British Columbia. During his PhD studies, he developed the first mathematical theory of predation. These concepts are now widely used to analyse predator-prey interactions.

In the 1960s and 1970s, Buzz extended his work using systems to understand diverse types of interactions between people and nature. He began to collaborate with experts outside universities and research labs, in order to understand land development, forest management, and pest management. It was from these experiences that he first began to formulate his ideas about resilience. This work continued in Vienna, where Buzz first visited and then

became director of the International Institute of Applied Systems Analysis (IIASA).

Buzz Holling highlighted the importance of considering surprise, system reorganisation and learning when trying to understand social-ecological dynamics. These efforts led to new ideas about the dynamic nature of resilience and the co-development of Adaptive Environmental Management and Assessment, a learning-based approach to the management of complex environmental problems.

The origin of social-ecological systems thinking

In the 1990s, Buzz began a long-term collaboration with Stockholm-based researchers, initially through the Beijer Institute and then with researchers at Stockholm University. The Resilience Alliance was established in 1999 as an international partnership of interdisciplinary researchers focusing on understanding transformations in human and natural systems. Buzz and other researchers behind the partnership published a number of influential papers and books in the 2000s, exploring the dynamics of resilience and transformation and the concept of social-ecological systems.

Buzz Holling trained many scientists who went on to have major impacts in behavioural ecology, forest management, fisheries, ecology and sustainability science. He was passionate about developing cross-disciplinary, international networks of younger scientists, and made sure that this was a central and continuing part of resilience science activities.

His contributions to the board of the Beijer Institute and the Santa Fe Institute, USA, advanced complexity science and sustainability research.

A true scientific giant

Buzz Holling received many honours for his contributions to science and society. He was a Fellow of the Royal Society of Canada and a foreign Fellow of the Royal Swedish Academy of Sciences. He received the Austrian Cross of Honour for Science and Art, and he became an Officer of the Order of Canada. He was awarded the Volvo Environmental Prize in 2008, for being “one of the most creative and influential ecologists of our times”.

Buzz Holling was a true scientific giant. His fundamental contributions to our understanding of the world will continue to deeply influence and inform us, and his warmth and curiosity will continue to inspire.

Research programmes x 4

Work at the Beijer Institute strives to create research frontiers at the interface of ecology, economics and related disciplines, in order to promote a deeper understanding of the interplay between ecological systems and social and economic development in relation to sustainability.

Our research framework recognises that economies and societies are components embedded within the Earth’s biosphere, the thin layer around our blue planet where life exists, resulting in biosphere dependence. The situation is different from just a few decades ago. Now, the globalised human world is shaping the operation of the biosphere at planetary level in truly intertwined systems of people and nature. In dialogue with the Institute’s international scientific advisory board, we discuss, assess and modify our research programmes to better capture and understand the intertwined world. There are currently four research programmes of the Beijer Institute, all combining important theoretical insights with novel and grounded empirical research. The focus and progress of each are presented under this section.

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Aquaculture and sustainable seafood

[1] Love, D. et al. 2020. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. SocArXiv. osf.io/preprints/socarxiv/x8aew

[2] Tlustý, M. F., P. Tyedmers, M. Bailey, F. Ziegler, P. J. G. Henriksson, C. Béné, S. Bush, R. Newton, F. Asche, D. C. Little, M. Troell, and M. Jonell. 2019. Reframing the sustainable seafood narrative. *Global Environmental Change* 59:101991.

[3] Stoll, J. S., M. Bailey, and M. Jonell. 2019. Alternative pathways to sustainable seafood. *Conservation Letters* 13:e12683.

A fundamental challenge facing humanity today is providing healthy food for a growing world population in a sustainable and inclusive way. Fish and shellfish comprise an estimated 17% of the global animal-based protein supply and are the primary source of animal protein for billions of people. As we now enter the UN Ocean Decade, there is strong momentum for developing a new course for our oceans and also for enabling the potential of blue foods to increase planetary and human health. The programme *Aquaculture and sustainable seafood*, with its aim to increase knowledge about the role that seafood can play in a sustainable food future, is well positioned.

New initiatives on the future of blue foods

The ongoing “Blue Food Assessment” (BFA) will address the many questions arising regarding the future role of blue foods in global food systems. BFA is a joint initiative between Stanford University, Stockholm Resilience Centre, the Beijer Institute and EAT. The initiative will increase understanding about the potential of aquatic foods through production of a series of scientific papers in collaboration with *Springer Nature*.

For more information see: www.bluefood.earth

Programme researchers are also involved in a EU-funded project developing a digital platform allowing researchers and producers across the agricultural and seafood supply-chain to store data on their environ-

mental impacts in a highly structured, open-source, standardised way, using Life Cycle Assessment.

For more information see: www.hestia.earth.

Covid-19 and the global seafood system

An international interdisciplinary scientific team led by Johns Hopkins University investigated Covid-19-related shocks and responses in the seafood sector. Insights from the study, published as a preprint, show that as the pandemic shifts and possibly re-emerges in countries world-wide, there will be a continuing need for coping strategies to maintain the sector's core functions and protect vulnerable people working in, or dependent on, the seafood sector¹. These responses will vary across regions and countries. A shift from short-term coping strategies to development and implementation of longer-term adaptation strategies and resilience building will be necessary to prevent future shocks and respond to ongoing stressors, such as climate change or political instability.

Broadening the view on seafood sustainability

In a paper in *Global Environmental Change*, programme researchers and Beijer colleagues argue that conventional narratives prioritising the role of seafood in promoting ‘ocean health’ need to be reframed to cover a broader set of environmental and social dimensions of sustainability². Seafood should not be treated as a single aggregated item in sustainability assessments, but rather recognized as a highly diverse set of foods, with variable environmental impacts, edible yield rates and nutritional profiles.

A study in *Conservation Letters* led by researchers at the University of Maine claims that too strict a focus on seafood certification neglects the diversity of tools that are actually needed to create sustainable fishing practices and conservation³. Certification may not be very effective in reducing negative environmental and

social impacts, as there is often a mismatch between demand for eco-certified seafood and the actual behaviour of consumers faced with higher prices. It also leaves non-certified small-scale and data-poor fisheries behind, which limits the supply of eco-labelled seafood on the market.

Projecting the future of seafood

China plays a dominant role in both production and consumption of seafood and also in the global seafood trade. A paper by Beijer Institute and GEDB researchers shows that by 2030, China is likely to see seafood consumption outstrip domestic production⁴. To meet the anticipated seafood gap, China will probably attempt to increase domestic freshwater and offshore aquaculture, increase seafood imports, possibly expand the distant water fishing industry, and also invest in seafood production abroad. The country's dominance means that its choices regarding what seafood to eat, and how and from where to source it, are also increasingly important for the rest of the world.

In a study in *Reviews in Fisheries Science and Aquaculture*, an interdisciplinary working group at the National Center for Socio-Environmental Synthesis (SESYN), USA, explored plausible aquaculture futures and their role in nutrition security, using a qualitative scenario approach⁵. Two dimensions of economic development (degree of globalization and dominant economic development philosophy) were considered in four scenarios representing globalized systems orientated toward maximizing sectoral economic growth, or localized systems meeting environmental and equity dimensions of sustainability. The study examined ways in which nutrition-sensitive aquaculture, which aims to benefit public health through production of diverse, nutrient-rich seafood and enabling equitable access, can be achieved in the different scenarios.

Indonesia is the world's second largest producer of fish, but domestic demand is now higher than the supply. Indonesian aquaculture is therefore expected to increase by 8.5% annually. A study in *Environmental Research Letters* explored options for environmentally friendly expansion of Indonesian aquaculture⁶. Environmental implications of six production systems were studied using a life-cycle assessment (LCA) framework. The analysis showed potential for substantial environmental gains related to e.g. greenhouse gas emissions, acidification and fossil energy use, but indicated that the planned expansion of shrimp farming risks extensive ecological degradation of mangrove forests.

The role of diversification

A method for quantifying and mapping species diversity in the global aquaculture industry is presented in a paper in *Reviews in Aquaculture*⁷. Of the 462 identified species available for cultivation, a mere 20 species account for 70% of total global volumes of farmed fish and shellfish. This reduced diversity may have implications for the industry's long-term sustainability. An im-

portant but troublesome finding was that almost one-third of the 74 million tonnes of farmed seafood is not classified down to species level. The authors argue that a mixed box of tools, involving technological development, enabling policies and consumer information and education, is needed to diversify global aquaculture.

Both sustainable and healthy?

Increased seafood consumption is recommended, due to the beneficial nutritional value and health effects. However, the great diversity of seafood species and production systems poses a challenge when formulating recommendations that score highly for both environmental performance and health benefits. A paper in *Journal of Cleaner Production* analysed the combined climate and nutritional performance of seafood types commonly consumed in Sweden⁸. The results showed that the seafood types differed widely in nutritional value and in climate impact, and that the two metrics were not correlated across all species. This research is a first step towards modelling the joint nutritional and climate benefits of seafood as a concrete baseline for policy-making, e.g. in dietary advice.

Building artificial coral reefs

The global loss of coral reefs threatens human lives because these ecosystems provide food, income and shoreline protection. In a new project, artificial coral reefs will be developed in Madagascar with the help of novel technology, to restore biodiversity, build fisheries and improve human health. The project will also investigate the potential for sustainable marine aquaculture alongside existing wild capture fisheries from reef ecosystems.

Programme director Max Troell will be involved in general feasibility studies of the new methodology (ARMS for short), but his main contribution will be to determine how the local fish resources generated affect the nutrition and wellbeing of the coastal communities involved.

The project is a 3-year collaboration between Harvard University, the Beijer Institute and the University of Toliara.



[4] Crona, B., E. Wasén, M. Troell, K. Barclay, T. Mallory, M. Fabinyi, W. Zhang, V. W. Y. Lam, L. Cao, P. J. G. Henriksson, and H. Eriksson. China's seafood sector at a crossroad? *One Earth*. In press.

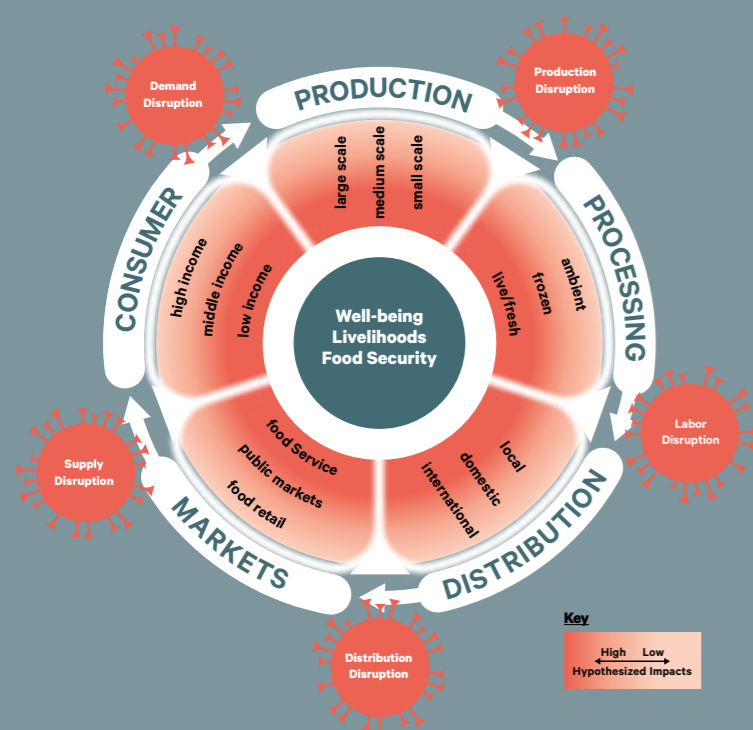
[5] Gephart, J., C. D. Golden, F. Asche, B. Belton, C. Brugere, E. Froehlich, J. P. Fry, B. S. Halpern, C. C. Hicks, R. C. Jones, D. H. Klinger, D. C. Little, D. J. McCauley, S. H. Thilsted, M. Troell, and E. H. Allison. Scenarios for global aquaculture and its role in human nutrition. *Reviews in Fisheries Science & Aquaculture*. In press.

[6] Henriksson, P. J. G., L. K. Banks, S. K. Suri, T. Y. Pratiwi, M. R. Fatan, and M. Troell. 2019. Indonesian aquaculture futures — identifying interventions for reducing environmental impacts. *Environmental Research Letters* 14:124062.

[7] Metian, M., M. Troell, V. Christensen, J. Steenbeek, and S. Pouli. 2019. Mapping diversity of species in global aquaculture. *Reviews in Aquaculture* 12(2): 1090–1100.

[8] Hallström, E., K. Bergman, K. Mifflin, R. Parker, P. Tyedmers, M. Troell, and F. Ziegler. 2019. Combined climate and nutritional performance of seafoods. *Journal of Cleaner Production* 230:402–411.

COVID-19 disruptions and impacts on seafood supply chains.



Behaviour, economics and nature (BEN)

The mission of the BEN programme is to develop an understanding of human behaviour that can assist in the design of robust institutions for environmental protection and sustainable development. BEN research seeks to understand fundamental drivers of individual behaviour, while recognising that people taking decisions are embedded within, and affected by, a social, economic and ecological context. We study behaviour and behavioural motivators at different levels, as reflected in our various research topics, our multi-method approach and the interdisciplinary expertise on which we rely.

[1] Schill, C., J. M. Anderies, T. Lindahl, C. Folke, S. Polasky, J. C. Cárdenas, A.-S. Crépin, M. A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075-1082.

[2] Muneeppeeraku, R. I., and J. M. Anderies. 2020. The emergence and resilience of self-organized governance in coupled infrastructure systems. *Proceedings of the National Academy of Sciences of the United States of America* 117(9):4617-4622.

How Covid-19 changed the context of our research

In November 2019, *Nature Sustainability* published the paper 'A more dynamic understanding of human behaviour for the Anthropocene'¹. This piece, which you can read more about on page 23 of this report, summarises the discussions and thinking at various BEN workshops and meetings over recent years. The paper highlights the role of social, cultural and ecological context for our perceptions, social interactions and behaviour, and how these interactions and behaviours in turn give rise to new contexts. Little did we know, while writing this paper, how our realities and the context in which we live, operate and perform research would change so dramatically in just a few weeks' time.

The ongoing Covid-19 pandemic has affected BEN research in many ways. Perhaps the most obvious is that we had to postpone much of the data collection we had planned. This year saw the start of a new exciting research project, *The new normal*, led by Beijer researcher Caroline Schill. It will explore, together with Inuit communities in North Slope, Alaska (USA), human responses to abrupt environmental change in the Arctic, using behavioural and interpretive social science. Because this project relies heavily on fieldwork, project plans for this year had to be substantially revised, although several activities can still be performed.

Experiments with small-scale fishers

Many small-scale coastal fisheries are severely threatened by chronic overfishing and climate change impacts. These combined pressures call for better management but solutions can be difficult to find, especially if they are dependent on the social and ecological context. In a project funded by Vetenskapsrådet (The Swedish Research Council), Therese Lindahl and Caroline Schill, with collaborators in Colombia and Thailand, aim to shed light on this issue. In experiments, they will study how various aspects of resource

dependency affect behaviour and the implications this may have for policies. During this year, the first phase of data collection took place in Thailand. The remaining data collection has had to be postponed due to the Covid-19 pandemic.

Modelling human behaviour

The BEN programme continues its efforts to develop a general, flexible modelling platform through which researchers can conduct experiments with data simulations in *silico*, to complement empirical research and practical policy work. The work on small-scale fisheries discussed in the previous section will be a key driver of BEN modelling research in the period 2020-2021. For example, while awaiting experimental data on behaviour, existing data can be used to build agent-based models. These models can then be applied in social simulation experiments to allow systematic exploration of how diverse resource users, facing different ecological realities, with respect to resource scarcity

Former Mäler Scholar Rawadee Jarungrattanapong and programme director Therese Lindahl during field work in Thailand.



Rawadee Jarungrattanapong instructing small-scale fishers in Thailand, participants in behavioural experiments.

and resource variability, respond and adapt to natural resource conditions, Model development work is a collaboration between Therese Lindahl, Caroline Schill and colleagues from Stockholm Resilience Centre.

A recent article by Marty Anderies and collaborators lays the foundation for rigorous assessment of the conditions in which governance can be expected to emerge in small-scale resource systems². This is an essential question for small-scale fisheries, which according to some estimates comprise more than 40% of world landings and which must rely on local governance structures to prevent over-exploitation.

“How to design policy mixes with the greatest potential to shift diets towards more sustainable and healthy options?”

Two new grants to continue work on policy design

Over the course of four years, Therese Lindahl and Malin Jonell will be part of a research programme funded by Mistra (Swedish Foundation for Strategic Environmental Research). The programme, *Mistra Food Futures*, which is spearheaded by the Swedish University of Agricultural Sciences (SLU) together with Stockholm Resilience Centre and RISE (Research Institute of Sweden) aims to develop strategies that can transform the food system by 2045. Lindahl and Jonell will study how

to design policy mixes with the greatest potential to shift diets towards more sustainable and healthy options. This will be a continuation of work carried out during the year. See for example related work within the project SEAWIN (more on page 38) and two published reports on transformation of the food system³⁻⁴ (more on page 37).

Therese Lindahl, Gustav Engström and Johan Gars received a four-year grant from Formas (Research Council for Sustainable Development) for a project in which they will empirically study attitudes of voters and politicians to climate policies. They will examine how these opinions co-vary with individual characteristics, such as income, geographical region of residence and ideological leanings, and how they may change with different socio-political and ecological realities. Results from empirical studies will then be used together with economic models to identify the efficient policies that are also politically feasible.

Looking ahead

The current coronavirus crisis has imposed constraints on our research, but at the same time it has provided us with a window for thinking strategically about the future. We look forward to the next year of BEN, when we will hopefully be able to resume our ongoing experimental work and re-engage with our collaborators in small working groups to address practical policy concerns and develop the theory regarding human behaviour in complex adaptive systems.

[3] Lindahl T., and M. Jonell 2020. *Metoder för att ändra kostvanor (Methods for changing diets)*. Konsumentverket (The Swedish Consumer Agency), report 2020:4.

[4] Rööf, E., J. Larsson, K. Resare Sahlin, M. Jonell, T. Lindahl, E. André, S. Säll, N. Harring, and M. Persson. 2020. *Styrmedel för hållbar matkonsumtion: En kunskapsöversikt och vägar framåt (Policy instruments for sustainable food consumption: A review of the evidence and ways forward)*. SLU Future Food Reports, Swedish University of Agricultural Sciences, report 19.

Governance, technology and complexity

This programme strives to combine important theoretical insights with novel and grounded empirical research. The emphasis is on how societal and technological change interacts with complex systems of the biosphere, and on governance issues associated with these interactions. The ambition is to continue to identify opportunities for cross-fertilisation and build partnerships with scholars from different fields such as sustainability sciences, finance, law, economics, political economy, computer sciences and risk studies.

The programme is run in close collaboration by the Beijer Institute, Stockholm Resilience Centre (Stockholm University), Princeton University and other international collaborators.

Technological advances shaping our planet

Technological change has always been viewed as rapid and disruptive. Automation was an issue discussed already by Aristotle in *Politics*, and Francis Bacon noted at the end of the 1500s the powerful forces unleashed by technological progress. Advances in robotics, artificial intelligence (AI) analytics, and a suite of intelligent autonomous technologies now surrounding us all in seamless ways, are making it increasingly clear that technological change will continue to be a major force shaping the trajectories of our living planet.

“Technological change will continue to be a major force shaping the trajectories of our living planet”

The speed and scope of climate, environmental, technological and socio-economic change pose serious challenges to the problem-solving capacities of norms, institutions and legal systems world-wide. This is exacerbated by the fact that, due to globalisation and technological change, the world can be viewed as increasingly shaped by the behaviour of complex systems. This includes: emergence, connectivity, surprise, non-linear changes and poorly understood interactions across regions and sectors in society. Hence, we face not only unprecedented climatic and ecological conditions, but also the influence of increasingly machine intelligence autonomous systems with the ability to create new connections between the social, the ecological and the technological.

Planetary responsible AI

In the past year, we have worked hard to create the international collaborations and ideas needed to move this complex issue as a clear research agenda. As part of this ambition, in October 2019 the programme organised a workshop and launch event on “*AI, People and the Planet*” at the Consulate General of Sweden in New York, in collaboration with colleagues at Princeton University. The event brought together academics and representatives from major tech companies such as Google and Ericsson, national partnerships like AI Innovation of Sweden, and international organisations such as USAID, UN Global Pulse and the United Nations Development Program (UNDP). This is only one of several events where we strategically aim to connect to new expertise in the artificial intelligence domain, and front-runners in a field that we have denoted “Planetary responsible AI”¹.

Machine intelligence supporting sustainability science

It has become increasingly clear that machine intelligence not only has practical applications, but also could help augment the capacity of the sustainability sciences to make sense of data and improve modelling. This point was made by W. Brian Arthur during his visit in Stockholm and is now eloquently summarised in a Beijer Discussion paper². As part of this general ambition, the programme has helped organise lectures and workshops exploring how machine intelligence approaches such as “deep learning” could help analyse social-ecological data in new ways.

Read more: www.aipeopleplanet.earth

The programme and its activities have also led to numerous publications that explore this area of research. At the end of 2019, the edited volume *Global Challenges, Governance, and Complexity: Applications and Frontiers* was published by Edward Elgar (UK/US)³. This vol-



ume brings together scholars from all over the world to explore and integrate insights from the complexity sciences with multiple disciplinary perspectives, studies of governance and policy of global challenges like climate change, and global systemic risks. Contributions to the volume show that complex systems insights have much to offer as we all strive to understand the role of institutions, law, policy, networks, leadership and mental models for dealing with urgent societal challenges. Read more on page 22.

Machine augmented misinformation

Another noteworthy product of our work was published in the prominent medical journal *The Lancet*. The paper is one of the outcomes of our collaborative work following from our workshops at Princeton about artificial intelligence, complexity and the biosphere. In this particular stream of work, we try to advance our understanding of how a rapidly changing and automated media landscape affects people's ability to make sense of and respond to planetary change. Digital media, especially social media, plays a fundamental role by supporting the global exchange of information and debate. The participatory aspects of social media give it a central role in shaping individual attitudes, feelings and behaviours, and organising social mobilisation and protests. However, this new digital infor-

mation landscape is also affected by the abundant and at times automated spread of misinformation, including hoaxes, conspiracy theories, click-bait headlines and junk science. The study ‘EAT-Lancet vs. yes2meat: Understanding the digital backlash to the ‘planetary health diet’⁴ showed that information dynamics and strategies by loosely coordinated groups online can successfully undermine the science communication work of the *EAT-Lancet Commission on Food, Planet and Health*. This study is only the beginning of a larger ambition to further explore how digital media and machine intelligence automation affect the diffusion of misinformation, sense-making and opinions about critical global challenges.

Looking ahead

Our work of creating strong international partnerships through international workshops and seminars, experimenting with machine intelligence methods for social-ecological research and advancing pilot research projects at the interface between our changing planet, technological change, economics and governance will continue in the next year. We look forward to sharing novel insights and inspiring new research and innovation, both within and outside academia, as the Governance, technology and complexity programme continues to develop.

[1] AI can tackle the climate emergency – if developed responsibly. Galaz, V. *The Conversation*. 23 April 2020.

[2] Arthur, W. B. 2020. Beijer Discussion Paper 269: Algorithms and the shift in modern science. *Beijer Discussion Paper Series*.

[3] Galaz, V. (editor) 2019. *Global Challenges, Complexity, and Governance: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

[4] Garcia, D., V. Galaz, and S. Daume. 2019. EATLancet vs yes2meat: the digital backlash to the planetary health diet. *The Lancet* 394:2153-2154.

Urban social-ecological systems

The world is urbanising at an unprecedented rate. Cities currently account for around 70% of both global energy use and global greenhouse gas emissions, and contribute to environmental degradation on a global scale. The highest rates of urban growth are in regions that were previously relatively undisturbed by urban development.

[1] Samuelsson, K., S. Barthel, J. Colding, G. Macassa, and M. Giusti. 2020. Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic. *OSF Preprints*. osf.io/3wx5a

[2] Colding, J., M. Colding, and S. Barthel. 2020. Applying seven resilience principles on the vision of the Digital City. *Cities* 103:102761.

[3] Holmgren, M., A. Kabanshi, L. Langeborg, S. Barthel, J. Colding, O. Eriksson, and P. Sörqvist. 2019. Deceptive sustainability: Cognitive bias in people's judgment of the benefits of CO2 emission cuts. *Journal of Environmental Psychology* 64:48-55.

[4] Sörqvist, P., J. Colding, and J. Marsh. Psychological obstacles to the efficacy of environmental footprint tools. *Environmental Research Letters*. In press.

The Covid-19 pandemic demonstrated how vulnerable our societies are to disturbance. Despite warnings by epidemiologists that a new virus would emerge sooner or later, most countries were badly prepared and taken by surprise. Suffice it to say, 2020 has been a strange year.

The pandemic highlights the need for urban green space

Researchers and activities linked to this programme have lately been forced to focus on solitary tasks. This has seen the completion of a number of studies and the initiation of new studies, one of which centres on the Covid-19 pandemic. In a forthcoming publication in *Landscape and Urban Planning* Johan Colding and colleagues from Stockholm Resilience Centre and the University of Gävle show the value of urban green spaces for reducing stress, promoting health and enabling social distancing during the extraordinary circumstances of the Covid-19 pandemic¹. The authors argue for general resilience planning through maintaining urban green areas.

“Planning for redundancy is a fundamental resilience principle in order to survive critical ICT system failures”

Including resilience in smart city planning

The programme's work in closely monitoring smart city development has resulted in two new publications. In one of these, the authors applied seven resilience principles in analysis of smart city designs and showed that city digitalisation presents new risks that need to be accounted for in greater detail than is currently the case². These resilience principles were originally developed by Berkes et al. (2003) and later refined by Biggs et al. (2015). While the digitalisation of city infrastructures and services yields many benefits, the

authors discuss how systems that draw on electricity are easily perturbed, as seen during Hurricane Katrina, the Hengchun earthquake and the failure of New York's information and communications technology (ICT) networks during Hurricane Sandy. The authors suggest that planning for redundancy is a fundamental resilience principle in order to survive critical ICT system failures. Such redundancy could involve simple solutions such as co-provision of analogue solutions that can kick in during times of digital failure.

Psychological obstacles to acting on facts

According to human geographer Mike Hulme, we need to abandon the idea of designing sustainability targets that works for everyone. Hulme claims that empirical data alone will never result in policies that combat climate change. He argues that climate change action can be driven equally well by “meta-narratives”, i.e. narratives of historical meaning, experience or knowledge that embody people's beliefs about the past, present and future.

Hulme's argument is supported by two recent studies³⁻⁴ co-authored by programme director Johan Colding. Drawing on environmental psychology, these studies demonstrate, through experiments, that cognitive barriers make it difficult for people to interpret climate facts correctly and then adopt more pro-environmental behaviours. Hence, we need to develop complementary approaches that can induce collective action more broadly in society.

Pros and cons of city compaction

The research project *Analysing the environmental rationale for city compaction in the Stockholm region*, based on a grant from Stockholm University and Stockholm County Council, ended in December 2019. The overall aim of this project was to gain knowledge about the environmental pros and cons of city compaction and its implications for urban planning in the Stockholm region.

The project revealed poor agreement on how urban density is measured and a lack of evidence on the

environmental gains deriving from city compaction. Project results showed that up to 37% of semi-natural areas in Stockholm County will be affected by current urban expansion plans⁵. Focusing on the effects on pollination potential, the authors showed that urban expansion indirectly affects food production and biodiversity.

A related paper in *Spatial Economic Analysis* (although outside this project) examined ways of valuing biodiversity and resilience, with the focus on pollinator diversity in the Stockholm region⁶.

In addition, the project demonstrated that densification in the Stockholm municipality is currently taking place in already densely built-up areas, in attractive residential neighbourhoods⁷. As policy advice, project researchers propose that policymakers abandon the current multi-functionality approach to use of space, also applied to public parks. They also point out that the ongoing densification is resulting in increased privatisation of public urban space⁸.

Flooding after Hurricane Katrina in New Orleans. In several projects programme research investigate ways to minimise negative effects of extreme events.



Activities

Until the onset of the Covid-19 pandemic, the programme was engaged in several workshops and seminars. Programme director Johan Colding presented the Beijer Institute's urban research at a Sustainability Research Day in October 2019, organised by KTH Royal Institute of Technology. He summarised almost twenty years of research in a presentation entitled “The Stockholm Approach”. The event attracted a large number of policymakers and prominent urban development scholars.

Åsa Gren and Johan Colding were also invited speakers at the event “The future of Nordic Cities”, organised by the Nordic Council of Ministers, Stockholm Resilience Centre and the University of Gävle, in conjunction with the 21st meeting of the UN Framework Convention on Climate Change (COP 21), in December 2019.

Åsa Gren was invited expert at a February workshop at FORMAS on development of a strategy for identifying research issues in the context of biodiversity and climate change, where scientific compilations are required.

Overall, it has indeed been both a productive and memorably strange year!

[5] Gren, Å., and E. Andersson. 2018. Being efficient and green by rethinking the urban-rural divide—Combining urban expansion and food production by integrating an ecosystem service perspective into urban planning. *Sustainable Cities and Society* 40:75–82.

[6] Engström, G., Å. Gren, C.-Z. Li, and C. K. B. Krishnamurthy. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

[7] Engström, G., and Å. Gren. 2017. Capturing the value of green space in urban parks in a sustainable urban planning and design context: pros and cons of hedonic pricing. *Ecology and Society* 22(2):21.

[8] Colding, J., Å. Gren, and S. Barthel. 2020. The Incremental Demise of Urban Green Spaces. *Land* 9(5):162.

Topics

Some areas of research at the Beijer institute are conducted outside the research programmes. This may occur for instance when the research is relevant for several research programmes or is in the form of early investigations into a new field that may develop into a research programme in the future. To highlight these and how they fit within our general research agenda, they have been collected under the section Topics.

Biosphere economics

The Beijer Institute is constantly seeking to promote a deeper understanding of the interplay between ecological systems and social and economic development, a question which is permeating all our research programmes. Grasping how the economy interplays with nature's complexity is essential to this understanding. In particular, in the past year we have focused on investigating how economic interests interact with potential ecosystem regime shifts, the water cycle, and intertwined global environmental problems. In addition, the Behaviour, Economics and Nature (BEN) Programme is studying how nature's complexity influences human behaviour and is influenced by it. Understanding economic dynamics is key in designing public policies that are successful in actually achieving their goals and in gaining social acceptance and respect.

Economic dimensions of regime shifts

The policy implications of ecosystem regime shifts, a core topic of Beijer Institute research for many years, have been difficult to determine to date, because many (but not all) economic policies need to be substantially adapted for resources or ecosystems that can undergo a regime shift, compared with policies designed for systems that do not shift. Beijer Institute researchers are helping to generate a more synthesised understanding of this evolving topic. In particular, Anne-Sophie Crépin considered the role of economics in approaching seven resilience principles (from Biggs et al. 2015) and suggests adding two more principles related to managing strategic decisions and property rights, because of their key role in economic dynamics, which is likely to influence social-ecological system resilience¹.

Given the large uncertainties surrounding future developments of these ecosystems, a recurring question is whether or not policies should be more precautionary. The answer appears to depend on many different aspects: whether people can influence the risk of a regime shift occurring, the impact of the shift, the possibility of slowly changing dynamics and more. Beijer researchers and colleagues have now shown that

the outcome also depends on how resource users value what they have today, compared with what they may have in the future². They found that if users are impatient or particularly vulnerable because they have difficulties fulfilling basic needs, the best they can do is to exploit the resource more fully. Their analysis suggests that appropriately dealing with resource users' time preferences will be important in ensuring sustainable resource use.

Land and water resources

Anne-Sophie Crépin participates in a SESYNC project *Advancing integrated process-based modelling of complex socio-environmental systems*, with the aim of improving decision support for policy makers who deal with land and water resources. Current decision support focuses on each aspect separately, but all aspects are intertwined, which means current decisions are based on partial and biased information. The project will deliver comprehensive integrated models of ecosystems, hydrology and economics that also incorporate relevant thresholds.

During the past year, Anne-Sophie Crépin has started new collaborations with hydrologists to improve methods for integrating atmospheric moisture into transport modelling and economics. She is also collaborating with Juan Carlos Rocha (SRC) to model cascading regime shifts in resource and pollution systems and their implications for policy.

Integrated assessment models of global environmental problems

Ongoing research in this area has primarily been concerned with extending standard climate-economy integrated assessment models to capture additional environmental processes and problems. The research methods employed include a variety of modelling approaches, using static, dynamic and stochastic general equilibrium frameworks of the economy-environment interaction. Much of this research has been conducted within the project *Global biophysical processes for climate-economy modelling*, which is described in more detail on page 20.

Anthropocene – the age of mankind

The recent major expansion of the human dimension into the Anthropocene – the age of humankind – has resulted in a highly interconnected world linking people and places with the planet in new ways. The global economy, societies and cultures are embedded in the biosphere. Social conditions, health, culture, democracy, power, justice, inequity, matters of security and even survival are interwoven with the Earth system and its biosphere in a complex interplay of local, regional and worldwide interactions and dependencies.

Growing population with a growing impact

In the Anthropocene, the human population and its activities have accelerated to become the dominant force shaping the dynamics of the biosphere and the Earth system as a whole. The speed, spread and connectivity of the human dimension is unprecedented. Humanity and our actions now constitute the major force in the evolution of life on Earth.

Existing as part of the biosphere means that the environment is not outside the economy or society, or a driver to be accounted for at will, but rather the very foundation that civilisations exist within and rely upon. Therefore, our research at the Beijer Institute is based on the understanding that the economy is embedded in the biosphere, and that the global economy operates within planetary boundaries of the Earth system and the new realities of the Anthropocene.



In the Anthropocene, extreme weather and geopolitical events interact with the dynamics of the food system, and can spill over multiple sectors and cause synchronous challenges that rapidly move across countries and regions. Understanding such complex dynamics was the focus of an earlier Beijer Institute research programme on Global Dynamics, Multiple Shocks, and Resilience. It generated much new research, inspired research programmes and created new insights.

Risk in the Anthropocene

During the past year alone, the intertwined dynamics have been exemplified by work on the rise of antibiotic and pesticide resistance and associated governance challenges, published in *Trends in Ecology and Evolution*¹, and in development of a new concept denoted Anthropocene Risk, presented in the journal *Nature Sustainability*². Anthropocene Risk integrates risks that emerge from human-driven processes; that interact with global human-environment connectivity; and that exhibit complex interactions from the local to the global and through time. Such risks are exemplified by moisture recycling connections between nations, aquaculture and stranded assets, and sea-level rise and megacities.

The rapid global spread of the recent coronavirus pandemic has exposed the fragility of the tightly interconnected globalised world of the Anthropocene. This fragility was analysed in an invited paper in *Nature* as part of its 150-year anniversary collection³. In the paper, Nyström et al. showed that simplified ecosystems, modified for the production of one or a few harvestable species, combined with tight couplings to international markets and urban areas, have produced a global production ecosystem that is homogenous, highly connected and characterised by low resilience. This enables novel and pervasive risks to emerge, interact and spread in contagious ways.

Futures in a new epoch

Crises can also open up windows of opportunity for societal shifts and tipping points for transformative change towards sustainable futures, as illustrated in a paper in *Global Environmental Change* analysing political shocks and governance transitions⁴.

Evolution in the Anthropocene is another rapidly developing area in which the Beijer Institute is engaged. We are studying how people and planet co-evolve. A review of human-driven evolution in the Anthropocene biosphere, published in 2019, highlighted strategies for governing such co-evolutionary dynamics⁵.

Finally, 'Our Future in the Anthropocene Biosphere', serving as a background document for the first Nobel Prize Summit on Global Sustainability in spring 2021, has been published in the Beijer Discussion Paper series⁶.

[1] Crépin, A.-S. 2019. Complexity, resilience and economics. Pages 166-187 in V. Galaz, editor: *Global Challenges, Governance, and Complexity: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

[2] Arvaniti, M., A.-S. Crépin, and C. K. B. Krishnamurthy. 2019. Time-consistent resource management with regime shifts. *CER-ETH Economics working paper series* 19/329. Center of Economic Research, ETH Zurich, Switzerland

[1] Jørgensen, P.S., C. Folke, P.J.G. Henriksson, K. Malmros, M. Troell, A. Zorzet, and the Living with Resistance Project. 2020. Coevolutionary Governance of Antibiotic and Pesticide Resistance. *Trends in Ecology and Evolution* 35:484-494.

[2] Keys, P., V. Galaz, M. Dyer, N. Matthews, C. Folke, M. Nyström, and S. Cornell. 2019. Anthropocene Risk. *Nature Sustainability* 2:667-673.

[3] Nyström, M., J.-B. Jouffray, A. Norström, P.S. Jørgensen, V. Galaz, B.E. Crona, S.R. Carpenter, and C. Folke. 2019. Anatomy and Resilience of the Global Production Ecosystem. *Nature* 575:98-108.

[4] Herrfahrdt-Pähle, E., M. Schlüter, P. Olsson, C. Folke, S. Gelcich, and C. Pahl-Wostl. 2020. Sustainability Transformations: Socio-Political Shocks as Opportunities for Governance Transitions. *Global Environmental Change* 63:102097.

[5] Jørgensen, P.S., C. Folke, and S.C. Carroll. 2019. Evolution in the Anthropocene: Informing Governance and Policy. *Annual Review of Ecology, Evolution and Systematics* 50: 527-546.

[6] Folke, C. et al. 2020. Beijer Discussion Paper 272: Our Future in the Anthropocene Biosphere: Global sustainability and resilient societies. *Beijer Discussion Paper Series*.

The economics of planetary boundaries

Last year was the tenth anniversary of the planetary boundaries framework, a concept that presents a set of nine planetary boundaries within which humanity can continue to develop and thrive (first developed by Rockström et al., 2009). Despite having become a central conceptual framework when considering how human activities interact with large-scale Earth system processes, our understanding still falls short when it comes to shaping underlying processes and drivers in order to avoid catastrophic outcomes. In particular, it seems crucial to gain a better understanding of how this planetary-scale change will affect human civilisation and its underlying economic development, and to design global-scale policies in order for humans to flourish.

“Our understanding still falls short when it comes to shaping underlying processes and drivers in order to avoid catastrophic outcomes”

[1] Engström, G., Å. Gren, C.-Z. Li, and C.K.B. Krishnamurthy. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

These reflections guided a team of Beijer researchers in our four-year research project entitled *Global bio-physical processes in climate economy modelling*, which is now coming to an end. The project provided funding to Gustav Engström, Johan Gars and Chandra Kiran Krishnamurthy through the Ragnar Söderberg foundation. This funding allowed the team to host two workshops on the topic, which involved a transdisciplinary group of international researchers. This has led to several research papers, describing work pursued both jointly and independently throughout the project period. The past year in particular has been exciting.

Valuation of biodiversity and resilience

First, a paper on valuation of biodiversity and resilience was published in the journal *Spatial Economics*¹. From the project start, the team realised that the role of biodiversity, a central planetary boundary process, was particularly difficult to include in the standard climate economy framework on which they relied for the analysis. The published paper can be seen as a first attempt to address this problem, by considering the example of diversity in pollination services in particular. The narrower scope of this example enabled them to scale down the broader and more difficult task of assessing the overall contribution of biodiversity to economic output. The results show that pollinator diversity can represent considerable general resilience value, due to variations in species traits and how different species respond to external factors. This research was a col-

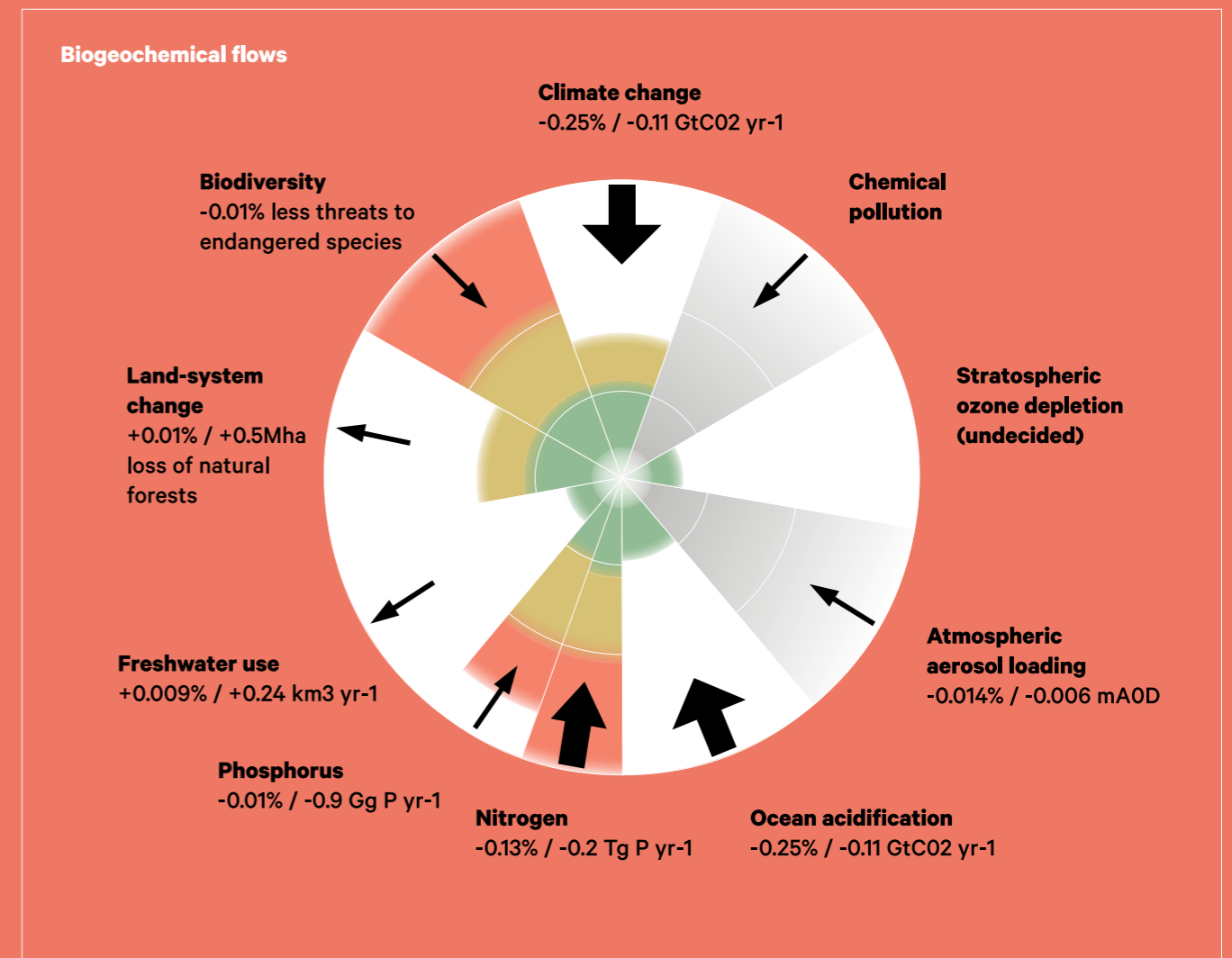
laboration at the Beijer Institute, with Åsa Gren, who provided the necessary ecological input, and Chuan-Zhong Li, who has previous experience of working on the topic from an economics perspective.

Carbon pricing and planetary boundaries

Second, we are now awaiting a final revision of a paper entitled ‘Carbon pricing and Planetary Boundaries’ inspired by the overarching research objective of our project. The paper assesses how the principal drivers of the planetary boundaries would be affected by a global carbon pricing policy. In particular, we make the point that the common notion of climate change mitigation as a matter of “applying the brakes” to greenhouse gas emissions may falter with a multi-boundary perspective, as it may inadvertently redirect economic activities in ways that exacerbate other planetary processes. In the paper, we explore the global environmental effects of a global carbon price, beyond reducing carbon emissions, by building an integrated global economic model featuring the most prominent planetary boundary processes. The model has been carefully parameterised using estimates from the literature and reliable data sources on global trade. Using this model, we show that the case for carbon pricing globally is actually even stronger in a multi-boundary world, since it can ameliorate many other planetary pressures (apart from climate change). However, it does exacerbate some planetary pressures (land use and water), largely as a consequence of a resulting increase in the incentive to produce biofuel. On extending the model with a biofuel policy, we show that, if implemented together with a global carbon price, it can alleviate all the planetary pressures.



The figure summarizes some of the results from the research paper titled ‘Carbon pricing and Planetary Boundaries’. The arrows indicate the change in planetary pressure which would result from a global carbon price increase. Outward (inward) pointing arrows indicate an increasing (decreasing) planetary pressure. The numbers are based on our model simulation output for a 1% increase in the global carbon price.



Book: Global challenges, governance, and complexity

IT IS CLEAR that the world is facing major problems, but the solutions required to solve these problems have to embrace the features of complex systems and the interconnectedness of society, the biosphere and technology. There is increasing interest in integrating insights from the complexity sciences into studies of governance and policy. In the book *'Global Challenges, Governance, and Complexity'*, stemming from the *Governance, technology and complexity* programme at the Beijer Institute, experts from a wide range of disciplines, including political sciences, law and economics, elaborate on important features of complex adaptive systems and their connections to key governmental and political issues.

These features include complexity leadership, environmental and sustainability challenges, the role of economics, policy-making, legal and social dimensions of systemic risks, and the effectiveness of polycentricity.

Through exploring application of a complex systems lens to important global challenges, the book, which is edited by programme director Victor Galaz, offers key insights into successful governance in our changing world. It illustrates a number of theoretical and methodological approaches to help understand the role of decision-making, policies, institutions and networks in navigating complexity.



Governing for emergence in social-ecological systems

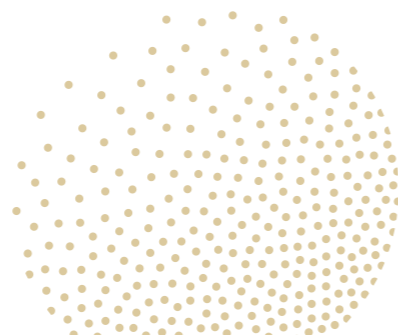
In a chapter in the book, Carl Folke describes, through a case-study approach, how systems of adaptive governance emerge and how they can transform governance towards biosphere stewardship and sustainable futures. The chapter clearly illustrates the dynamic interplay in complex adaptive systems between the adaptive responses of the parts (or agents) and the emergent properties of the whole. Carl Folke identifies twelve critical dynamic processes in adaptive governance, and places resilience thinking in this context, emphasising flexibility and capacity for living with uncertainty and surprise.

Complexity, resilience and economics

The complexity of the world in which we live generates challenges for policy design, with e.g. regime shifts, spatial variations, teleconnections and missing institutions, to name a few. Economic research tends to address individual challenges or sometimes two or three in combination, but holistic perspectives are lacking. Resilience theory instead takes a holistic approach and has identified seven resilience principles relating to managing diversity and redundancy, connectivity, slow variables and feedbacks, emergence and multiple regimes, learning, participation and polycentric governance. However, this approach often avoids analysing the additional complexity created by economic incentives.

In another chapter in the book, Anne-Sophie Crépin investigates how the seven principles of resilience can be combined with social-ecological systems thinking and economic theory to inform the design of economic policies for sustainable development. The analysis reveals areas where resilience thinking and economic theory could better inform each other and generate new knowledge. In particular, combining both theories suggests that property rights and the strategic decisions of actors must be explicitly managed in addition to the seven principles, to ensure system resilience and sustain ecosystems services in social-ecological systems.

Galaz, V. (editor) 2019. *Global Challenges, Complexity, and Governance: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.



A more dynamic understanding of human behaviour

ENSURING A LIVEABLE planet and well-being for future generations will require a major shift in human behaviour. This behavioural change is both one of the greatest challenges and one of the greatest opportunities for sustainable development. In a paper published in the journal *Nature Sustainability*, researchers from the Beijer Institute and its close network of collaborators suggest a new approach for conceptualising human behaviour to better explore potential pathways towards sustainability.

At the core of this approach is an understanding that our behaviours shape, and are shaped by, the diverse contexts in which we live. These contexts include the specific moment in which we make decisions, the diverse social and cultural groups of which we are part, and the biophysical and ecological environments all around us. The authors argue that a complex adaptive systems approach is critical as a basis for environmental governance.

Why simplified models simply don't fit

The paper begins by highlighting that, although human behaviour is of profound significance for sustainability, the approach to human behaviour in many fields remains reliant on overly simplistic models of behaviour. The dominant view focuses exclusively on individual responses to material incentives. However, the authors argue that the role of broader contexts in shaping behaviour, and how behaviour continuously co-evolves with changing local to global contexts, should also be taken into account.

The paper takes the reader on a journey from models of human behaviour based on *Homo economicus* to models where human behaviour is regarded as part of complex adaptive systems. During this journey, the paper invites the reader to reflect on research insights underlying the recognition that people are diverse and intrinsically pro-social, do not always act on their plans, and are generally not consistent optimisers. These recognitions are based on the bulk of work to date in cognitive psychology and behavioural economics.

Reflections on writing process

The paper came about through a unique and rewarding process. It would not have been possible without the BEN programme (see page 12), which allowed the core writing team and the other authors to meet and discuss ideas on several occasions. There was early agreement among the core writing team that the paper could act as the foundation for future BEN research. Therefore the priority was not to 'get it out' fast, but to take the time to carefully develop and shape the content. Seeds of this work originated from BEN workshops in 2014 and 2015 and from the PhD thesis of lead author Caroline Schill. The team hopes that the seeds sown with the paper will grow to inform and inspire many new research collaborations in the future.

Expanding the view of behaviour

The authors continue by presenting relevant insights from social, environmental and cultural psychology and from cultural sociology and sustainability science about the more 'durable' influences of different socio-cultural and biophysical contexts on individuals, as well as their interactions with others and their environments. In their words, humans are 'quasi-rational', 'enculturated' and 'enearthed'. The term 'enearthed' is an original contribution of the paper conveying that, irrespective of where we live and how we earn our living, we are embedded in the biosphere and thus our actions and overall well-being intimately depend on the biosphere.

The authors conclude with reflections on the implications for policy design and research. They argue that utilising more realistic models of human behaviour with an emphasis on context, can improve policy design, but will require new research collaborations. The specific lens that the paper provides may in fact facilitate such novel collaborations. A complex adaptive systems approach can serve as a bridge enabling scholars in different fields, and even with contrasting perspectives on human action, to engage in fertile cross-disciplinary dialogue around the interface of human behaviour and sustainability.



Schill, C., J. M. Anderies, T. Lindahl, C. Folke, S. Polasky, J. C. Cárdenas, A.-S. Crépin, M. A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075–1082.

Fuel for economic growth

THE TRANSITION TO sustained growth, which began with the Industrial Revolution, has not been universal. Many countries around the world have remained stagnant or experienced only limited growth throughout history and there are currently large and growing differences in income per capita across countries, referred to as the Great Divergence. Using a macroeconomic model, a study published in the *Journal of Economic Theory* demonstrates that international competition for fossil fuel can help explain this divergence.

The starting point of the study is the empirical observation that GDP and growth in GDP are larger in countries and times where a relatively large share of the energy supply is derived from fossil fuel. While more fossil fuel use can generally be expected in richer countries, it is not self-evident that the share of fossil fuels should be larger.

“The work on this paper started from the observation that the role of energy had received surprisingly little attention in macroeconomic research on growth, especially given the centrality of the energy sector for climate change”, explains Beijer Institute researcher Johan Gars, co-author of the study together with Conny Olovsson at Sveriges Riksbank. “We therefore wanted to study how energy availability may have contributed to the most important international patterns of growth.”



The international competition for fossil fuel can help explain the Great Divergence.



Modelling the role of energy in the global economy

The study goes on to build a multi-country macroeconomic model with endogenous and directed technological progress. In this model, a number of countries grow by investing in physical capital and research to improve productivity. Investments in research in individual countries give positive spillovers by improving the global state of knowledge about different types of technology. Individual innovation efforts then draw on the international state of knowledge, creating positive spillovers between innovation efforts in different countries. However, making great advances in technological knowledge is assumed to be more costly, thus limiting the ability to benefit from the positive spillovers. Furthermore, the model features an international market for fossil fuel.

Two important empirically grounded assumptions in the model are that energy is complementary to other inputs in production, implying that significant long-term growth requires increased energy use, and that it is easier to improve the productivity of fossil energy use than use of other energy sources. With these assumptions, the model gives rise to two interesting results: First, the discovery of fossil fuels was an important factor behind the Industrial Revolution. Second, international competition for fossil fuel can help explain the Great Divergence.

The implication behind the second result is that in order to benefit from the increased knowledge about energy technology, investments into domestic research must still be made. If international fossil fuel prices are determined by more advanced countries, such investments may not be profitable, since fossil fuels are too expensive. Hence, countries may be forced to use less efficient energy sources.

Looking ahead

Looking forward, it seems likely that the assumption that energy is important for growth will continue to hold. However, recent rapid improvements in alternative, and less polluting, energy sources mean that fossil fuels may not be necessary in the future. Hence growth, not least in currently poor countries, could become feasible even while achieving the significant global reductions in fossil fuel use required to limit climate change.

Johan Gars believes the model can serve many other purposes: “The model we develop in this work strikes a good balance between on the one hand including several important components, such as multiple energy sources, multiple countries and endogenous directed technological progress, and on the other hand being compact and tractable. We believe that these properties make the model well suited for studying many other questions about the role of energy in the global economy.”

Gars, J. and C. Olovsson. 2019. Fuel for economic growth? *Journal of Economic Theory* 184:104941.

Algorithms and the shift in modern science



A nautilus shell.

IN THE 1600S, science shifted from being expressed in geometric form to being expressed in terms of algebraic equations. In a Beijer Discussion Paper, Beijer associate Brian Arthur, Santa Fe Institute, argues that a new shift is under way. Scientific thought is expanding from being expressed in equations to being expressed in algorithms. Systems, whether physical, biological or social, are rarely passive and fixed in structure, but constantly changing, evolving and reforming, forming new structures on the way. In other words, they behave algorithmically.

Science has changed in the past century. It has become increasingly curious about matters of formation. How did the brain evolve? How did continents form? By what steps did language arise? How did multicellular organisms arise? Can a self-reproducing machine be constructed? Science has thus expanded from deducing the implications of closed, given, formal structures to exploring the implications of open, evolving, generative structures.

The algorithmic system brings new problems within the reach of science, as it allows expression of event-driven processes. Closely aligned with complexity science, it allows formal expression in procedural sciences such as biology.

Algorithms are instructions for constructing some form of structure, which feeds back to querying the algorithm that produced it. It is possible to study formation through this feedback

between the pattern or structure created and the algorithm that created it. Algorithms are about context and formation and algorithmic expression relates to the wider context of the system, whether local, global or external, a context that the system itself changes and constantly re-forms. Complex adaptive systems also react to the context, or the overall pattern, in which they find themselves, and in doing so they modify that context. There appear to be strong similarities between algorithms and complex adaptive systems.

Algorithms bring a new world of possibilities, a new means of expression for science to explore and explain. They show a world that is organic, contingent and alive.

Arthur, W.B. 2020. Beijer Discussion Paper 269: Algorithms and the shift in modern science. *Beijer Discussion Paper Series*.

A green pathway out of crisis?

Research related to Covid-19

[1]
Folke, C. et al. 2020. Beijer Discussion Paper 272: Our Future in the Anthropocene Biosphere: Global sustainability and resilient societies. *Beijer Discussion Paper Series*.

WE ARE IN the midst of the Covid-19 pandemic. This is not surprising, as a pandemic of some sort has long been anticipated, with precursors such as HIV, avian influenza and ebola. The current pandemic has exposed the fragility of the tightly interconnected globalised world of the Anthropocene, where humans and their activities have accelerated to become the dominant force shaping the dynamics of the biosphere and the Earth system as a whole. The speed, spread and connectivity of the human dimension is unprecedented in human history.



Research at the Beijer Institute, with its systems focus, has a long tradition of analysing the dynamics of complex, adaptive and interacting social, economic and ecological systems. We have shown that economies, societies and civilisations are embedded in the biosphere, and that people and nature are intertwined social-ecological systems now co-evolving and shaping the operation of the planet as a whole. Insights have

been gained on the complex dynamic behaviour of ecological and economic interactions. We have long been investigating how slower and deeper changes interplay with abrupt and rapid changes, and how seemingly unrelated shocks influence economic performance, societal development and sustainability.

Consequently, it is not surprising that Beijer Institute researchers are in a good position to analyse the Covid-19 situation and its broader implications from a systems perspective. Below, we describe some current and planned work of relevance for understanding and acting on the pandemic, as part of building flexibility and resilience. On the Beijer website, we list recent articles that provide an introduction to the dynamic thinking important for understanding changes, both incremental and abrupt, in this intertwined world.

“The current pandemic has exposed the fragility of the tightly interconnected globalised world of the Anthropocene”

White Paper for the Nobel Prize Summit 2021 – Our Planet, Our Future

This paper, written by a team led by Carl Folke in preparation for the Nobel Prize Summit in Washington 2021, contrasts the hyper-connected globalised world of today with transformation pathways towards global sustainable futures¹.

The challenges of achieving a resilient future are summarised, based on the contemporary threats of climate change, extreme events (including pandemics), biodiversity loss and social inequality. This white paper discusses alternative paths towards biosphere stewardship, ranging from technological change to social innovation and cultural shifts in beliefs and values, and how those relate to intertwined systems of people and nature embedded in the biosphere.

The Nobel Prize Summit was planned for May 2020, but had to be postponed due to the Covid-19 pandemic. It is hosted by the Nobel Foundation and organised by the US National Academy of Sciences, in partnership with the Potsdam Institute for Climate Impact Research and Stockholm Resilience Centre, together with the Beijer Institute.

Navigating the chaos of an incipient global cycle

The Covid-19 pandemic is coinciding and interacting with other systemic changes worldwide, such as droughts and climate extremes, and social and political conflicts. As people increasingly recognise the unsustainability of the present tightly interconnected world, more are arguing that the Covid-19 crisis could be an opportunity to shift towards a more sustainable and equitable future with the help of green recovery investment packages and new green deals.

Under the lead of Beijer Fellow Brian Walker, several Beijer Fellows have embarked on a project to develop a cohesive framework for understanding such dynamic change, including the windows of opportunities for change that emerge during turbulent times. They have taken as their starting point the “adaptive cycle” of systemic change, developed by the late Beijer Fellow C.S. Holling.

Policies to address both the Covid-19 crisis and the climate crisis

Many countries have introduced unprecedented economic recovery packages to minimise the pending recession resulting from the economic shutdown to prevent the spread of Covid-19. At the same time, there are calls for governments to prioritise climate change when designing economic stimulus packages.

In this project, Beijer Institute economists together with colleagues in Sweden and the US are examining the long-term implications of various policy options, to identify:

1. Long-term climate impacts of economic recovery policies related to Covid-19
2. How long-term climate policies may impact on economic recovery post Covid-19.

The main findings are that, among potential climate policies, labour-intensive green infrastructure projects, planting trees and, in particular, pricing carbon coupled with reduced labour taxation boost economic recovery². Among coronavirus policies, those supporting the services sector (leisure services like restaurants and culture or professional services like technology), education and the healthcare sector appear most promising, as these sectors are labour-intensive yet have low emissions. Such sectoral aid should be conditioned on creating employment and on low-carbon supply chains.

The pandemic highlights the need for city green space

In times of social distancing, green areas in towns and cities are more important than ever. Ensuring access to nature for the public should be a fundamental strategy of cities when coping with the Covid-19 crisis. In a preprint the authors points out that, during these extraordinary circumstances, urban green areas offer resilience for maintaining well-being in urban populations, while still enabling social distancing³. The

stress-reducing effects of interacting with nature are well-established scientifically and access to nature can also help people stay physically healthy, not least when other forms of exercise are limited. The article also discusses the critical role of urban nature in times of crisis, an important area of research within the research programme Urban social-ecological systems.

Governance in the shadow of extreme events

This project explores extreme events such as floods, fires and pandemic diseases that seem to be occurring more frequently and with increasing force, and possible strategies for dealing with these events. Read more on page 29.

Covid-19 and the seafood challenge

An international interdisciplinary scientific team has investigated Covid-19-related shocks and responses in the seafood sector. Insights from the study have been published as a preprint⁴, read more on page 10.



[2]
Engström, G., J. Gars, N. Jaakkola, T. Lindahl, D. Spiro, and A. van Benthem. 2020. Beijer Discussion Paper 271: What policies address both the corona virus crisis and the climate crisis? *Beijer Discussion Paper Series*. Also accepted for publication in *Environmental and Resource Economics*.

[3]
Samuelsson, K., S. Barthel, J. Colding, G. Macassa, and M. Giusti. 2020. Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic. *OSF Preprints*. osf.io/3wx5a.

[4]
Love, D. et al. 2020. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *SocArXiv*. osf.io/preprints/socarxiv/x8aew.

The Askö meetings

– bringing disciplines together for sustainable solutions

[1] Folke, C., H. Österbom, J.-B. Jouffray, E. Lambin, M. Scheffer, B.I. Crona, M. Nyström, et al. 2019. Transnational Corporations and the Challenge of Biosphere Stewardship. *Nature, Ecology and Evolution* 3:1396–1403

[2] Barrett, S., A. Dasgupta, P. Dasgupta, W.N. Adger, J. Anderies et al. 2020. Social Dimensions of Fertility Behavior and Consumption Patterns in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America*, USA 117: 6300–6307.

SINCE 1993, THE BEIJER INSTITUTE has organised an annual meeting in September for informal discussions between ecologists and economists at the Askö laboratory (part of Stockholm University), at the small island of Askö in the Baltic Sea. The Askö meetings have generated unique cooperation between these disciplines, which has now extended to other disciplines. Each year, an exciting frontier issue is discussed, which generally results in a scientific paper, often published in a leading scientific journal.

The past year has been very productive: we published two scientific articles resulting from previous Askö meetings and worked intensively on four more that we hope will be published soon.

Time for corporate biosphere stewardship?

Influenced by the Keystone Dialogues and the SeaBOS Initiative (see page 38), Askö participants in 2015 were curious about whether transnational corporations also play a dominant role in other sectors of the economy and could thus influence the operation of the biosphere. The meeting resulted in an article in *Nature, Ecology and Evolution* identifying a handful of transnational corporations that disproportionately influence the planet's climate and ecosystem (see figure)¹. The paper argues that such concentration of power brings

great responsibilities and also opportunities. Although voluntary corporate responsibility so far has proven ineffective, market concentration could be transformed into a positive force for sustainability, the authors claim. They identify leverage points where these corporations could have a positive impact on sustainability, but add some possible caveats.

Group dynamics in the service of sustainability

In a study published in *PNAS* 2020, building on discussions from the Askö meeting in 2016, the team of authors investigated how group dynamics can boost the quest for a more ecologically desirable environment². Specifically, they considered two aspects of the human enterprise that profoundly affect the planet: population and consumption. By studying fertility patterns in sub-Saharan Africa and consumption in the rich world, the researchers found commonalities that can help spur actions to alleviate the human pressure on the biosphere. For consumption, the desire for goods and services among individuals is substantially influenced by the tastes of people in their social networks and other groups to which they aspire. This means that a strong need to consume can either be encouraged or curbed by people's surroundings. Similarly, having children is not only connected with a private desire to have a large family, but also with the opportunity to acquire higher social status through reproductive success. It is also associated with a range of complex social, cultural and even religious aspects.

Both examples demonstrate how bottom-up social mechanisms, rather than top-down government interventions, can be better placed to bring about positive change for the environment. According to the team of authors, the fact that “human attitudes and practices are socially embedded suggests that it is possible for people to reduce their fertility rates and consumption demands without experiencing a loss in wellbeing”.

Earth stewardship

Ongoing global environmental change requires efforts to transform society toward sustainability. However, it is unclear what would make such transformation successful. A forthcoming paper, initiated at the Askö meeting in 2019, led by Terry Chapin, suggests that it should build on a shift in vision from maximising material wealth to sustaining the inclusive wealth of nations, i.e. their built, natural, hu-

man and social capital, and distributing it equitably across society. Triggers for such transformation could include incentives to change social norms; engagement of new actors, including businesses and NGOs, as agents of change; and design of new institutions, such as citizen assemblies, that foster pro-societal changes and stewardship. The key challenge is to align them in ways that are synergistic, persistent and amenable to cross-scale integration.

Governance in the shadow of extreme events

Extreme events like storms, flooding, wildfires and species extinctions are increasing in magnitude, frequency and intensity, and may have compounding and cascading impacts. Society needs strategies for handling and monitoring these extreme events and minimising their consequences. According to a forthcoming paper, led by Simon Levin and based on the 2018 Askö meeting, effective governance of extreme events requires careful assessments of the risks and benefits of responses and their interactions, and evaluations of how various combinations of responses change the wealth distribution. Then different infrastructures to predict and respond to the risk should be established and ways to coordinate responses across local, regional and global levels should be designed.

Overcoming uncertainty paralysis

The ideas from an Askö meeting sometimes reappear years later for further analysis, as in the case of a forthcoming paper initiated in 2009 at Askö and now in press³. It looks at how global environmental change challenges humanity because of its broad scale, long-lasting and potentially irreversible consequences. The authors argue that the right scientific lens can help penetrate the mist of uncertainty that threatens timely and appropriate decisions surrounding these complex issues. The key is understanding issues sufficiently well to justify policy action. To this end, the authors suggest four principles: 1) Follow the most direct path between decisions and impacts, 2) find just enough evidence for policy purposes, 3) prioritise obvious, no-regrets policies and 4) get the big picture roughly right, rather than focusing on some details.

Steve Polasky and Kathleen Segerson on the boat to Askö.



Enjoying breaks at the Askö meeting 2019. Middle: Scott Barrett and Jason Shogren. Photos: Sofia Käll



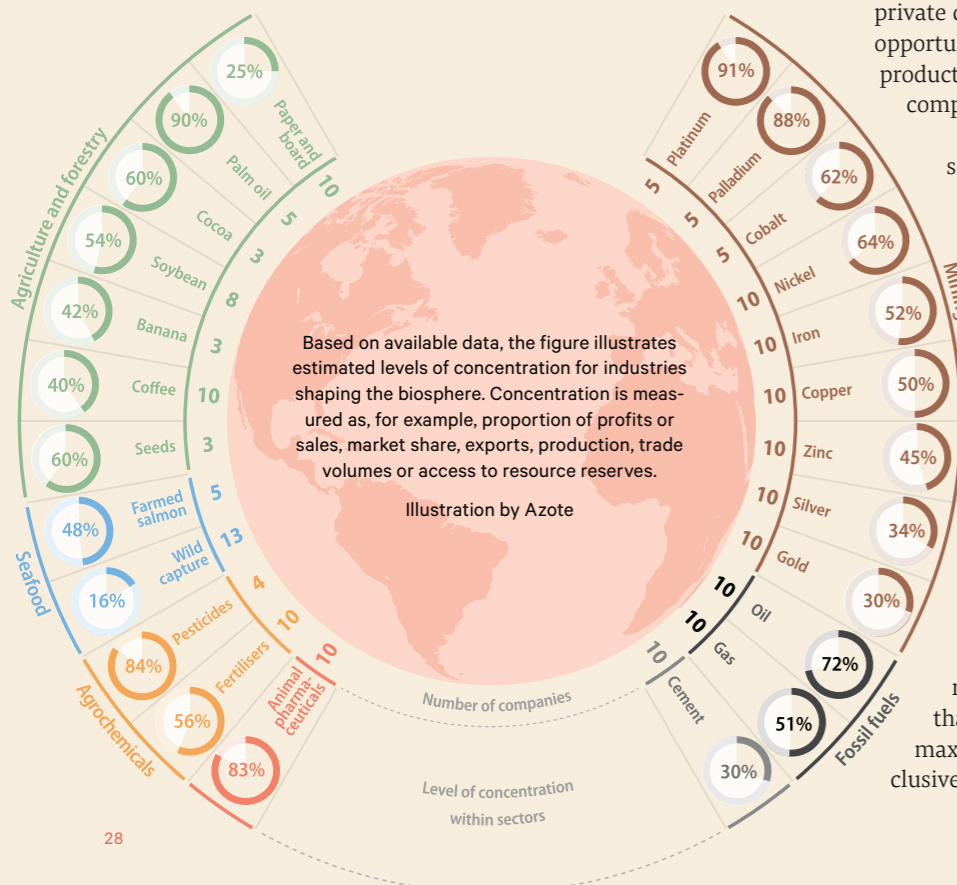
Migration and climate change

The Askö group of 2017 discussed ways in which climate change can trigger new forms of migration, with significant associated social costs. People will have to move permanently if they live in regions becoming too dry or too warm for human survival, or where sea level rise threatens their livelihood. In other regions, they will have to move at least temporarily because of extreme weather events, which are increasing in magnitude and frequency due to climate change. This adds economic or humanitarian concerns to the already complex migration situation. Yet migration can also facilitate adaptation to climate change and a Beijer study seeks to identify several ways of doing so. In particular, it focuses on how coordinated policies can help realise the benefits and minimise the costs of planned relocations within national borders and internationally.

Askö 2020

The Askö meeting 2020 will be different. Because of the Covid-19 pandemic, it was decided early on to move the meeting online, a new experiment. This digital Askö meeting will focus on *Responding to change in diverse ways in social, economic, and ecological systems*. As always, we look forward to interesting and creative discussions with the goal of learning from each other and combining our knowledge to trigger creative solutions to some of the most pressing problems of our time.

[3] Polasky, S., A.-S. Crépin, R. Biggs, S. R. Carpenter, C. Folke et al. Corridors of Clarity: Four Principles to Overcome Uncertainty Paralysis in the Anthropocene. *BioScience*. In press.



The Beijer Young Scholars

THE BEIJER YOUNG SCHOLARS (BYS) programme was started in 2012 with the aim of creating an international network of early-career researchers and stimulating emergence of new research paths and new ways of interdisciplinary collaboration on global sustainability topics. Conducting collaborative, integrative and interdisciplinary research is a time-consuming endeavour that is not always well recognised in the academic incentives system. One important aim of the BYS programme is to facilitate and provide space for such research.

BYS3, virtual workshop 2020

For the third cohort of the Beijer Young Scholars (BYS3) Programme, 2020 is the second year. A second in-person workshop bringing together the whole group was planned for May, but unfortunately Covid-19 made this impossible, so the group had to think of another strategy to spend time together and continue developing joint projects. Although an online workshop posed big logistic challenges, given the wide time-zone differences (from the Philippines to California), the decision was made to hold a three-day online workshop in late May, but to narrow down the huge topic of ‘globalisation and the biosphere’ with which BYS3 started last year.

As the Covid-19 pandemic has dominated academic, policy and public debate this year, it was considered an attractive topic for the workshop, especially given its obvious relationship with various dimensions of globalisation (including international travel and supply chains) and sustainability issues (including wildlife commerce and transportation GHG emissions). Despite concern that this was quickly becoming an over-crowded topic for academic commentary and research, the group felt that the diverse expertise represented by BYS gave it a particularly strong and unique position to contribute to the conversation. From this enthusiastic starting point, an agenda was designed jointly during quarterly online meetings, which Elsa Ordway, Aleah Bowie and Jamila Haider played a great role

in planning and organising. It was also vital to have an experienced facilitator, Conchi Piñeiro from Altekio, who helped optimise online time and avoid some of the pitfalls of virtual meetings.

Workshop participants decided to develop a creative visualisation of alternative scenarios of how the Covid-19 pandemic might shape future patterns of social-ecological interaction, either alleviating or deepening the multiple environmental crises humanity faces today. Exploring multiple narratives and academic perspectives in different scenarios

“The outcomes will hopefully be useful to all, inside and outside academia, who are trying to predict the post-pandemic world”

can stimulate transdisciplinary debate on a topic that defies any simplistic attempt at forecasting. For BYS3, it will be a way to guide the internal dialogue and learn from each other.

The outcomes will hopefully be useful to all, inside and outside academia, who are trying to predict the post-pandemic world and devise ways to seize the moment to foster change towards sustainability.

BYS2 – Inequality and the Sustainable Development Goals

For the second cohort (2016–2018) of Beijer Young Scholars (BYS2), the past year was characterised by continued work on inequality and the biosphere. Reducing inequalities is one of the defining challenges of our time, and has the potential to influence many other dimensions of sustainable development (see Selected Publications in last year’s Annual Report). However, the interactions between inequality and biosphere-based Sustainable Development Goals (SDGs) are poorly understood.

Concretely, the BYS2 group developed and submitted a major research proposal to the targeted call ‘Realising the global

Sustainable Development Goals 2019’ of the Swedish government research council for sustainable development (Formas). This work was supported by a pre-proposal grant secured in 2018.

To identify and expand relevant research questions about potential synergies and trade-offs between reducing inequalities and biosphere-related SDGs, several sub-groups worked on different pre-studies focusing on different scales (national, subnational, individual). The group also held a stakeholder dialogue on methodological approaches and rele-

vant case studies with participants from academia and NGOs at the XVII biennial International Association for the Study of the Commons (IASC) conference in Lima, Peru, in July 2019.

In December 2019, ten BYS2 members met for a productive proposal writing workshop in Stockholm. This laid the foundations for the major proposal, which continues to focus on identifying synergies and trade-offs between reducing inequalities (SDG 10) and safeguarding the biosphere (SDGs 14 and 15).

Two of the four pre-studies were developed into scientific papers. One (under submission) explores the relationships between prosperity, equality and the environment through an international comparison of representative indicators. The study shows that many developing countries have to bear disproportionate burdens in achieving sustainability, due to continued structural inequities in the global economy.

The other paper examines aquaculture’s contribution to macro- and micro-nutrient availability in Indonesia. It highlights the importance of seafood for human nutrition and the lack of correlation between food security, nutritional

quality, equal access to food and health, and environmental impacts.

A third pre-study focusing on inequalities in market power in palm oil production developed a modelling framework and created a dataset to test and fit the model. And the fourth pre-study developed a behavioural economics experiment which was piloted with 120 students from the University of Exeter (UK), to test implications of inequalities and social thresholds on cooperation and individual decision-making in natural resource management contexts.

BYS2 members during proposal writing workshop in Sweden December 2019. From left: Tracie Curry, Caroline Schill, Tom Chaigneau, Andrew Tilman and Yolanda Lopez. Photo: Emilie Lindkvist



Stakeholder dialogue in Lima, Peru 2019, arranged by the BYS2 group. Photo: Yolanda Lopez.

Training for transformational leadership

TWO EARLY-CAREER Beijer researchers are currently members of The Postdoc Academy for Transformational Leadership, which is designed to train the next generation of leaders in sustainability and transformation research. It provides intensive high-end training, with four seminars in two years that broaden research competencies and promote qualifications in transdisciplinary leadership.

Caroline Schill is part of the programme's first cohort (2018-2020), with the focus topic 'Food Systems', and Malin Jonell is part of the second cohort (2019-2021), with the focus topic 'Scaling Sustainability'. During the report period, Caroline attended the seminar 'Transformative capacity and agency for people and planet' at SRC, while Malin attended the seminars 'Transformations in human-environment research: Mode and logics' at Humboldt University and 'Transdisciplinary research environments and transdisciplinary learning' at Leuphana University.

Due to the Covid-19 pandemic, the first cohort's fourth and final seminar at DRIFT, planned for March 2020, was cancelled

at the last minute. However, within 48 hours the group organised an online workshop at which it developed a Comment on leadership in sustainability science, based on members' collective experiences and reflections on the programme, and, more broadly, within academia. In a blog post and longer report, the group shares its experiences on how to create online workshops that are productive and also engaging, caring and entertaining.

Both Malin and Caroline are very pleased with the programme and see great potential for future collaborations. "Through this programme, we have the chance to connect with researchers in our generational cohort, share and develop ideas, and identify future challenges and opportunities for our field".

Blog post:
Outbreaks, break-outs and break-times: Creating caring online workshops. The Care Operative. *Integration and Implementation Insights: Research resources for understanding and acting on complex real-world problems* blog (i2insights.org), 16 June 2020.

Longer report:
The Care Operative. 2020. *Collaborating with care in virtual sessions*. Open Science Foundation. Online: <https://osf.io/c6mk8/>

Members of the second cohort in Berlin, Germany, September 2019.



Nobel Prize Summit 2021

The first ever Nobel Prize Summit *Our Planet, Our Future*, which was originally planned for April-May 2020, has been postponed to spring 2021 because of the Covid-19 pandemic. The event is being hosted by the Nobel Foundation and organised by the National Academy of Sciences (NAS) in partnership with the Potsdam Institute for Climate Impact Research (PIK), and Stockholm Resilience Centre and the Beijer Institute. The Summit will provide a world stage to discuss pathways to help ensure our common future on a stable, resilient planet.

The Nobel Prize Summit will be held at the US National Academy of Sciences in Washington D.C., and will bring together

er around 20 Nobel Laureates, plus leading scientists, policy-makers, business leaders and today's youth leaders, to explore the question: What can be achieved in this decade to put the world on the path to a more sustainable and more prosperous future for all humanity?

In October 2019, a Nobel Prize Summit preparatory workshop was organised by NAS and PIK in Potsdam, Germany. In December 2019, Beijer director Carl Folke gave a Nobel Prize Summit lecture for the Nobel Foundation. A White Paper 'Our future in the Anthropocene Biosphere' serving as a basis for discussions at the meeting, has been published in the Beijer Discussion Papers Series (read more page 26).

Planetary Boundaries framework 10 years on

In 2009, former Stockholm Resilience Centre director and Beijer Fellow Johan Rockström led a group of 28 internationally renowned scientists, including Beijer director Carl Folke, in efforts to identify the nine processes that regulate the stability and resilience of the Earth system. The scientists proposed quantitative planetary boundaries within which humanity can continue to develop and thrive for generations to come. Crossing these boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes. Since then, the planetary boundaries framework has generated enormous interest within science, policy and practice.

In a full-day seminar at the Royal Swedish Academy of Sciences on 1 October 2019, organised by Stockholm Resilience Centre and the Beijer Institute, Johan Rockström and co-author Will Steffen shared their reflections on the development of the planetary boundaries framework with colleagues from the research community and beyond. The day, which included music and poetry reading, was filmed and is available at stockholmresilience.org.



Line Gordon, director of Stockholm Resilience Centre, with her predecessor Johan Rockström, now director of Potsdam Institute for Climate Impact Research (PIK). Photo: Stockholm Resilience Centre.



Volvo Environment Prize laureate, Terry Chapin (second from the right) performed with folk music group and his wife Mimi (second from the left).

Earth stewardship – a foundation for sustainability

In a public seminar in Stockholm on 6 November 2019, Beijer Institute and Stockholm Resilience Centre researchers, together with the 2019 Volvo Environment Prize winner, Stuart "Terry" Chapin III, explored the concept 'Earth Stewardship', through different perspectives, as a prerequisite for meeting the major environmental and social challenges of our time.

'Earth Stewardship' is a set of guiding principles on ecology and ethics aimed at preserving biodiversity and the planetary life support system by acting responsibly. Beijer Fellow Terry Chapin is a world-leading ecologist and one of the world's most profound thinkers and actors on stewardship of the Earth System.

Speakers:
Professor Terry Chapin (University of Alaska), Professor Carl Folke (Beijer Institute), Dr. Per Olsson and Dr. Maria Tengö (Stockholm Resilience Centre).

Panel:
Jamila Haider (Stockholm Resilience Centre), Patrik Henriksson and Caroline Schill (Beijer Institute). Moderator: Therese Lindahl (Beijer Institute). Co-organised with Stockholm Resilience Centre (SRC) and the Volvo Environment Prize. Music by HärMedJämt.

Science, business, finance and the biosphere

Engagement by business and finance in sustainability, the circular economy and the biosphere is growing, and there have been interactions with e.g. banks, investors, and other financial actors in Sweden and internationally. This interest is reflected, for example, in the participants in the Executive Programme in Resilience Thinking (for a list of participants, see page 39), for which the Beijer director Carl Folke is scientific director. It is also reflected in establishment of the Ecosperity Advisory Group by the investor Temasek, Singapore, for which Carl Folke is senior advisor, and in an invitation to speak at a Via Summa Day of portfolio investors for the sustainability investor Summa Equity in Stockholm in September. There is close collaboration with the Academy's GEDB programme on finance and the biosphere.

Swedish Environmental Protection Agency

Deputy director Anne-Sophie Crépin is a board member of the Environmental Research Council of the Swedish Environmental Protection Agency (Naturvårdsverkets miljöforskningsråd), since 2018. As such she provides advice to the Agency regarding relevant topics, design of research calls and evaluation processes relating to selection of appropriate applied projects that require substantial stakeholder involvement and with outputs directly useful to the Agency's policy work.

Monaco Blue Initiative

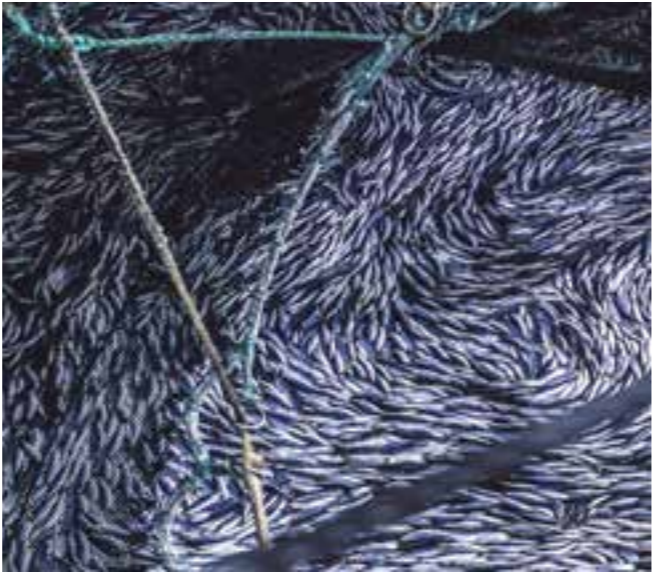
The Monaco Blue Initiative is a platform for discussion co-organised by the Monaco Oceanographic Institute and the Prince Albert II of Monaco Foundation, launched in 2010 on the initiative of HSH Prince Albert II of Monaco. The event provides a valuable framework for fostering discussions between business, scientific representatives and policy makers, and for analysing and highlighting possible synergies between protection of the marine environment and socio-economic development. Carl Folke was invited to the Monaco Blue Initiative – 11th Edition, where he was part of the panel of the online workshop “How can the Blue Economy and sustainable management of the ocean in the fields of tourism, transport, energy, fishing and aquaculture be combined?”, held in June 2020. He is also a member of the Monaco Ocean Science Federation, a platform of ocean sciences on European scale, which aims to bring the challenges of knowledge and sustainable management of the oceans to the attention of decision makers and the public.

High impact for research on sustainable food and health

The search engine Altmetric tracks a unique range of online sources to capture conversations relating to research outputs, including media, blogs and social media (e.g. Twitter, Facebook). Altmetric tracks about 10 million research outputs annually from all research fields and produces a collection of the Top 100 research papers in terms of media impact. The EAT-Lancet publication *Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems* (highlighted in last year's Annual Report), was impressively listed as number 18 in the world in 2019. By the end of 2019, the publication was covered in 510 news stories in more than 350 different outlets and had an online score of close to 4700.

Green tax shifting for improved land use in Sweden

Anne-Sophie Crépin contributed to compilation of articles proposing potential areas for green tax shifting. Her contribution builds on the joint use of the Sustainable Development Goals (SDGs), the planetary boundaries framework and the Swedish environmental goals as a foundation to identify priority areas for green taxes of particular relevance for Sweden. She identifies land use and CO₂ emissions as areas that seem particularly fit for green tax shifting, because they are relatively easy to tax, can be potentially cost-efficient and have good potential to improve the environment and generate synergies. She also discusses more specifically how a land-use tax could be designed to this end. For more information in Swedish, see <https://fores.se/gron-skattevaxling-publikation/>.



Art collaborations

The fruitful collaboration with Swedish design firm Svenskt Tenn continues. Through the Kjell and Märta Beijer Foundation, Svenskt Tenn's profits support research at the Beijer Institute and in October 2019, the Beijer Institute hosted the 95th anniversary of Svenskt Tenn, with presentations at Stockholm University and dinner at the Academy's Club Villa.

Exhibition: Welcome to the Biosphere

An exciting project during the year was the art exhibition ‘Welcome to the Biosphere’. In an accessible, provocative and amusing fashion, artists Lars Arrhenius and Eric Ericson interpreted Beijer Institute research and perspectives on the Anthropocene challenge and the role of humans as the major driver of biosphere dynamics.

The exhibition opened at Svenskt Tenn on 22 August 2019 and closed in late October 2019. Institute researchers presented their research and discussed it with the artists. They were also involved in the inauguration and in dialogue with invited guests, and held presentations at Svenskt Tenn employees during the exhibition period.

Sadly, the artist Lars Arrhenius passed away in April 2020, at the age of 53. Educated at the Royal Institute of Art, Sweden, and the Rijksakademie, the Netherlands, Lars was an internationally renowned artist, represented for example at the National and Modern Museums in Stockholm, Stedelijk Museum in Amsterdam and the Victoria & Albert museum in London. He was deeply engaged in the climate issue, which was reflected in many of his art works, and was one of the founders of ‘Artists for Future’, regularly striking on Fridays with the youth movement ‘Fridays for Future’.

Design students interpret research on Tipping Points

For the fourth consecutive year, design students from Beckmans School of Design in Stockholm visualised research carried out by the Beijer Institute. This year the theme was ‘Tipping Points’ and the students received lectures and tutoring by the researchers, from diverse viewpoints of this complex issue throughout their five-week course in visual communication. An exhibition in the Stockholm store was due to open in March 2020, but has been postponed until September 2020 due to the Covid-19 pandemic.



The late artist Lars Arrhenius with fellow artist Eric Ericson together with Beijer director Carl Folke, Svenskt Tenn curator Karin Södergren and CEO of Svenskt Tenn, Maria Veerasamy.



Central banks and climate change

The Beijer Institute co-organised the first official speech by the Central Bank of Sweden’s new deputy general, Anna Breman, on 3 March in Stockholm. In her speech, Anna Breman emphasised that the bank must fully incorporate the risk of irreversible regime shifts in the climate system and act accordingly. “The Central Bank, together with other institutions, has to apply policies that aim at avoiding such regime shifts. If we pass critical tipping points, we have to be humble and recognise that the Bank has limited means of action”, she said. She also presented key measures that the Central Bank could use to mitigate the effects of climate change, but also how it can act to prevent it escalating. Putting a price on CO₂ needs to be a priority for society, she claimed, pointing to a study showing that a high tax on CO₂ emissions is a cheap measure, while the losses for society are higher with a low carbon tax. Co-organisers were the Royal Swedish Academy of Sciences, Stockholm Environment Institute, Stockholm Resilience Centre and Stockholm School of Business.



Beijer Institute programme director Victor Galaz and Anna Breman, deputy general of the Central Bank of Sweden. Photo: Agneta Sundin

Swedish-US initiative on AI and sustainability

Representatives from U.S. and Swedish academia, the Swedish government, Google, Ericsson, USAID and two UN agencies (UNDP and UN Global Pulse) met on 15 October 2019 at the Swedish Ambassador’s Residence in New York to explore how application of artificial intelligence (AI) can help achieve targets related to the UN Sustainable Development Goals. The event marked the beginning of a new initiative, *AI, People and the Planet*, coordinated by the Beijer Institute, Princeton University

(Princeton Institute for International and Regional Studies) and Stockholm Resilience Centre.

Project members see a need for serious discussion across academia, civil society, policy and business about how AI can help expand our planetary support systems (climate stability, biodiversity and living oceans), to prevent AI technologies instead leading to accelerated climate and ecological disruption.

Read more: aipeopleplanet.earth



Changing eating habits

In Sweden, food generates 15% of consumption-based greenhouse gas emissions. With 51% of the population currently overweight, many common diseases and causes of death are food-related. Two Swedish reports published in spring 2020 review methods for steering food consumption in a more sustainable direction. Both advocate a change in focus from consumers to instruments that target the retail and food industry, and also increased action from the government.

Recommendations to speed up the transition

The first report identifies what public actors in Sweden can do right away to promote positive development. The authors, including Beijer Institute researchers Malin Jonell and Therese Lindahl, provide three recommendations for public actors in order to increase the pace of the transition to a more sustainable food system: 1) Intensify public sector work; 2) develop national goals for sustainable food consumption; and 3) develop and introduce effective and attractive policy packages, since individual instruments usually have a relatively weak effect. Packages of instruments together can balance conflicts of aims and reduce the conflict between effectiveness and acceptance.

All three recommendations are based on a review of 17 policy instruments that operate through either knowledge and support, changed relative prices or regulation. The report was a collaboration between Mistra Sustainable Consumption, SLU Future Food, the Beijer Institute, Chalmers and CeCAR/Gothenburg University.

Balancing hard and soft measures to reduce meat consumption

The second report, commissioned by the Swedish Consumer Agency and written by Therese Lindahl and Malin Jonell, focuses on methods for reducing consumption of animal-based foods, especially red meat, given its negative environmental impact and potentially negative health effects.

Among the measures identified as most effective, but also more challenging to implement, are economic instruments such as a carbon tax on food and choice restrictions in the retail and restaurant sectors. The drawback is that the risk of public resistance is relatively high and restaurants and stores risk losing market share and customers.



The SeaBOS initiative moving forward

“SeaBOS serves as the model, and ocean stewardship is the way forward”. Such statements are becoming increasingly common by many striving for sustainable oceans. The Seafood Business for Ocean Stewardship, or SeaBOS, is a global science-business initiative created by Stockholm Resilience Centre in collaboration with the Beijer Institute and the GEDB programme of the Royal Swedish Academy of Sciences.

SeaBOS is the result of a science-based identification of ‘key-stone actors’ in global seafood, published in 2015. Keystone actors represent a central phenomenon of the Anthropocene – a handful of corporations that connect the global economy across the planet and influence the dynamics of the biosphere. The initiative engages, at CEO level, ten of the world’s largest commercial seafood corporations, including wild catch, aquaculture and feed production, with companies based in Europe, North America and Asia.

The aim of the SeaBOS initiative is to stimulate industry leadership for ocean stewardship in accordance with best available science. The initiative uses a transdisciplinary approach of adaptive, learning-based collaboration on responsibility and ethics, aiming to safeguard the resilience and productivity of ocean ecosystems for human well-being. It offers a potential short-cut wherein leadership by keystone actors could result in cascading effects throughout the entire seafood industry and enable transformations towards stewardship for healthy oceans.

“The aim of the SeaBOS initiative is to stimulate industry leadership for ocean stewardship in accordance with the best available science.”

As so many other meetings this spring, the SeaBos working meeting in May 2020 was held online. Photo: Carl Folke.



The SeaBOS initiative was set in motion in 2016 as a result of the first keystone dialogue. Since then, some 270 meetings have been held, including seven as CEO Keystone Dialogues and Working Meetings in which high representatives from all companies participate.

Progress includes a shift in focus among the corporations from seeing themselves as producers of seafood to producing seafood in a sustainable manner, and on to becoming active stewards of healthy oceans as a prerequisite for producing sustainable seafood.

There have been two major meetings during the period. The first, the Phuket Dialogue in Thailand in September 2019, was the 4th Keystone Dialogue, hosted by Thai Union and CP Foods. The second, a Working Meeting originally planned for Stockholm, was held online in May 2020 due to the pandemic. This worked well, and allowed more staff from the different corporations to participate. Now, the task forces are proposing commitments, concrete actions and schedules for moving forward, proposals which will be on the table for executive decisions at the 5th Keystone Dialogue, in October 2020.

SeaBOS partnerships with other organisations and networks have been established. Furthermore, the science-business initiative involves many other organisations and networks. These include the World Benchmarking Alliance, the High-Level Panel for a Sustainable Ocean Economy, the UN Global Compact on Sustainable Ocean Business Action Platform, and the Friends of Ocean Action.

HRH Crown Princess Victoria of Sweden has been engaged with SeaBOS from the very start of the initiative and took part in the working meeting in May. The contributions to the dialogues by the Crown Princess, a global advocate for the Sustainable Development Goals (SDGs), are of great significance for the success of the SeaBOS initiative. Beijer Fellow Professor Jane Lubchenco, who co-leads the expert group of the Ocean Panel, an initiative of 14 serving presidents and prime-ministers building momentum toward a sustainable ocean economy, is also strongly engaged in SeaBOS.

For more information see: keystonedialogues.earth

Collaborations

The Global Economic Dynamics and the Biosphere (GEDB) Academy Programme

With renewed funding from 2019, GEDB continued its successful work, focusing on two broad areas of research. The first, *Biosphere Finance*, studies finance and capital markets linked to the latest research on planet Earth as a system. With this combination, there are new opportunities for progressive social development in conjunction with the dynamics of the biosphere. This is uncharted research terrain with enormous development potential. A remarkable outcome is escalating interest and engagement by companies and financial actors, with many interactions with e.g. banks, pension funds, investors and other financial actors in Sweden and internationally during the year.

The second broad area of research is on *Global Health and Biosphere Stewardship*. Collaborations have been initiated with several research groups, including medical professionals, psychologists, behavioural economists and food actors, to tackle everything from antibiotic resistance to human health, habitats and food production. This research is linked to the ambition to support innovation and asset management of landscapes, seas and the biosphere as a whole. Work has focused on a Blue Food Assessment and risks and resilience of the global food production system, as well as antimicrobial resilience building, and health, evolution and biosphere stewardship.

As envisioned, GEDB has become a significant channel for research, synthesis and synergies between the Beijer Institute and Stockholm Resilience Centre. A number of events, workshops and activities have been organised, networks of collaborations have been developed and strengthened, and new forms of collaboration between science, practice and business have been initiated.

GEDB is funded by the Erling-Persson Family Foundation. Read more about GEDB at www.gedb.se

Stockholm Resilience Centre

The close collaboration with Stockholm Resilience Centre (SRC) continues to be very productive, with multiple synergies and benefits through joint projects, grants, workshops and publications. SRC researchers are engaged in the Beijer’s research programmes on Urban social-ecological systems, Sustainable seafood, BEN, and Complexity, technology and governance. Beijer researchers are leaders and participants in the themes and streams of SRC, and collaborate and participate in seminars, teaching, supervision etc. The communication, outreach and policy engagements of the Beijer Institute are substantially enhanced through the interplay with SRC.

Stanford collaboration

Work on two significant grants (*Advancing Fundamental Knowledge of Natural Capital, Resilience and Biosphere Stewardship* and

Fundamental Research in Biosphere-based Sustainability Science) from the Marianne and Marcus Wallenberg Foundation is progressing well, strengthening and extending the collaboration between the Beijer Institute, SRC and Stanford University. The grants provide a research platform for the development of new theory, analysis and synthesis on stewardship of natural capital and the biosphere, for social-ecological resilience, human wellbeing and sustainability. They draw on the long legacy of Beijer collaborations with Stanford researchers and also on new collaborations with the Beijer/GEDB/SRC cluster. Carl Folke and Gretchen Daily serve as project leaders.

Executive programme in resilience thinking

The second executive programme of SRC was held in autumn 2019 and spring 2020. Carefully selected CEOs and board members of influential companies within various business sectors in Sweden met scientists and leading thinkers to deepen their understanding of the latest research and accelerate the transformation towards sustainability. The course continues to be a great success, clearly reflecting

Participants of the SRC’s Executive programme in resilience thinking 2019-2020. From left to right: Mats Rahmström, CEO Atlas Copco, Sofia Svingby, VP Sustainability Atlas Copco, Magnus Billing, CEO Alecta, Henrik Furhoff, CEO Ipco, Sara Öhrvall, Chief Digital. Customer Experience and Communications Officer, SEB, Lotta Lyrå, CEO Clas Ohlson, Freddy Sobin, CEO Kicks, Magdalena Gerger, CEO Systembolaget, Malin Sandquist, Director Corporate, Public and Legal Affairs, Systembolaget, Siv Malmgren, CEO John Mattsson Fastigheter, Staffan Pehrson, CEO Nefab, Jerker Johansson, Executive Chairman Blue Water Energy, Klas Balkow, CEO Axfood, Marcus Wallenberg, Chair FAM, SAAB, SEB, Patricia industries, Jonas Samuelsson, CEO Electrolux



the major ongoing shift in perspective on environmental issues within business. In all, around 30 high-level participants have attended the course. Corporations represented include Atlas Copco, Alecta, Electrolux, Handelsbanken, Investor, Scania, SEB, Stora Enso, Swedbank and Vattenfall. Conversations covered how business can play a pivotal role in sustainability transformations, informed by science and driven by purpose. The deeper meaning and challenge of ‘corporate biosphere stewardship’ in turbulent times is increasingly appreciated. Carl Folke is the science director for the programme and the Beijer Institute played an essential role in the course. For more information, see www.executive.stockholmresilience.org/
www.stockholmresilience.org

Environment and Development Economics

The journal *Environment and Development Economics (EDE)* was founded by, and is published in association with, the Beijer Institute. *EDE* is positioned at the intersection of environmental, resource and development economics and encourages submissions from researchers in both developed and developing countries. The journal is divided into two main sections, *Theory and Applications*, which includes regular academic papers, and *Policy Options*, which includes papers that may be of interest to the wider policy community. The editors are Carlos Chavez, Susana Ferreira, E. Somanathan and Beijer Fellow Jeff Vincent. The journal encourages and gives maximum support to papers on high-quality theoretical and empirical research in environmental and development economics, paying special attention to contributions from developing areas without compromising the quality of the papers published, and planning and publishing special issues that focus on specific areas of policy interest.

HiG Urban Studio, University of Gävle

The Urban social-ecological systems programme at the Beijer Institute collaborates with *HiG Urban Studio* at the University of Gävle. Johan Colding is currently employed part-time as research coordinator at *HiG Urban Studio*, which conducts research that supports urban development confined within the Earth’s carrying capacity, while maintaining a focus on human well-being. A key mission of *HiG Urban Studio* is to promote collaboration with other prominent research settings in Sweden working on sustainable urban development. These include the *SMOG* group at Chalmers Technical University, Sweden, which is an international leader in research related to architecture and urban morphology, and the environmental psychology groups at Aalto University, Finland, and Uppsala University, Sweden.

The Resilience Alliance

A central network for collaboration is the Resilience Alliance (RA), an international consortium of leading research groups and organisations collaborating to explore the dynamics of social-ecological systems and identify novel ways to integrate science and policy in order to lay the foundations for sustainability. RA and the focus on social-ecological systems emerged from research programmes at the Beijer Institute in the 1990s, and the Institute is an active member.

www.resalliance.org

RISE — Research Institute of Sweden

RISE (the Research Institute of Sweden) is an innovation partner in international collaborations with industry, academia and the public sector. RISE ensures the

competitiveness of the business community and contributes to a sustainable society. It is an independent, state-owned body that advances research in a broad spectrum of areas. In a long-term FORMAS project, the Beijer Institute has established a formal collaboration with the seafood group at RISE, which is an internationally highly recognised research group in the field. Main collaborators include Max Troell, Therese Lindahl, Patrik Henriksson and Malin Jonell, representing Beijer and SRC. The collective expertise also involves international collaborators, adding insights on the role and challenges related to the future of global seafood.

www.ri.se

SARAS — The South American Institute for Resilience and Sustainability Studies

The Beijer Institute has been engaged since 2007 in the South American Institute for Resilience and Sustainability Studies (SARAS). SARAS is an interdisciplinary research institute based in Maldonado, Uruguay, and is intended to catalyse high-impact science that serves to enhance South America’s long-term resilience and sustainable development. SARAS is working towards becoming a regional centre, cooperating closely with the scientific community and relevant funding agencies in several South American countries and with an established set of international key scientists. Beijer Fellows Marten Scheffer, Steve Carpenter, Frances Westley and Beijer director Carl Folke have been deeply engaged in setting up SARAS over the years. A major special feature, ‘Seeking sustainable pathways for land use in Latin America’, was published in *Ecology and Society* during the year, with former Beijer Institute researcher Juan Carlos Rocha (now at Stockholm Resilience Centre) playing a key role in this work.

www.saras-institute.org



WorldFish teamed up with the West Are’are Rokotanikeni Women’s Association in a project to strengthen capacities and enhance livelihoods in the Solomon Islands. Here, members receive solar panels to power freezers to store fish and other perishable foods, in their small-scale food businesses.

Photo: Hampus Eriksson, WorldFish

WorldFish

WorldFish is an integral part of the Consultative Group on International Agricultural Research (CGIAR). It is an international, non-profit, scientific research centre created to conduct, stimulate and accelerate research on fisheries, aquaculture and other living aquatic resources for the sustainable benefit of present and future generations of low-income users in developing countries. WorldFish was early to pick up on contemporary resilience research, upon which it builds its research

and actions in poor and vulnerable communities. During the past 10 years, the mode of cooperation between Beijer and WorldFish has changed from mainly informal partnerships to collaborative research projects. One project investigating equitable development of aquaculture in East Africa is led by Max Troell. Formal support from WorldFish also includes supporting activities within the Beijer Institute programme on sustainable seafood, as well as co-funding a post-doc (Patrik Henriksson) for several years.

www.worldfishcenter.org

Generative Collisions: Reflections of a Beijer Fellow

EACH TIME I ARRIVE at the Beijer Institute, I feel that I have been transported to Mount Olympus. The world's best ecologists, economists, and environmental thinkers are gathered together to consider critical challenges to civilization. At first, the gathered greatness seems a bit intimidating. Yet the Gods are friendly. They enjoy walks and meals together, chatting about science and families, catching up with old friends, occasionally stopping to watch a bird or marvel at the life cycle of wild mushrooms. Once we are in the meeting, the debate can be intense as we try to resolve differences among expert opinions and to reach consensus on solutions to very hard problems. The Gods are respectful; ideas may be criticized but the speaker is not. And the Gods know how to party; the dinner on Askö Island will be accompanied by music, humor, and laughter. The process of these remarkable meetings is organized by the brilliant staff of the Beijer Institute.

After each meeting, one or two of us must distill a paper from the notes. Drafts written in advance are thrown away, for the outcome of an Askö meeting is not predictable or controllable. The only thing knowable in advance is that it will be interesting and innovative. The collision of economic and biophysical sciences on a pressing environmental problem never fails to generate surprising insights. This is fortunate, for there seems to be no end to the flow of new environmental problems. And so, over the decades, novel synthetic papers emerge from these meetings. Perhaps the most important product is the evolving community of interdisciplinary friends.

The problems are becoming more severe, not because solutions are unknown but because known solutions are not employed. In the next generation, land area for humanity will shrink as sea level rises and the tropics and semi-tropics become unbearably hot. The impact of agricultural production on water quality will cause more illness and starvation. Arable land will shrink as deserts and flooded lands expand. Natural ecosystems that purify air, water, and soil and provide the diversity that drives evolution will shrink and disappear.



Though this existential crisis is only a generation away, there is time to deploy known solutions: decarbonize energy, reduce impacts of agriculture by shifting to more plant-based diets, stop overpopulation, and conserve natural ecosystems. These biophysical solutions are known, although details must be worked out for particular places and resources. But much work remains on the economic, political, and social features of solutions. The research priorities were stated by the Millennium Ecosystem Assessment in 2005: quantify feedbacks among social and ecological systems, and determine the effectiveness of governance systems and influence of institutions on social distribution of ecosystem services. Yet progress is slow. The pathway to institutional solutions has been illuminated by the past work of the Beijer Institute, and surely the need for the Beijer style of thinking will grow as we enter an uncertain future.

Steve Carpenter, February 2020

Appendix

Scientific advisory board

Board members of the Beijer Institute of Ecological Economics are appointed by the Royal Swedish Academy of Sciences for a three-year period, and may not be re-elected more than once according to the standing instructions for the Beijer Institute approved by the Royal Swedish Academy of Sciences on 5 June 1991. The first Board of Directors for the current Beijer Institute was elected on 5 June 1991. The 29th annual board meeting was held at the National Museum, Stockholm, on 13 September 2020 due to the renovation of the Academy. This meeting was the first for Professor Elke Weber, Princeton University, USA, who was welcomed as a new member of the board. Professor J. Marty Anderies reached the end of his term. The Beijer Institute wishes to express its warmest gratitude for his great for the Institute as member of the Board.

Chair

Neil Adger
Professor, University of Exeter, UK

Ex-officio members

Anne-Sophie Crépin
Associate Professor, Deputy Director of the Beijer Institute

Carl Folke*
Professor, Director of the Beijer Institute

Göran K. Hansson*
Professor, Permanent Secretary of the Royal Swedish Academy of Sciences

Members

J. Marty Anderies
Professor, Arizona State University, USA

Elena Bennett
Professor, McGill University, Canada

Reinette (Oonsie) Biggs
Professor, Stellenbosch University, South Africa

Juan Camilo Cárdenas
Professor, Universidad de los Andes, Colombia

Joern Fischer
Professor, Leuphana University, Germany

Kathleen Segerson
Professor, University of Connecticut, USA

Jason Shogren*
Professor, University of Wyoming, USA

Jeroen van den Bergh
Professor, Universitat Autònoma de Barcelona, Spain

Elke Weber
Professor, Princeton University, USA

James Wilen
Professor Emeritus, University of California, Davis, USA

*Member of the Royal Swedish Academy of Sciences

Staff members

Carl Folke
Professor, Director

Anne-Sophie Crépin
Associate Professor, Deputy Director

Amar Causevic
MA, Research assistant

Johan Colding
Associate Professor, Programme Director

Gustav Engström
PhD, Researcher

Johan Gars
PhD, Researcher

Åsa Gren
PhD, Researcher

Malin Jonell
PhD, Researcher

Chandra Kiran Krishnamurthy
PhD, Researcher

Sofia-Kristin Kokinelis
MSc, Finance and HR Administrator

Sofia Käll
PhD candidate

Christina Leijonhufvud
BA, Administrator

Therese Lindahl
PhD, Programme Director

Daniel Ospina
PhD candidate

Caroline Schill
PhD, Researcher

Agneta Sundin
Communications Officer

Max Troell
Associate Professor, Programme Director

Affiliated researchers

J. Marty Anderies
Professor, Programme Director
(Arizona State University, USA)

Victor Galaz
Associate Professor, Programme Director
(Stockholm Resilience Centre, Stockholm University)

Patrik Henriksson
PhD, Researcher
(Stockholm Resilience Centre, Stockholm University
and WorldFish, Malaysia)

Chuan-Zhong Li
Professor, Researcher
(Uppsala University, Sweden)

Staff news

Malin Jonell

We welcome Malin as a new member of staff. Malin is a systems ecologist by training and a sustainability governance scholar. Her main research interest is sustainable food production, and in particular the role of markets, trade and the private sector in driving positive change in the growing seafood sector. As a member of the SEAWIN project, part of the *Aquaculture and sustainable seafood programme*, she is focusing on the role of the retail sector, consumers and other market actors in driving demand for sustainable seafood. Moreover, she is interested in investigating the environmental effects of implementation of aquaculture eco-certification schemes.

Scientific Advisory Board meeting September 2019.
Photo: Agneta Sundin



Before joining the Beijer Institute, Malin worked at Stockholm Resilience Centre, as a postdoctoral fellow on the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems. Her work focused on food sustainability metrics and in particular the role of ‘blue foods’ (fish, shellfish and algae) in the global food system.

Jean-Baptiste Jouffray

Jean-Baptiste successfully defended his PhD thesis *The Anthropocene Ocean – Risks and Opportunities for Global Sustainability* in Sustainability Science at Stockholm Resilience Centre, Stockholm University, on 17 January 2020. He was a joint PhD candidate at the Beijer Institute, the Global Economic Dynamics and Biosphere programme at the Royal Swedish Academy of Sciences, and Stockholm Resilience Centre.

Jean-Baptiste’s interest lied in exploring the interlinked social, economic and ecological challenges that shape the new global ocean context. Much of his work consisted in a curiosity-driven endeavour aimed at describing and analysing what the Anthropocene means for the ocean, what it entails for how we study marine social-ecological systems and, essentially, what can be done to improve sustainability. His thesis involved inter- and transdisciplinary approaches, ranging from the Hawaiian archipelago and indicators for effective coral reef management, to the global seafood industry, the role of transnational corporations, and whether there could be entry points for sustainability considerations into mainstream financial mechanisms.

With the UN Decade of Ocean Science for Sustainable Development poised to begin in 2021, the thesis provides novel conceptual and mechanistic ways to link ecosystems to their distal socio-economic drivers and offers a useful contribution to both academic and policy discussions on how to approach ocean sustainability in the 21st century.

Jean-Baptiste is currently a postdoctoral researcher at the Stockholm Resilience Centre, primarily involved in the Ocean Risk and Resilience Action Alliance and the Seafood Business for Ocean Stewardship initiative. His original plan to join the Centre for Ocean Solutions at Stanford University had to be put on hold due to the coronavirus crisis.



Beijer Fellow prizes, honours and awards

Stuart “Terry” Chapin III

Terry was awarded the Volvo Environment Prize 2019 for work that will have a long-lasting impact on the ways we seek to build a sustainable future, with the concept of *Earth Stewardship* supporting the deep institutional and structural change required to meet the challenges ahead.

Gretchen C. Daily

Gretchen was awarded the Tyler Prize 2020, together with Pavan Sukhdev, for pioneering work on valuation of natural capital – in rigorous scientific and economic terms – recognising nature’s vital role in supporting human wellbeing.

Terry Hughes

Terry was recognised, together with Carlos Duarte and Daniel Pauly, with the Frontiers of Knowledge Award in the category Ecology and Conservation Biology. “*Their research has expanded our knowledge about the Earth’s oceans and has contributed to the protection and conservation of marine biodiversity and ocean ecosystem services.*”

Eric Lambin

Eric received the Blue Planet Prize 2019, together with Jared Diamond, for outstanding achievements in scientific research and its application, and in so doing helping to solve global environmental problems.

Eric Lambin receiving the Blue Planet Prize 2019.

Jane Lubchenco

Jane received the Mary Sears medal 2020 from the Oceanography Society for her exceptional leadership and original contributions to research on biodiversity and rocky seashore ecology, and solutions to restore ocean health and sustainable fisheries.

Johan Rockström

Johan received the Prince Albert II of Monaco Foundation Climate Change Award 2020 for remarkable commitment to limiting the effects of climate change.

Brian Walker

Brian was made an Officer in the prestigious Order of Australia in 2020, for “*distinguished service to science, particularly to eco-system ecology and research, and to professional scientific bodies.*”



Visiting researchers

Yana Jin College of William and Mary, Virginia, USA 26 March-15 August 2019
James Wilen University of California, Davis, USA 10-26 September 2019
Sander van der Leeuw Arizona State University, USA 6-12 October 2019
Aart de Zeeuw Tilburg University, the Netherlands 9-12 February 2020

Beijer Fellows

J. Marty Anderies Professor, Arizona State University, USA
Scott Barrett Professor, Columbia University, USA
Fikret Berkes Professor, University of Manitoba, Canada
William “Buz” Brock Professor Emeritus, University of Wisconsin, Madison, USA
Stephen R. Carpenter Professor Emeritus, University of Wisconsin, Madison, USA

Stuart “Terry” Chapin III Professor Emeritus, University of Alaska Fairbanks, USA
Kanchan Chopra Professor Emerita, University of Delhi, India
Gretchen C. Daily Professor, Stanford University, USA
Partha Dasgupta Professor Emeritus, University of Cambridge, UK
Paul R. Erlich Professor Emeritus, Stanford University, USA
Sander van der Leeuw Professor, Arizona State University, USA
Lance Gunderson Professor, Emory University, USA
Michael Hoel Professor, University of Oslo, Norway
Terry Hughes Professor, ARC Centre of Excellence for Coral Reef Studies, James Cook University, Australia
Eric Lambin Professor, Stanford University, USA and Université Catholique de Louvain, Belgium
Simon A. Levin Professor, Princeton University, USA
Jane Lubchenco Professor, Oregon State University, USA
Karine Nyborg Professor, University of Oslo, Norway
Rosamond. L. Naylor Professor, Stanford University, USA
Stephen Polasky Professor, University of Minnesota, USA
Johan Rockström Professor, Potsdam Institute for Climate Impact Research (PIK) and Potsdam University, Germany
Thomas Rosswall Professor Emeritus, Member of the Royal Swedish Academy of Sciences
Marten Scheffer Professor, Wageningen University & Research, the Netherlands
Jason Shogren Professor, University of Wyoming, USA
David A. Starrett Professor Emeritus, Stanford University, USA
Will Steffen Professor Emeritus, The Australian National University, Australia
Thomas Sterner Professor, University of Gothenburg, Sweden
M. Scott Taylor Professor, University of Calgary, Canada
Jeffrey Vincent Professor, Duke University, USA
Brian Walker PhD, Honorary Post-Retirement Fellow, CSIRO (national science research agency), Australia

Frances Westley Professor, University of Waterloo, Canada
James Wilen Professor Emeritus, University of California, Davis, USA
Anastasios Xepapadeas Professor, Athens University of Economics and Business, Greece
Aart de Zeeuw Professor Emeritus, Tilburg University, the Netherlands

Administration

Office location

The Beijer Institute is located in a wing of the early 20th century building of the Royal Swedish Academy of Sciences at Frescati, a science and university area about 2 km north of Stockholm City. The area is situated in one of Stockholm’s green belts, Ekoparken, which also includes some of the inlets of the Baltic Sea. Ekoparken has been declared a Royal National City Park by the Swedish parliament. The Institute’s visiting address is Lilla Frescativägen 4A, Stockholm.

Organisation

The Institute’s administration is partly carried out by, or coordinated with, the Royal Swedish Academy of Sciences, for example accounting and maintenance of premises and computers. Other administrative procedures are performed independently by the Beijer Institute.



Funding

Core funding for the Beijer Institute is provided by the Kjell and Märta Beijer Foundation, founded in 1974 through a donation from Kjell and Märta Beijer. The Foundation’s purpose is to support research and education, as well as supporting culture, especially design and interior decoration, and also music and literature. The Beijer Institute is its single largest beneficiary, but the Kjell and Märta Beijer Foundation also makes large donations to research in genetic science, neuroscience and pharmaceutical research at Uppsala University and to dairy cattle research at the Swedish University of Agricultural Sciences.

Kjell Beijer was a Swedish businessman who met his wife Märta when she was working in the furniture and design store Svenskt Tenn in Stock-

holm, which is renowned for classical designs and high quality. This store was later bought by the Kjell and Märta Beijer Foundation and the profits go to the Foundation.

Funding for the Beijer Institute’s research activities between 1 July 2019 and 30 June 2020 was also provided by:

- Formas (a Swedish government research council for sustainable development)
- Swedish Research Council (Vetenskapsrådet)
- The Crafoord Foundation
- The European Fisheries Inventory in the Central Arctic Ocean (EFICA)
- The Ragnar Söderbergs Foundation
- The Swedish International Development Cooperation Agency (Sida)
- Stiftelse till bröderna Jacob och Markus Wallenbergs minne (Foundation in memory of the brothers Jacob and Markus Wallenberg)
- Western Indian Ocean Marine Science Association (WIOMSA)

Teaching and training

In addition to the course organised by the Beijer Institute listed below, a number of institute researchers give lectures within courses run by other institutions (see under staff members’ individual activities).

Governance and management of social-ecological systems: Economic perspectives – Master’s course

Beijer Institute researchers organise and teach the module *Economic perspectives* in the course *Governance and management of social-ecological systems* of the Master’s programme *Social-Ecological Resilience for Sustainable Development* at Stockholm Resilience Centre, Stockholm University. The objective of the module is to help students understand a broad spectrum of economic perspectives relevant to the governance and management of social-ecological systems. 2020 was the 8th year in which the course was held. During spring 2020, Gustav Engström, Anne-Sophie Crépin, Therese Lindahl and Johan Gars taught a class of 20 students over a period of 2.5 weeks. The focus was on economic approaches for dealing with regime shifts, behavioural biases, climate change and international trade. Together with the students, alternative approaches for analysing how people make choices individually and collectively when managing social-ecological systems, and the consequences/trade-offs these choices involve, were explored.

Supervisory work

- PhD candidate Alice Dauriach, GEDB and Stockholm Resilience Centre, Stockholm University (Victor Galáz, co-supervisor)
- PhD candidate Laura Elsler, Stockholm Resilience Centre, Stockholm University (Anne-Sophie Crépin, co-supervisor)

- PhD candidate Ami Golland (Global Economic Dynamics and Biosphere programme and Stockholm Resilience Centre, Stockholm University (Victor Galáz, main supervisor)
- PhD candidate Xiao Hu, Department of Forest Economics, Swedish University of Agricultural Sciences, Umeå (Chandra Kiran Krishnamurthy, main supervisor)
- PhD candidate Lina Isacs, Division of Environmental Strategies Research, Royal Institute of Technology, Stockholm (Therese Lindahl, co-supervisor)
- PhD candidate Noah Linder, Department of Building, Energy and Environmental Engineering, University of Gävle, Gävle (Therese Lindahl, co-supervisor)
- PhD candidate Oskar Nyberg, Department of Ecology, Environment and Plant Sciences, Stockholm University (Patrik Henriksson, co-supervisor)
- PhD candidate Daniel Ospina, Beijer Institute and Stockholm Resilience Centre, Stockholm University (Anne-Sophie Crépin, co-supervisor)
- Master's student Stefan Fogelkvist, Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University (Åsa Gren, co-supervisor)
- Master's student Olivie Rostang, Department of Earth Sciences, Uppsala University (Åsa Gren, main supervisor)
- Master's student Blanca Sivertsen, Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University (Åsa Gren, main supervisor)
- Bachelor's students Johanna Fridh and Lisa Blom, Faculty of Engineering and Sustainable Development, University of Gävle, Gävle (Johan Colding, main supervisor)
- Master's student trainee Paula Sanchez Garcia, Stockholm Resilience Centre, Stockholm University (Caroline Schill, co-supervisor)

Seminar and workshop series

The Stockholm Seminars: Frontiers in Sustainability Science and Policy

The Stockholm Seminars are arranged by Albaeco, the Beijer Institute, Future Earth and Stockholm Resilience Centre. They cover a broad range of perspectives on sustainability issues and focus on the need for a sound scientific basis for sustainable development policy.

The seminars are given at the Royal Swedish Academy of Sciences (occasionally at Stockholm Resilience Centre) and are attended by an audience including researchers, students, the media and policymakers in the public and private sector.

Between July 2019 and June 2020, the following seminars were held:

2019

- 21 August: Professor Markus Reichstein *Deep learning for a better understanding of the Earth System?*

- 12 December: Associate Professor John Ingram *Enhancing food system resilience, with examples from the UK and Australia*

Brown Bag Lunch Seminars

The Brown Bag Lunch Seminars are a joint initiative between the Beijer Institute, Stockholm Resilience Centre and Albaeco, and are held at Stockholm Resilience Centre. The seminars aim to provide a platform for staff, students and visitors at the institutions that together form Stockholm Resilience Centre, to share their work in an informal manner with ample time for discussion.

The Askö meeting

Since 1993, the Beijer Institute has organised an annual meeting in September for informal discussions between ecologists, economists and related disciplines at the Askö Laboratory (part of Stockholm University Baltic Sea Centre) on a Swedish island in the Baltic Sea. The Askö meetings have generated unique cooperation between these disciplines and each meeting has resulted in a consensus document, often published in a leading scientific journal. The theme of Askö 2019 was *Transformative actions towards social-ecological stewardship in the Anthropocene*. Read more on page 28.

Staff members’ publications and activities



Amar Causevic
MA, Research assistant

Research focus

Sustainable finance, human-machine-ecology interactions, climate change and security.

Publications

- » Causevic, A. and I. Al-Marashi. 2020. Can NATO evolve into a climate alliance treaty organization in the Middle East? *Bulletin of the Atomic Scientists* 76(2):97-101.



Johan Colding
Associate Professor,
Programme Director *Urban social-ecological systems*

Research focus

Urban social-ecological systems.

Publications

- » Colding, J., S. Barthel, and P. Sörqvist. 2019. Wicked problems of smart cities. *Smart Cities* 2(4):512-521.

- » Colding, J., M. Colding, and S. Barthel. 2020. Applying seven resilience principles on the vision of the Digital City. *Cities* 103:102761.

- » Colding, J., M. Giusti, A. Haga, M. Wallhagen, and S. Barthel. 2020. Enabling relationships with nature in cities. *Sustainability* 12(11):4394.

- » Colding, J., Å. Gren, and S. Barthel. 2020. The incremental demise of urban green spaces. *Land* 9(5):162.

- » Colding, J., M. Wallhagen, P. Sörqvist, L. Marcus, K. Hillman, K. Samuelsson, and S. Barthel. 2020. Applying a systems perspective on the notion of the Smart City. *Smart Cities* 3(2):420-429.

- » Samuelsson, K., S. Barthel, J. Colding, G. Macassa, and M. Giusti. 2020. Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic. *OSF Preprints*. osf.io/3wx5a.

- » Sanecka, J., S. Barthel, and J. Colding. 2020. Countryside within the city: A motivating vision behind civic green area stewardship in Warsaw, Poland. *Sustainability* 12(6):2313.

- » Sörqvist, P., J. Colding, and J. Marsh. 2020. Psychological obstacles to the efficacy of environmental footprint tools. *Environmental Research Letters*. In press.

Conferences, workshops and presentations

- » Workshop on grant application to Vinnova (Sweden's innovation agency), Beijer Institute, September 2019. Organiser and presentation: *Gröna miljöers betydelse för hälsa i ett urbant landskap (Importance of green areas for health in an urban landscape)*.

- » KTH (Royal Institute of Technology) Sustainability Research Day, Royal Institute of Technology, Stockholm, October 2019. Speaker: *Beijerinstitutets urbanforskning: Stockholmsapproachen (The Beijer Institute's urban research: The Stockholm approach)*.

- » Workshop on Occupational Health Science and Psychology, University of Gävle, November 2019. Participant.

- » Workshop on Strategic Research Areas at University of Gävle: Populism, Democracy and the Humanities, University of Gävle, November 2019. Speaker: *Smarta städer, demokrati och populism (Smart cities, democracy and populism)*.

- » Climate Action Weeks, organised by the Nordic Council of Ministers (Nordiska ministerrådet), Stockholm, December 2019. Speaker: *The Smart City approach: a critical perspective*.

- » Seminar organised by project Innovationsklivet, Gävle Innovation Hub, Gävle, January 2020. Participant.

- » Seminar and launching of the Företagsforskarskolan (Research School) "Future-Proof

Cities", the Knowledge Foundation, Uppsala, January 2020. Participant.

- » Strategy workshop for the new Research School "Future-Proof Cities", the Knowledge Foundation, Uppsala, February 2020. Participant.

Teaching and training

- » Supervisor of Bachelor's students Johanna Fridh and Lisa Blom, Miljöteknik/Miljöstrateg (Environmental Technology/Environmental Strategy), Faculty of Engineering and Sustainable Development, University of Gävle.

- » Lecturer, undergraduate level programme Miljöteknik/Miljöstrateg (Environmental Technology/Environmental Strategy) lecture: *Studier av social-ekologiska system (Studies of social-ecological systems)*, Faculty of Engineering and Sustainable Development, University of Gävle, spring 2020.

Commissions

- » Chair of half-time PhD thesis seminar of Noah Linder, Environmental Psychology, Department of Building, Energy and Environmental Engineering, University of Gävle, 11 December 2019.

- » Member of the Campus Albano Reference Group.

- » Member of the Scandinavian Turfgrass Research Foundation (STERF).

- » Member of the Live Baltic Campus Network Group.

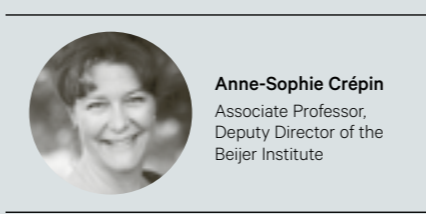
- » Director of HiG Urban Studio, University of Gävle, Sweden.

- » Member of the Steering board of the Swedish Knowledge Foundation's Research School "Future-Proof Cities".

Other

- » Member of the research consortium "Social-Ecological Urbanism".

- » Member of the working group "Smarta hållbara städer och samhällen" (Smart sustainable cities and societies"), Region Gävleborg.



Anne-Sophie Crépin
Associate Professor,
Deputy Director of the
Beijer Institute

Research focus

Social-ecological systems, regime shifts and economics, risk, global dynamics and resilience, complex system approach on the Arctic Ocean, behavioural responses to regime shifts, modelling.

Publications

- » Arvaniti, M., A.-S. Crépin, and C.K. Krishnamurthy. 2019. Time-consistent resource management with regime shifts. *CER-ETH*

Economics working paper series 19/329. Center of Economic Research, ETH Zurich, Switzerland.

- » Barrett, S., A. Dasgupta, P. Dasgupta, W. Neil Adger, J. Anderies, J. van den Bergh, C. Bledsoe, J. Bongaarts, S. Carpenter, F.S. Chapin, A.-S. Crépin, G. Daily, P. Ehrlich, C. Folke, N. Kautsky, E.F. Lambin, S.A. Levin, K.G. Mäler, R. Naylor, K. Nyborg, S. Polasky, M. Scheffer, J. Shogren, P.S. Jørgensen, B. Walker, and J. Wilen. 2020. Social dimensions of fertility behavior and consumption patterns in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America* 117(12):6300–6307.

- » Crépin, A.-S. 2019. Complexity, resilience and economics. Pages 166-187 in V. Galaz, editor: *Global Challenges, Governance, and Complexity: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

- » Folke, C., H. Österblom, J.B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2019. Transnational corporations and the challenge of biosphere stewardship. *Nature Ecology and Evolution* 3(10):1396-1403.

- » Folke, C., H. Österblom, J.-B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2020. An invitation for more research on transnational corporations and the biosphere. *Nature Ecology and Evolution* 4:494.

- » Schill, C., J.M. Anderies, T. Lindahl, C. Folke, S. Polasky, J.C. Cárdenas, A.-S. Crépin, M.A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075-1082.

- » Zipper, S.C., F. Jaramillo, L. Wang Erlandsson, S.E. Cornell, T. Gleeson, M. Porkka, T. Häyhä, A.-S. Crépin, I. Fetzer, D. Gerten, H. Hoff, N. Matthews, C. Ricaurte-Villota, M. Kummu, Y. Wada, and L. Gordon. 2019. Integrating the water planetary boundary with water management from local to global scales. *Earth's Future* 8(2):e2019EF001377.

Reports

- » Crépin, A.-S. 2020. Grön skatteväxling för hållbar markanvändning (Green tax shifting for sustainable land-use). Pages 45-69 in R. Henriksson, editor: *Växla upp! 12 inspirerande bidrag för en bättre grön skatteväxling (Gear up! 12 Inspiring Contributions for Better Green Tax Shifting)* FORES, Stockholm.

- » Snoeijjs-Leijonmalm, P., H. Flores, F. Volck-aert, B. Niehoff, F.L. Schaafsma, J. Hjelm, J. Hentati-Sundberg, S. Niiranen, A.-S. Crépin, and H. Österblom. 2020. *Review of Research Knowledge and Gaps on Fish Populations, Fisheries and Linked Ecosystems in the Central Arctic Ocean (CAO)*. European Commission, Executive Agency for Small and Medium-sized Enterprises (EASME).

Conferences, workshops and presentations

- » Transformative actions towards social-ecological stewardship in the Anthropocene, the Askö meeting 2019, Askö, September 2019. Participant.

- » Advancing Integrated Process-Based Modeling of Complex Socio-Environmental Systems, workshop, The National Socio-Environmental Synthesis Center (SESYNC), Annapolis, Maryland, USA, October 2019. Participant.

- » Så kan Riksbanken bidra till klimatpolitiken (How the Central Bank of Sweden can contribute to climate policy), seminar, presentation by Anna Breman (the new deputy governor of the Central Bank of Sweden) with panel discussion, Stockholm, March 2020. Panel member.

- » Advancing Integrated Process-Based Modeling of Complex Socio-Environmental Systems, workshop, SESYNC, online, May 2020. Participant.

- » Arctic II: Resilience in Rapidly Changing Arctic Systems, kick-off meeting, Belmont Forum, online, May 2020. Participant representing the Marine Arctic Resilience, Adaptation and Transformation (MARAT) project.

- » Beijer Young Scholars 3, online workshop, June 2020. Participant.

Teaching and training

- » Lecturer and examiner, Master's level course *Governance and management of social-ecological systems: Economic perspectives*, Stockholm Resilience Centre, Stockholm University, spring 2020.

- » Co-supervisor of PhD candidates Daniel Ospina and Laura Elsler (Sustainability Science, Stockholm Resilience Centre, Stockholm University).

Commissions

- » Ex officio member, Environment and Energy Committee, Royal Swedish Academy of Sciences, since 2016.

- » Board member, Environmental Research Council, Swedish Environmental Protection Agency (Naturvårdsverkets miljöforskningsråd), Stockholm, since 2018.

- » Committee member, National Committee for Global Environmental Change, Royal Swedish Academy of Sciences, Stockholm, since 2018.

- » Committee member, Committee for Applied Systems Analysis (Kommittén för tillämpad systemanalys), Stockholm, since 2020.
- » Member of the Council for Evidence-based Environmental Analysis (Rådet för evidensbaserad miljöanalys) under FORMAS (Swedish government research council for sustainable development), since 2020.
- » Member of the scientific committee for the Conference of the European Association of Environmental and Resource Economists (EAERE).
- » Participant and member of the steering committee (substitute) of the European Fisheries Inventory in the Central Arctic Ocean (EFICA) Consortium, financed by the European Commission.
- » Associate editor of *Ecological Economics*, since 2019.
- » Journal reviewer for *Scandinavian Journal of Economics* and *Havsmiljöinstitutet* (Swedish government institute for the marine environment).



Gustav Engström
PhD, Researcher

Research focus

Various economic aspects of global environmental change, in particular the economics of climate change and issues related to energy supply and tipping points in the climate system. Other research interests include urban economics and other aspects of the economy and environment interaction.

Publications

- » Engström, G., J. Gars, N. Jaakkola, T. Lindahl, D. Spiro, and A. van Benthem. 2020. Beijer Discussion Paper 271: What policies address both the corona virus crisis and the climate crisis? *Beijer Discussion Paper Series*.
- » Engström, G., Å. Gren, C.-Z. Li, and C.K.B. Krishnamurthy. 2020. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

Teaching and training

- » Module leader, lecturer and examiner, Master’s level course *Governance and management of social-ecological: Economic perspectives*, Stockholm Resilience Centre, Stockholm University, spring 2020.

Grants awarded in competition

- » “What makes effective climate policies politically feasible”, FORMAS (Swedish government research council for sustainable development) grant, 5 years, SEK 10m. Co-applicant.



Carl Folke
Professor, Director of the Beijer Institute

Research focus

Social-ecological systems, resilience thinking, ecological economics, Anthropocene, transformation for stewardship that reconnects development to the biosphere.

Publications

- » Barrett, S., A. Dasgupta, P. Dasgupta, W. Neil Adger, J. Anderies, J. van den Bergh, C. Bledsoe, J. Bongaarts, S. Carpenter, F.S. Chapin, A.-S. Crépin, G. Daily, P. Ehrlich, C. Folke, N. Kautsky, E.F. Lambin, S.A. Levin, K.G. Mäler, R. Naylor, K. Nyborg, S. Polasky, M. Scheffer, J. Shogren, P.S. Jørgensen, B. Walker, and J. Wilen. 2020. Social dimensions of fertility behavior and consumption patterns in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America* 117(12):6300–6307.
- » Boltz, F., N. LeRoy Poff, C. Folke, N. Kete, C.M. Brown, S. St. George Freeman, J.H. Matthews, A. Martinez, and J. Rockström. 2019. Water is a master variable: Solving for resilience in the modern era. *Water Security* 8:100048.
- » Bratman, G.N., C.B. Anderson, M.G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J.J. Gross, T. Hartig, P.H. Kahn Jr., M. Kuo, J.J. Lawler, P.S. Levin, T. Lindahl, A. Meyer-Lindenberg, R. Mitchell, Z. Ouyang, J. Roe, L. Scarlett, J.R. Smith, M. van den Bosch, B.W. Wheeler, M.P. White, H. Zheng, and G.C. Daily. 2019. Nature and mental health: An ecosystem service perspective. *Science Advances* 5:eaax0903.
- » Folke, C. 2019. Governing for emergence in social-ecological systems. Pages 24–37 in V. Galaz, editor: *Global Challenges, Governance, and Complexity: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.
- » Folke, C. et al. 2020. Beijer Discussion Paper 272: Our Future in the Anthropocene Biosphere: Global sustainability and resilient societies. *Beijer Discussion Paper Series*.
- » Folke, C., B.E. Crona, V. Galaz, L.J. Gordon, L. Schultz, and H. Österblom. 2019. Collaborative approaches to biosphere stewardship. Pages 41–50 in L. Mandle, Z. Ouyang, J. Salzman, and G.C. Daily, editors: *Green Growth That Works: Natural Capital Policy and Finance Mechanisms Around the World*. Island Press, Washington, D.C., USA.
- » Folke, C., H. Österblom, J.B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauri-

- ach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2019. Transnational corporations and the challenge of biosphere stewardship. *Nature Ecology and Evolution* 3(10):1396–1403.
- » Folke, C., H. Österblom, J.-B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2020. An invitation for more research on transnational corporations and the biosphere. *Nature Ecology and Evolution* 4:494.
- » Garmestani, A.S., J.B. Ruhl, B.C. Chaffin, R.K. Craig, H.F.M.W. van Rijswijk, D.G. Angeler, C. Folke, L.H. Gunderson, D. Twidwell, and C.R. Allen. 2019. Untapped capacity for resilience in environmental law. *Proceedings of the National Academy of Sciences of the United States of America* 116:19899–19904.
- » Gunderson, L., C. Folke, and M.A. Janssen. 2019. Remembering Buzz Holling. *Ecology and Society* 24(4):39.
- » Herrfahrdt-Pähle, E., M. Schlüter, P. Olsson, C. Folke, S. Gelcich, and C. Pahl-Wostl. 2020. Sustainability transformations: socio-political shocks as opportunities for governance transitions. *Global Environmental Change* 63:102097.
- » Jørgensen, P.S., C. Folke, P.J.G. Henriksson, K. Malmros, M. Troell, A. Zorzet, and members of the Living with Resistance project. 2020. Coevolutionary governance of antibiotic and pesticide resistance. *Trends in Ecology and Evolution* 35(6):484–494.
- » Jørgensen, P.S., C. Folke, and S.C. Carroll. 2019. Evolution in the Anthropocene: Informing governance and policy. *Annual Review of Ecology, Evolution, and Systematics* 50:527–546.
- » Keys, P., V. Galaz, M. Dyer, N. Matthews, C. Folke, M. Nyström, and S. Cornell. 2019. Anthropocene risk. *Nature Sustainability* 2:667–673.
- » Mandle, L., Z. Ouyang, J. Salzman, I. Bateman, C. Folke, A. D. Guerry, C. Li, J. Li, S. Li, J. Liu, S. Polasky, M. Ruckelshaus, B. Vira, A. U. Quesada, W. Xu, H. Zheng, and G.C. Daily. 2019. The case and movement for securing people and nature. Pages 3–16 in L. Mandle, Z. Ouyang, J. Salzman, and G.C. Daily, editors: *Green Growth That Works: Natural Capital Policy and Finance Mechanisms Around the World*. Island Press, Washington, D.C., USA.
- » Norström, A.V., C. Cvitnanovic, M.F. Löf, S. West, C. Wyborn, P. Balvanera, A.T. Bednarek, E.M. Bennett, R. Biggs, A. de Bremond, B.M. Campbell, J.G. Canadell, S.R. Carpenter, C. Folke, E.A. Fulton, O. Gaffney, S. Gelcich, J.B. Jouffray, M. Leach, M. Le Tissier, B. Martín-López, E. Louder, M.F. Loutre, A.M. Meadow,

- H. Nagendra, D. Payne, G.D. Peterson, B. Reyers, R. Scholes, C.I. Speranza, M. Spierenburg, M. Stafford-Smith, M. Tengö, S. van der Hel, I. van Putten, and H. Österblom. 2020. Principles for knowledge co-production in sustainability research. *Nature Sustainability* 3(3):182–190.
- » Nyström, M., J.-B. Jouffray, A. Norström, P. P.S. Jørgensen, V. Galaz, B.E. Crona, S.R. Carpenter, and C. Folke. 2019. Anatomy and resilience of the global production ecosystem. *Nature* 575:98–108.
- » Schill, C., J.M. Anderies, T. Lindahl, C. Folke, S. Polasky, J.C. Cárdenas, A.-S. Crépin, M.A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075–1082.
- » Schlüter, M., L.J. Haider, S.J. Lade, E. Lindkvist, R. Martin, K. Orach, N. Wijermans, and C. Folke. 2019. Capturing emergent phenomena in social-ecological systems: An analytical framework. *Ecology and Society* 24(3):11.

Conferences, workshops and presentations

- » Welcome to the Biosphere exhibition, Svenskt Tenn, Svenskt Tenn and the Beijer Institute, Stockholm, August–October 2019. Inauguration speech, press meetings, and presentation for staff.
- » Stockholm Resilience Centre International Advisory Board meeting, Rosenön, Dalarö, August 2019. Presentation.
- » The Phuket Keystone Dialogue and the SeaBOS (Seafood Business for Ocean Stewardship) initiative, Phuket, Thailand, September 2019. Participant and speaker.
- » Transformative actions towards social-ecological stewardship in the Anthropocene, The Askö meeting 2019, Askö, September 2019. Organiser and participant.
- » The International Science Advisory Council, Stockholm Resilience Centre, September 2019.
- » The Surprise Group, workshop, Villa Carlsten, Falsterbo, September 2019. Participant.
- » Via Summa Day, Summa Equity and portfolio companies, Stockholm, September 2019.
- » Complexity and GRAID workshop, Stockholm, September 2019. Participant.
- » Acknowledging 10 years of Planetary Boundaries, symposium, the Royal Swedish Academy of Sciences, October 2019. Presentation.
- » Evening event, Postdoc Academy for Transformational Leadership Seminar II, Bosch Foundation and Stockholm Resilience Centre, Restauranglabbet, Stockholm, October 2019. Presentation and reflection.
- » Beijer Foundation seminar, Hovstallet, Stockholm, October 2019. Presentation.

- » “Our Planet, Our Future”, Nobel Prize Summit preparatory workshop, Potsdam, Germany, October 2019. Participant.
- » Svenskt Tenn 95 years, Stockholm University, October 2019. Presentation.
- » Emergence, Complex Adaptive Systems Group workshop, Stockholm Resilience Centre, October 2019. Participant.
- » Earth Stewardship – a foundation for sustainability, Volvo Environment Prize Seminar, the Swedish Royal Museum of Natural History, November 2019. Presentation.
- » Where next for sustainability science, LUCSUS, Lund University, November 2019. Presentation.
- » Stockholm Resilience Centre International Advisory Board, individual member meetings, Stockholm, November 2019.
- » Nobel Prize Summit lecture, Nobel Foundation, Stockholm, December 2019.
- » Response Diversity workshop, Djurö, January 2020. Participant.
- » Stockholm Resilience Centre PhD research day, Stockholm Resilience Centre, January 2020. Presentation.
- » Svenskt Tenn and Sveriges Marknadsförbund, Svenskt Tenn, Stockholm, February 2020. Presentation.
- » SeaBOS (Seafood Business for Ocean Stewardship) science meeting, Stockholm Resilience Centre, February 2020.
- » Preparing for SeaBOS, meetings at the Royal Castle and online, February, March, and May 2020.
- » SIGHT (The Swedish Institute for Global Health Transformation) advisory board meeting, April, June 2020.
- » Seafood working meeting, May 2020. Presentation.
- » Beijer Young Scholars 3, online workshop, June 2020. Presentation.
- » Conversation with researchers from Arizona State University, The New School New York, Georgia State University, the US Forest Service, and Barnard College on resilience thinking, June 2020. Participant.
- » Alumni meeting CEO Executive Programme in Resilience Thinking, June 2020.
- » EAT Advisory Board meeting, June 2020.
- » Monaco Blue Initiative, online workshop, June 2020. Panel member.

Teaching and training

- » Lecturer, CEO Executive Programme *Resilience Thinking: Transformative Business Leadership for a Prosperous Planet*, Stockholm Resilience Centre.
- » Lecturer for leadership of Atlas Copco, Stockholm Resilience Centre.

- » Lecturer, Master’s level course *Resilience and sustainable development*, LUMES, Lund University.
- » Lecturer, undergraduate and PhD-courses, Stockholm University.

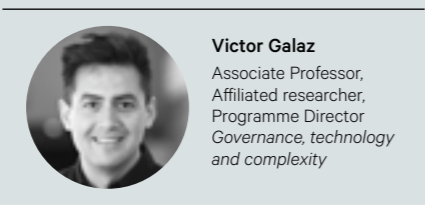
Commissions

- » Founder, Science Director, Chairman of the Board, Stockholm Resilience Centre.
- » Co-director (with Beatrice Crona) of the Erlling-Persson Family Academy Programmes, Global Economic Dynamics and the Biosphere and New Approaches to the Grand Challenge: Global Finance, Global Health and the Biosphere, the Royal Swedish Academy of Sciences.
- » Principal investigator (with Gretchen Daily, Stanford University) of the research collaboration programme Fundamental Research in Biosphere-based Sustainability Science and Advancing Fundamental Knowledge of Natural Capital, Resilience and Biosphere Stewardship, Stockholm University, both funded by the Marianne and Marcus Wallenberg Foundation.
- » Member of the Royal Swedish Academy of Sciences.
- » International Member of the United States National Academy of Sciences, Washington, USA.
- » Member of the Royal Norwegian Society of Sciences and Letters (DKNVS), Trondheim, Norway.
- » Member of the Royal Swedish Academy of Agriculture and Forestry (KSLA).
- » Fellow of the Resilience Alliance.
- » Honorary Fellow, South American Institute for Resilience and Sustainability Studies (SARAS), Maldonado, Uruguay.
- » Fellow of the Synergy Program for Analyzing Resilience and Critical transitionS (SparcS), Wageningen, Netherlands.
- » Fellow of STIAS (Stellenbosch Institute for Advanced Study), Stellenbosch, South Africa.
- » Senior Fellow of IHOPE (Integrated History and Future of People on Earth).
- » Member of the Ralph Yorque Society.
- » Member of the Monaco Ocean Science Federation.
- » Member of the Academic Advisory Board of STIAS, Stellenbosch Institute for Advanced Study, Stellenbosch, South Africa.
- » Member of the SIGHT Advisory Committee (The Swedish Institute for Global Health Transformation), the Royal Swedish Academy of Sciences.
- » Member of the International Scientific Advisory Board, Helsinki Institute of Sustainability Science, HELSUS, University of Helsinki, Finland.

- » Member of the International Scientific Advisory Council, The Waterloo Institute for Complexity and Innovation (WICI), University of Waterloo, Ontario, Canada.
- » Member of the Advisory board, International Network of Research on Coupled Human and Natural Systems (CHANS-Net).
- » Lead faculty of Earth System Governance Project.
- » Scientific Director for the CEO Executive Programme in Resilience Thinking: Transformative Business Leadership for a Prosperous Planet, Stockholm Resilience Centre.
- » Advisory board of EAT and EAT Forum.
- » Board member of the SeaBOS (Seafood Business for Ocean Stewardship) Foundation.
- » Senior Advisor of the Ecosperity Advisory Group, Temasek.
- » Chair of the scientific committee of the Volvo Environment Prize.
- » Selection committee of the Kenneth Boulding Award, International Society for Ecological Economics.
- » Advisory and editorial board member of *Ambio*, *the Anthropocene Review*, *Ecological Economics*, *Ecology and Society*, *Environmental Conservation*, *Environment and Development Economics*, *Environmental Innovation and Societal Transitions*, *Frontiers in Ecology and the Environment*, *Global Sustainability*, *One Earth*, *Proceedings of the National Academy of Sciences of the United States of America*, *Resilience: International Policies, Practices and Discourses*, *Reviews in Ecological Economics*, *Sustainability*, and *Sustainability Science*.
- » Lord-in-Waiting (Kabinettskammarherre), Swedish Royal Court.

Other

- » Work with Svenskt Tenn, Eric Ericsson and Lars Arrhenius on the exhibition *Welcome to the Biosphere*, Svenskt Tenn, August-October 2019.
- » Member of the Steering Committee of the Nobel Prize Summit 2020-2021 “Our Planet, Our Future”. The United States National Academies of Sciences, Engineering, and Medicine, in partnership with the Nobel Foundation (Stockholm), the Potsdam Institute for Climate Impact Research (Potsdam, Germany), and Stockholm Resilience Centre/Beijer Institute.
- » Member of the Technical Working Group of the Global Seafood Markets strategy evaluation, The David and Lucile Packard Foundation and The Walton Family Foundation, 2019-2020.
- » Recognised as Highly Cited Researcher by Thompson Reuters 2019.



Victor Galaz

Associate Professor,
Affiliated researcher,
Programme Director
*Governance, technology
and complexity*

Research focus

Governance, institutions, Earth system governance, complex adaptive systems, networked risks, technological change, financial systems.

Publications

- » Folke, C. et al. 2020. Beijer Discussion Paper 272: Our Future in the Anthropocene Biosphere: Global sustainability and resilient societies. *Beijer Discussion Paper Series*.
- » Folke, C., B.E. Crona, V. Galaz, L.J. Gordon, L. Schultz, and H. Österblom. 2019. Collaborative approaches to biosphere stewardship. Pages 41-50 in L. Mandie, Z. Ouyang, J. Salzman, and G.C. Daily, editors: *Green Growth That Works: Natural Capital Policy and Finance Mechanisms Around the World*. Island Press, Washington, D.C., USA.
- » Folke, C., H. Österblom, J.B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2019. Transnational corporations and the challenge of biosphere stewardship. *Nature Ecology and Evolution* 3(10):1396-1403.
- » Folke, C., H. Österblom, J.-B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2020. An invitation for more research on transnational corporations and the biosphere. *Nature Ecology and Evolution* 4:494.
- » Galaz, V. (editor) 2019. *Global Challenges, Complexity, and Governance: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.
- » Galaz, V. 2020. Climate and environmental crises. In E. Stern, editor: *Encyclopaedia of Crisis Analysis*. Oxford University Press, UK. In press.
- » Garcia, D., V. Galaz, and S. Daume. 2019. EATLancet vs yes2meat: The digital backlash to the planetary health diet. *The Lancet* 394:2153-2154.
- » Keys, P., V. Galaz, M. Dyer, N. Matthews, C. Folke, M. Nyström, and S. Cornell. 2019. Anthropocene risk. *Nature Sustainability* 2:667-673.
- » Nyström, M., J.-B. Jouffray, A. Norström, P. Sogaard-Jørgensen, V. Galaz, B.-E. Crona,

S.R. Carpenter, and C. Folke. 2019. Anatomy and resilience of the global production ecosystem. *Nature* 575:98-108.

- » Peters, G.B., J. Pierre, and V. Galaz. 2019. Simple solutions for complexity? Pages 188-210 in V. Galaz, editor: *Global Challenges, Complexity, and Governance: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

Conferences, workshops and presentations

- » AI, People and the Planet, international scientific workshop and evening event, hosted by the Consulate General of Sweden in New York and Princeton University, New York City, USA, October 2019. Main organiser, speaker and panel member.
- » KIKK festival, Namur, Belgium, November 2019. Keynote speaker: *Our planet on the Edge: can technology really save us?*
- » Du sköra nya värld? AI, ekonomin och planeten (Frail new world? AI, the economy and the planet), breakfast seminar, Institute for Futures Studies, Stockholm, November 2019. Main organiser.
- » Så kan Riksbanken bidra till klimatpolitiken (How the Central Bank of Sweden can contribute to climate policy), seminar, presentation by Anna Breman (the new deputy governor of the Central Bank of Sweden) with panel discussion, Stockholm, March 2020. Main organiser and moderator.
- » The Geopolitics of COVID-19 and Climate Change, webinar, Mistra Geopolitics, April 2020. Keynote speaker: *After the pandemic – what can we expect?*
- » AI:s roll för att möta stora samhällsutmaningar (The role of AI in facing major societal challenges), Vinnova (Sweden's innovation agency), online seminar, May 2020. Keynote speaker: *AI och klimatutmaningen (AI and the climate challenge)*.
- » Digitala Föreläsningar: Kropp, själ och samhälle under corona (Digital lectures: Body, soul and society under coronavirus), Karolinska Institute, Stockholm University and Kulturhuset Stadsteatern, May 2020. Lecturer: *Hur påverkas klimatarbetet av coronapandemin? (Effects of the coronavirus epidemic on climate work)*
- » Digital festival *Reflex*, May 2020. Speaker: *Hur påverkas klimatarbetet av Coronapandemin och klimatet (Effects of the coronavirus epidemic on climate work and the climate)*.
- » Couch Lesson: AI + Climate Change, Goethe Institute, Stockholm, June 2020. Keynote speaker.

Teaching and training

- » Main supervisor of PhD candidate Ami Golland and co-supervisor of PhD candidate Alice Dauriach (Sustainability Science, Stockholm Resilience Centre, Stockholm University).

Commissions

- » Deputy Director at Stockholm Resilience Centre.
- » External evaluator of the PhD thesis of Edith Wilkinson, Cranfield Defence and Security, Cranfield University, UK, 3 December 2019.
- » Evaluator of application by Dr. Irina Brass for promotion to Associate Professor, University College London, London, UK.
- » Steering Group Member of Exponential Roadmap, a science-business initiative including Stockholm Resilience Centre, Future Earth, Ericsson, Sitra, Potsdam Institute for Climate Impact Research, and others, since 2019.
- » Co-founder and Council Member of the Stockholm Climate Security Hub, a science-policy initiative with support from the Swedish Ministry of Foreign Affairs including Stockholm Resilience Centre, Stockholm Environment Institute, Stockholm International Water Institute, and Stockholm International Peace Research Institute, since 2018.
- » Editor of journal *Global Perspectives*, since 2019.
- » Subject editor for journal *Ecology and Society*, since 2008.
- » Journal reviewer for *Ecology and Society*, *Ecological Economics*, *Earth System Governance*, *Proceedings of the National Academy of Sciences of the United States of America*, *Nature Ecology and Evolution*, *Nature Sustainability*, *Ambio*, *Global Governance*, *Public Administration*, *European Political Science Review*, *Global Environmental Change*, *Environment*, *Development and Sustainability*, and *Environmental Politics*.

Media coverage

- » Maskinerna undrar allt mer hur du mår (Machines are monitoring how you feel). Galaz, V. *Svenska Dagbladet*, Under Strecket, 9 March 2020.
- » AI can tackle the climate emergency – if developed responsibly. Galaz, V. *The Conversation*. 23 April 2020.
- » Planeten efter pandemin (The planet after the pandemic). Galaz, V. *Sveriges Natur*, 3 June 2020.
- » Är klimatoptismen klimatets största hot? (Is climate optimism the greatest threat to the climate?). Galaz, V. *Svenska Dagbladet*, Under Strecket, 31 October 2019.
- » Felen om felen om Amazonas (The problems with the Amazon problem). Galaz, V.

Svenska Dagbladet, Under Strecket, 31 September 2019.

- » Appearances in Swedish media including *Sveriges Radio (Dystopia, Studio Ett, Klotet, Korrespondenterna)*, *Svenska Dagbladet*, *Dagens Nyheter*, *Expressen*, and podcasts *Det Dagliga Värvet*, *Expressen Klimatprat*, *Rethink*.



Johan Gars

PhD, Researcher

Research focus

Economics of natural resource use and global environmental problems.

Publications

- » Engström, G., J. Gars, N. Jaakkola, T. Lindahl, D. Spiro, and A. van Benthem. 2020. Beijer Discussion Paper 271: What policies address both the corona virus crisis and the climate crisis? *Beijer Discussion Paper Series*.
- » Gars, J. and C. Olovsson. 2019. Fuel for economic growth? *Journal of Economic Theory* 184:104941.
- » Lecturer, Master's level course *Governance and management of social-ecological systems: Economic perspectives*, Stockholm Resilience Centre, Stockholm University, spring 2020.
- » Guest lecturer, undergraduate level course *Ekologisk ekonomi (Ecological economics)* (lecture: *Economics of climate change*), Department of Physical Geography and Stockholm Resilience Centre, Stockholm University, spring 2020.
- » Supervisor of three students (Ivan Gedin, Sofia Hjortberg and Elisabet Lindén Calatayud) within the Visual Design programme at Beckman's Design School.

Commissions

- » Journal reviewer for *Economic Policy*, *International Journal of Environmental Research and Public Health*, and *Sustainability*.

Grants awarded in competition

- » “What makes effective climate policies politically feasible”, FORMAS (Swedish government research council for sustainable development) grant, 5 years, SEK 10m. Co-applicant.



Åsa Gren

PhD, Researcher

Research focus

Creating resilient, sustainable and healthy urban areas by integrating ecosystem services into spatial urban planning and design, e.g. by using the ecosystem service of pollination as an entry point for navigating climate change and urban expansion in cities and by combining urban expansion and sustainable food production in urban agricultural landscapes. Applying an ecosystem service lens for navigating different human health aspects in an urban planning and design context.

Publications


- » Colding, J., Å. Gren, and S. Barthel. 2020. The incremental demise of urban green spaces. *Land* 9(5):162.
- » Engström, G., Å. Gren, C.-Z. Li, and C.K.B. Krishnamurthy. 2020. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

Conferences, workshops and presentations

- » Climate Action Weeks, organised by the Nordic Council of Ministers (Nordiska ministerrådet), Stockholm, December 2019. Presentation: *Smart growth and environmental performance*.
- » Strategic workshop, Strategi för identifiering av frågor att utreda inom ramen för systematiska forskningsssammanställningar (Strategy for identification of research topics within the systematic research compilation framework), FORMAS (Swedish government research council for sustainable development, Stockholm, February 2020. Participant).

Teaching and training

- » Lecturer, Master's level course *Sustainable Development and the Design Professions* (lecture: *Ecosystem services and resilience in an urban planning and design context*), Chalmers University of Technology, Gothenburg, autumn 2019 and spring 2020.
- » Main supervisor of Master's student Olivie Rostang (Sustainable Development, Uppsala University, Uppsala).
- » Main supervisor of Master's student Blanca Sivertsen (Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University).
- » Co-supervisor of Master's student Stefan Fogelkvist (Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University).



Patrik Henriksson
PhD, Affiliated researcher

Research focus
Aquaculture and seafood, life cycle assessments (LCA), and antimicrobial use.

- Publications**
- » Heijungs, R., J.B. Guinée, A. Mendoza Beltrán, P.J.G. Henriksson, and E. Groen. 2019. Everything is relative and nothing is certain. Toward a theory and practice of comparative probabilistic LCA. *International Journal of Life Cycle Assessment* 24(9):1573-1579.
 - » Henriksson, P.J.G., L.K. Banks, S.K. Suri, T.Y. Pratiwi, M.R. Fatan, and M. Troell. 2019. Indonesian aquaculture futures — identifying interventions for reducing environmental impacts. *Environmental Research Letters* 14:124062.
 - » Jørgensen, P.S., C. Folke, P.J.G. Henriksson, K. Malmros, M. Troell, A. Zorzet, and members of the Living with Resistance project. 2020. Coevolutionary governance of antibiotic and pesticide resistance. *Trends in Ecology and Evolution* 35(6):484-494.
 - » Pelletier, N., R.W.R. Parker, and P.J.G. Henriksson. 2019. Environmental nutrition and LCA. Pages 141-156 in J. Sabaté, editor: *Environmental Nutrition: Connecting Health and Nutrition with Environmentally Sustainable Diets*. Elsevier Academic Press, London, UK.
 - » Tlusty, M.F., P. Tyedmers, M. Bailey, F. Ziegler, P.J.G. Henriksson, C. Béné, S. Bush, R. Newton, F. Asche, D.C. Little, M. Troell, and M. Jonell. 2019. Reframing the sustainable seafood narrative. *Global Environmental Change* 59:101991.

- Reports**
- » Henriksson, P.J.G., L.K. Banks, S. Suri, T.Y. Pratiwi, N. Ahmad Fatan, and M. Troell. 2019. *The Future of Aquaculture in Indonesia: A Transformation Toward Increased Sustainability*. Penang, Malaysia: WorldFish. Policy Brief: 2019-14.

- Conferences, workshops and presentations**
- » Exploring factors influencing antimicrobial resistance in Europe, workshop, AMResilience Project, Stockholm Resilience Centre, September, 2019. Participant.
 - » AMResilience Project, workshop, Penang, Malaysia, October 2019. Participant.
 - » 5th Global Science Conference on Climate-Smart Agriculture, Denpasar, Indonesia, October 2019. Participant.

- » Earth Stewardship – a foundation for sustainability, Volvo Environment Prize Seminar, the Swedish Royal Museum of Natural History, November 2019. Panel member.
- » Beijer Young Scholars 2, proposal writing workshop (Inequality and the Biosphere: Achieving the Sustainable Development Goals in an Unequal World), Stockholm, December 2019. Organiser and participant.
- » SeaBOS (Seafood Business for Ocean Stewardship), workshop, online, May 2020. Participant.

- Teaching and training**
- » Co-supervisor of PhD candidate Oskar Nyberg (Department of Ecology, Environment and Plant Sciences, Stockholm University).

- Commissions**
- » Journal reviewer for *The International Journal of Life Cycle Assessment*, *One Earth*, *Lancet Planetary Health*, and *American Journal of Clinical Nutrition*.



Malin Jonell
PhD, Researcher

Research focus
Food systems, sustainable aquatic production and the role of private regulatory mechanisms in transforming food production and consumption.

- Publications**
- » Stoll, J.S., M. Bailey, and M. Jonell. 2019. Alternative pathways to sustainable seafood. *Conservation Letters* 13:e12683.
 - » Tlusty, M.F., P. Tyedmers, M. Bailey, F. Ziegler, P.J.G. Henriksson, C. Béné, S. Bush, R. Newton, F. Asche, D.C. Little, M. Troell, and M. Jonell. 2019. Reframing the sustainable seafood narrative. *Global Environmental Change* 59:101991.

- Reports**
- » Lindahl T. and M. Jonell. 2020. *Metoder för att ändra kostvanor (Methods for Changing Diets)*. Konsumentverket (The Swedish Consumer Agency), report 2020:4.
 - » Röös, E., J. Larsson, K. Resare Sahlin, M. Jonell, T. Lindahl, E. André, S. Säll, N. Harring, and M. Persson. 2020. *Styrmedel för hållbar matkonsumtion: En kunskapsöversikt och vägar framåt (Policy Instruments for Sustainable Food Consumption: A Review of the Evidence and Ways Forward)*. SLU Future Food Reports 13, Swedish University of Agricultural Sciences, SLU Future Food.
 - » Troell, M., M. Jonell, and B. Crona. 2019. Scoping report: *The Role of Seafood in Sustainable and Healthy Diets, The EAT-Lancet*

Commission Report Through a Blue Lens. Stockholm Resilience Centre, Beijer Institute, Global Economic Dynamics and the Biosphere, Stockholm, Sweden.

- Conferences, workshops and presentations**
- » Blue Food: Placing Aquatic Foods at the Centre of a Sustainable and Healthy Future, Side event, Our Ocean Conference, Oslo, October 2019. Panellist and presentation: *The Blue Food Assessment - Putting aquatic production at the heart of global food systems*.
 - » Postdoc Academy for Transformational Leadership Seminar I, Bosch Foundation, Transformations in human-environment research: Mode and logics, Humboldt University of Berlin, Berlin, Germany, September 2019. Participant.
 - » Food, climate change and our future, panel discussion, The Swedish Forum for Human Rights, Linköping, November 2019. Panel member.
 - » En hållbar matkonsumtion för planeten och hälsan: hur kommer vi dit? (Sustainable food consumption for planet and health: how do we get there?), seminar, Konsumentverket (Swedish Consumer Agency), Stockholm, November 2019. Invited speaker (with Therese Lindahl): *Metoder att förändra matvanor – vilka styrmedel fungerar på riktigt? (Methods to change eating habits - Which policies work?)*.
 - » Det friktionsfria livet – hållbar production och consumption (The friction-free life - sustainable production and consumption), seminar, the Royal Swedish Academy of Agriculture and Forestry (KSLA), Stockholm, January 2020. Presentation: *Nudging – en knuff i rätt riktning (Nudging – a push in the right direction)*.
 - » Workshop Blue Food Assessment, Stanford University, Palo Alto, USA, January 2020. Co-organiser.
 - » Postdoc Academy for Transformational Leadership Seminar II, Bosch Foundation, Transdisciplinary Research Environments and Transdisciplinary Learning, Leuphana University of Lüneburg, Lüneburg, Germany, February 2020. Participant.
 - » Small Scale Fisheries Funders Network Monthly Webinar: Blue Food Assessment, March 2020. Presentation: *The Blue Food Assessment - Putting aquatic production at the heart of global food systems*.
 - » Webinar organised by Konsumentverket (Swedish Consumer Agency), May 2020. Invited speaker (with Therese Lindahl): *Metoder för att ändra kostvanor (Methods for changing diets)*.
 - » How to make food consumption more sustainable, webinar organised by Mistra Sustainable Consumption, SLU Future Foods,

Beijer Institute, Chalmers University of Technology CeCAR (Centre for Collective Action Research), June 2020. Presentation: *Policies for sustainable food consumption – an overview of knowledge and ways forward*.

- Teaching and training**
- » Lecturer, undergraduate level course *Sustainability perspectives on contemporary fisheries - Where Have all the Fishes Gone?*, Swedish University of Agricultural Sciences, autumn 2019.

- Commissions**
- » Member of the Aquaculture Stewardship Council's technical working group on revision of the shrimp aquaculture standard, 2019-2020.
 - » Journal reviewer for *Ambio*, *One Earth* and *Reviews in Aquaculture*.

- Grants awarded in competition**
- » "Mistra food Futures", Mistra (the Swedish Foundation for Strategic Environmental Research) grant, 5 years, SEK 80m. Co-aplicant.

- Media coverage**
- » Från köttnorm till vegonorm - vilka metoder är mest effektiva för att nå ett grönt paradigmskifte? (From meat norm to vego norm – what are the most effective methods for achieving a green paradigm shift?). *Mat & Klimat*, 10 June 2020.
 - » Det behöver bli lätt att äta rätt (It has to be easy to eat right). André E., N. Harring, M. Jonell, J. Larsson, T. Lindahl, M. Persson, E. Röös, K. Resare Sahlin, and S. Säll. *Dagens Nyheter*, debate article, June 15 2020.
 - » Stat och kommun kan spela en större roll för vår matkultur (State and municipality can play a greater role in our food culture). André E., N. Harring, M. Jonell, J. Larsson, T. Lindahl, M. Persson, E. Röös, K. Resare Sahlin, and S. Säll. 2020. *Dagens Nyheter*, debate article, 26 June 2020.

- Other**
- » Member of the Postdoc Academy for Transformational Leadership of the Robert Bosch Foundation (second cohort), since 2019.
 - » Contribution to *One Earth* Voices: Transforming Society's Food Choices. Crona, B., and M. Jonell. 2019. Sustainable Blue Food Systems. *One Earth* 1(3):273.
 - » Jonell, M. 2020. Kost som gör gott för hälsan och planeten (Diets that are good for human health and the planet). *Barnläkaren* Nr.2/2020:26–27.
 - » Featured in short film by Stockholm University Media: "Can one "help" consumers to make sustainable decisions?" Available at: <https://www.su.se/om-oss/fakta/agenda-2030/filmer-om-h%C3%A5llbarhetsforskning>



Sofia Kristin Kokinelis
MSc, Finance and HR Administrator

Sofia is Finance and HR Administrator for both the Beijer Institute and the Global Economic Dynamics and the Biosphere Programme (GEDB) at the Royal Swedish Academy of Sciences. Her main tasks are accounting, financial reporting and budgeting. She also provides support and financial information to researchers about their projects, assisting them with budgeting and financial reporting. In her role as HR administrator, she prepares staff contracts and assists staff members with different issues. Owing to the research collaboration between the Beijer Institute and Stockholm Resilience Centre (SRC), her work requires close cooperation with the administration team at SRC.



Chandra Kiran Krishnamurthy
PhD, Researcher

Research focus
Environmental and resource economics, and the economics of energy.

- Publications**
- » Arvaniti, M., A.-S. Crépin, and C.K. Krishnamurthy. 2019. Time-consistent resource management with regime shifts. *CER-ETH Economics working paper series* 19/329. Center of Economic Research, ETH Zurich, Switzerland.
 - » Krishnamurthy, C.K.B. and N. Ngo. 2020. The effects of smart-parking on transit and traffic: Evidence from SFpark. *Journal of Environmental Economics and Management* 99:102273.
 - » Engström, G., Å. Gren, C.-Z. Li, and C.K.B. Krishnamurthy. 2020. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

- Reports**
- » Jaraitė, J., A. Kažukauskas, R. Brännlund, C.K.B. Krishnamurthy, and B. Kriström. 2019. *Intermittency and Pricing Flexibility in Electricity Markets*, Report 2019:588, Energiforsk.

- Conferences, workshops and presentations**
- » Sustainable Development Symposium, Columbia University, New York City, USA. October 2019. Presentation: *Zero carbon electricity markets with grid-scale storage*.


- » Future Electricity Markets Summit, Sydney, Australia, November 2019. Presentation: *Zero carbon electricity markets with grid-scale storage*.

- Teaching and training**
- » Lecturer, Master's level course *Environmental Economics and Policy*, Swedish University of Agricultural Sciences, Umeå, autumn 2019.
 - » Lecturer, Master's level course *Forest Economic Analysis*, Swedish University of Agricultural Sciences, Umeå, autumn 2019.
 - » Main supervisor of PhD candidate Xiao Hu (Department of Forest Economics, Swedish University of Agricultural Sciences, Umeå).



Sofia Käll
PhD candidate

Sofia is a PhD candidate with the Global Economic Dynamics and the Biosphere (GEDB) Academy programme. She has also been employed part-time at the Beijer Institute during the past year, mainly to help develop the institute's new website, which was launched in December 2019. Among other things, she also assisted in organising workshops, including the yearly Askö meeting.



Christina Leijonhufvud
BA, Chief Administrator

Christina was responsible for administration of the Board and Askö meetings in September 2019. She organised the Volvo Environment Prize seminar in November 2019. She is responsible for administration of guest research posts and the Beijer Fellows network, and deals with various office tasks.



Chuan-Zhong Li
Professor, Affiliated researcher

Research focus
Environmental and resource economics, dynamic welfare analysis, sustainability, energy economics, resilience studies.

- Publications**
- » Engström, G., Å. Gren, C.-Z. Li, and C.K.B. Krishnamurthy. 2020. Valuing biodiversity and resilience: An application to pollinator diversity in the Stockholm region. *Spatial Economic Analysis*. In press.

- » Li, C.-Z., Wei, C., and Y. Yu. 2020. Income threshold, household appliance ownership and residential energy consumption in urban China. *China Economic Review* 60:1-12.
- » Shen, M., D. Mao, H. Xie, and C.-Z. Li. 2019. The social costs of marine litter along the East China Sea: Evidence from ten coastal scenic spots of Zhejiang province, China. *Sustainability* 11:1-15.
- » Wu, S., X. Zheng, J. Guo, C.-Z. Li, and C. Wei. 2020. Quantifying energy consumption in household surveys: An alternative device-based accounting approach. *Field Methods* 32:213-232.
- » Yu, Y., and C.-Z. Li. 2020. Green certificate trading, renewable portfolio standard and tax burden reductions. *Chinese Journal of Population, Resources and Environment* 2:80-88 (in Chinese with an English abstract).

Conferences, workshops and presentations

- » The 10th International Research Meeting on Business and Management, subconference in Environmental Economics, Nice, France, July 2019. Presentation: *An explicit formula for optimal carbon taxes under general economic settings*.
- » The first RUC (Renmin University of China) and CAERE (Chinese Association of Environment and Resource Economists) joint workshop, Beijing, China, July 2019. Keynote lecture: *Ecological resilience and economic sustainability: Theory and methods*.



Therese Lindahl
PhD, Programme Director
Behaviour, economics
and nature

Research focus

Human behaviour in social-ecological systems, in particular how ecosystem dynamics (e.g. threshold effects, uncertainty, variability, spatial dynamics) influence resource users' exploitation and cooperation behaviour and implications for natural resource management. Methods for changing attitudes, perceptions and behaviour towards the environment.

Publications

- » Bratman, G.N., C.B. Anderson, M.G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J.J. Gross, T. Hartig, P.H. Kahn Jr., M. Kuo, J.J. Lawler, P.S. Levin, T. Lindahl, A. Meyer-Lindenberg, R. Mitchell, Z. Ouyang, J. Roe, L. Scarlett, J.R. Smith, M. van den Bosch, B.W. Wheeler, M.P. White, H. Zheng, and G.C. Daily. 2019. Nature and mental health: An ecosystem service perspective. *Science Advances* 5:eaax0903.

- » Engström, G., J. Gars, N. Jaakkola, T. Lindahl, D. Spiro, and A. van Benthem. 2020. Beijer Discussion Paper 271: What policies address both the coronavirus crisis and the climate crisis? *Beijer Discussion Paper Series*.
- » Hassler, J., B. Carlén, J. Eliasson, F. Johnsson, P. Krusell, T. Lindahl, J. Nycander, Å. Romson, and T. Sterner. 2020. *Konjunkturrådets rapport 2020: Svensk politik för globalt klimat (The Economic Policy Council Report 2020: Swedish Policy for the Global Climate)*. SNS publisher, Stockholm, Sweden.
- » Schill, C., J. M. Anderies, T. Lindahl, C. Folke, S. Polasky, J.C. Cárdenas, A.-S. Crépin, M.A. Janssen, J. Norberg, and M. Schlüter, 2019. A more dynamic understanding of human behaviour for the Anthropocene, *Nature Sustainability* 2:1075-1082.

Reports

- » Lindahl T. and M. Jonell. 2020. *Metoder för att ändra kostvanor (Methods for Changing Diets)*. Konsumentverket (The Swedish Consumer Agency), report 2020:4.
- » Resare Sahlin K., E. Röö, and T. Lindahl. 2019. *Hållbara val av kött: Konsumenters möjligheter att agera hållbart på den svenska köttmarknaden (Sustainable Meat Choices: Consumer Options to Act Sustainably on the Swedish Meat Market)*, Konsumentverket (The Swedish Consumer Agency), report 2019:5.
- » Röö, E., J. Larsson, K. Resare Sahlin, M. Jonell, T. Lindahl, E. André, S. Säll, N. Harring, and M. Persson. 2020. *Styrmedel för hållbar matkonsumtion: En kunskapsöversikt och vägar framåt (Policy Instruments for Sustainable Food Consumption: A Review of the Evidence and Ways Forward)*. SLU Future Food Reports 13, Swedish University of Agricultural Sciences, SLU Future Food.

Conferences, workshops and presentations

- » Klimatsmart mat och hållbar livsmedelsproduktion (Climate smart food and sustainable food systems), seminar, Studieförbundet Näringsliv och Samhälle (Centre for business and policy studies), Stockholm, October 2019. Invited speaker: *Att skapa ett hållbart livsmedelssystem (Creating a sustainable food system)* (broadcast on Swedish television).
- » En hållbar matkonsumtion för planeten och hälsan: hur kommer vi dit? (Sustainable food consumption for planet and health: how do we get there?), seminar, Konsumentverket (Swedish Consumer Agency), Stockholm, November 2019. Invited speaker (with Malin Jonell): *Metoder att förändra matvanor – vilka styrmedel fungerar på riktigt? (Methods to change eating habits - Which policies work?)*.
- » Earth Stewardship – a foundation for sustainability, Volvo Environment Prize Semi-

nar, the Swedish Royal Museum of Natural History, November 2019. Moderator.

- » Seminar in economics, Thailand Development Research Institute (TDRI), Bangkok, Thailand, January 2020. Invited speaker: *Collective action for avoiding ecological regime shifts: insights from behavioural experiments*.
- » Konjunkturrådsrapporten 2020 (Economic Policy Council Report 2020), seminar and panel discussion, Studieförbundet Näringsliv och Samhälle (Centre for Business and Policy Studies), Stockholm, January 2020. Panellist.
- » Economics seminar series, Department of Economics, Swedish University of Agricultural Sciences, Ultuna, March 2020. Invited speaker: *Collective action for avoiding ecological regime shifts: insights from behavioural experiments*.
- » Research seminar series, Institute for Future Studies (IFFS), online, April 2020. Invited speaker: *Swedish policy for global climate: what is it and how can we get there?*
- » Utvecklingsprogrammet (the Development Programme) KlimATval, digital workshop, Stockholm Resilience Centre, Albaeco, and Sveriges kommuner och Regioner (Sweden's Municipalities and Regions), April 2020. Organiser and presentation.
- » Webinar organised by Konsumentverket (Swedish Consumer Agency), May 2020. Invited speaker (with Malin Jonell): *Metoder för att ändra kostvanor (Methods for changing diets)*.
- » Kunskapsklustret för hållbara städer (Knowledge cluster for sustainable cities), online workshop series, Centre for Sustainable Urban Futures, University of Gothenburg and Chalmers University of Technology, Gothenburg, April-June 2020. Participant.
- » Framtidens matbutik (Future food stores), online workshop, Vinnova (Sweden's innovation agency), June 2020. Participant.

Teaching and training

- » Lecturer and examiner, Master's level course *Governance and management of social-ecological systems: Economic perspectives*, Stockholm Resilience Centre, Stockholm University, spring 2020.
- » Lecturer, undergraduate level course *Ekologisk ekonomi (Ecological economics)*, Department of Physical Geography and Stockholm Resilience Centre, Stockholm University, spring 2020.
- » Lecturer, undergraduate level course *Environmental management in planning*, Department of Physical Geography, Stockholm University, spring 2020.
- » Co-supervisor of PhD candidate Noah Linder (Environmental Psychology, Department of Building, Energy, and Environmental Engineering, University of Gävle, Gävle).

- » Co-supervisor of PhD candidate Lina Isacs (Division of Environmental Strategies Research, Royal Institute of Technology, Stockholm).

Commissions

- » Scientific council member, Fores, Stockholm, since 2010.
- » Co-stream leader of Biosphere Stewardship Stream, Stockholm Resilience Centre, Stockholm University, since 2016.
- » SARAS Associate, South American Institute for Resilience and Sustainability Studies (SARAS), since 2018.
- » Journal reviewer for *Proceedings of the National Academy of Sciences of the United States of America*, *Environmental and Resource Economics*, *Journal of Environmental Economics and Management*, *Economic Policy*, *Ecological Economics*, and *Resources, Conservations & Recycling*.

Grants awarded in competition

- » "What makes effective climate policies politically feasible", FORMAS (Swedish government research council for sustainable development) grant, 5 years, SEK 10 M. Principal investigator.
- » "Mistra food Futures", Mistra (the Swedish Foundation for Strategic Environmental Research) grant, 5 years, SEK 80m. Co-applicant and work package leader.

Media coverage

- » Inrikta svensk klimatpolitik på globala utsläppsminskningar (Steer Swedish climate policy towards global emission reductions). Hassler J., B. Carlén, J. Eliasson, F. Johnsson, P. Krusell, T. Lindahl, J. Nycander, Å. Romson, and T. Sterner. *Dagens Nyheter*, debate article, 15 January 2020.
- » Det behöver bli lätt att äta rätt (It has to be easy to eat right). André E., N. Harring, M. Jonell, J. Larsson, T. Lindahl, M. Persson, E. Röö, K. Resare Sahlin, and S. Säll. *Dagens Nyheter*, debate article, June 15 2020.
- » Stat och kommun kan spela en större roll för vår matkultur (State and municipality can play a greater role in our food culture). André E., N. Harring, M. Jonell, J. Larsson, T. Lindahl, M. Persson, E. Röö, K. Resare Sahlin, and S. Säll 2020. *Dagens Nyheter*, debate article, 26 June 2020.
- » Från köttnorm till vegonorm - vilka metoder är mest effektiva för att nå ett grönt paradigmskifte? (From meat norm to vego norm – what are the most effective methods for achieving a green paradigm shift?). *Mat & Klimat*, 10 June 2020.



Daniel Ospina
PhD candidate

Research focus

Coupled dynamics of rural livelihoods and landscapes in developing regions, amidst increasing global connectivity and urbanisation. Understanding how rural out-migration and remittances shape land use/management decisions, and particularly the conditions under which these rural-urban teleconnections can contribute to forest regrowth.

Conferences, workshops and presentations

- » SES-link project winter retreat, Stockholm, January 2020. Participant.
- » Beijer Young Scholars 3, online workshop, June 2020. Participant.

Teaching and training

- » Lecturer, Master's level course *Resilience Reflections and Applications*, Stockholm Resilience Centre, Stockholm University, spring 2020.

Other

- » Member of Beijer Young Scholars 3, topic: Globalisation and the Biosphere, since 2019.
- » Parental leave: July-December 2019 (100%); January-March 2020 (50%); April-June 2020 (20%)



Caroline Schill
PhD, Researcher

Research focus

Human behaviour in social-ecological systems. How human behaviour shapes, and is shaped by, different social-ecological contexts. Particular interest in collective action and sustainability in contexts of environmental change and uncertainty.

Publications

- » Rocha, J., C. Schill, L.M. Saavedra-Díaz, R. del Pilar Moreno-Sánchez, and J.H. Maldonado. 2019. Beijer Discussion Paper 268: Cooperation in the face of thresholds, risk, and uncertainty. *Beijer Discussion Paper Series*.
- » Schill, C., J.M. Anderies, T. Lindahl, C. Folke, S. Polasky, J.C. Cárdenas, A.-S. Crépin, M.A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075-1082.

- » Schill, C. and J.C. Rocha. 2019. Beijer Discussion Paper 270: Uncertainty can help protect local commons in the face of climate change. *Beijer Discussion Paper Series*.

Reports

- » The Care Operative (Bernstein, M.J., M. Chapman, I. Diaz-Reviriego, G. Dressler, M. Felipe Lucia, C. Friis, S. Graham, H. Haenke, J. Haider, M. Hernandez, H. Hoffmann, M. Kernecker, P. Nicol, C. Piñeiro, H. Pitt, C. Schill, V. Seufert, K. Shu, V. Valencia, and J. Zaehringer). 2020. *Collaborating with Care in Virtual Sessions*. Open Science Foundation. Available at: <https://doi.org/10.17605/OSF.IO/HG3SW>.
- » Postdoc Academy for Transformational Leadership Seminar III, Bosch Foundation, Transformative capacity and agency for people and planet, Stockholm Resilience Centre, Stockholm University, October 2019. Participant.
- » Earth Stewardship – a foundation for sustainability, Volvo Environment Prize Seminar, the Swedish Royal Museum of Natural History, November 2019. Panel member.
- » Beijer Young Scholars 2, proposal writing workshop (Inequality and the Biosphere: Achieving the Sustainable Development Goals in an Unequal World), Stockholm, December 2019. Organiser and participant.
- » Postdoc Academy for Transformational Leadership, Care Operative workshop, online, March 2019. Participant.

Teaching and training

- » Module leader, lecturer and examiner, Master's level course *Governance and management of social-ecological systems: Theories and methods for governance of the commons*, Stockholm Resilience Centre, Stockholm University, spring 2020.
- » Co-supervisor of Master's student trainee Paula Sanchez Garcia (Social-Ecological Resilience for Sustainable Development, Stockholm Resilience Centre, Stockholm University).

Commissions

- » Journal reviewer for *Ecological Economics* and *One Earth*.

Other

- » Member of the Postdoc Academy for Transformational Leadership of the Robert Bosch Foundation (first cohort), since 2018.
- » Blog post: Outbreaks, break-outs and break-times: Creating caring online workshops. The Care Operative. *Integration and Implementation Insights: Research resources for understanding and acting on complex*

real-world problems blog (i2insights.org), 16 June 2020.

- » Parental leave: July–August 2019 (100%); January–March 2020 (50%); April–June 2020 (20%).



Agneta Sundin
Communications Officer

Agneta’s responsibilities include developing and editing the website and the annual report and administering the Beijer publication series, as well as taking part in organising workshops and other events. A member of Stockholm Resilience Centre’s (SRC) communications team, Agneta is involved in activities arranged jointly by SRC, Beijer and Albaeco, for example the Stockholm Seminars series. In addition, she was project leader for the course for students at the Beckman School of Design in February–March and the subsequent exhibition Tipping Points, which has been postponed to September 2020. In autumn 2019, she led the project to develop a new website for the institute, which was successfully launched in December 2019.



Max Troell
Associate Professor,
Programme Director
Aquaculture and sustainable seafood

Research focus

Sustainability of global seafood system, aquaculture, capture fisheries, governance of coastal and marine ecosystems, ecosystem functions and services, biodiversity, resilience, regime shifts, food systems, nutrition and food security, integrated aquaculture, food/seafood trade dynamics, sustainability metrics, life-cycle analysis, seafood certification standards.

Publications

- » Crona, B., E. Wassénius, M. Troell, K. Barclay, T. Mallory, M. Fabinyi, W. Zhang, V.W.Y. Lam, L. Cao, P.J.G. Henriksson, and H. Eriksson. China’s seafood sector at a crossroads? *One Earth*. In press.
- » Gephart, J., C.D. Golden, F. Asche, B. Belton, C. Brugere, H.E. Froehlich, J.P. Fry, B.S. Halpern, C.C. Hicks, R.C. Jones, D.H. Klinger, D.C. Little, D.J. McCauley, S.H. Thilsted, M. Troell, and E.H. Allisom. Scenarios for global aquaculture and its role in human nutrition. *Reviews in Fisheries Science & Aquaculture*. In press.
- » Hallström, E., K. Bergman, K. Mifflin, R. Parker, P. Tyedmers, M. Troell, and F. Ziegler. 2019. Combined climate and nutritional performance of seafoods. *Journal of Cleaner*

Production 230:402–411.

- » Henriksson, P.J.G., L.K. Banks, S.K. Suri, T.Y. Pratiwi, M.R. Fatan, and M. Troell. 2019. Indonesian aquaculture futures — identifying interventions for reducing environmental impacts. *Environmental Research Letters* 14:124062.
- » Jørgensen, P.S., C. Folke, P.J.G. Henriksson, K. Malmros, M. Troell, A. Zorzet, and members of the Living with Resistance project. 2020. Coevolutionary governance of antibiotic and pesticide resistance. *Trends in Ecology and Evolution* 35(6):484–494.
- » Kummu, M., P. Kinnunen, E. Lehikoinen, M. Porkka, C. Queiroz, E. Röö, M. Troell, and C. Weil. 2020. Interplay of trade and food system resilience: Gains on supply diversity over time at the cost of trade interdependency. *Global Food Security* 24:100360.
- » Metian, M., M. Troell, V. Christensen, J. Steenbeek, and S. Poui. 2019. Mapping diversity of species in global aquaculture. *Reviews in Aquaculture* 12(2):1090–1100.
- » Tlustý, M.F., P. Tyedmers, M. Bailey, F. Ziegler, P.J.G. Henriksson, C. Béné, S. Bush, R. Newton, F. Asche, D.C. Little, M. Troell, and M. Jonell. 2019. Reframing the sustainable seafood narrative. *Global Environmental Change* 59:101991.

Reports

- » Axfoundation. 2020. *Kriterier och frågebatteri för ansvarsfull användning av antibiotika till livsmedelsproducerande djur Version 2.0 (Criteria and Issues Regarding Responsible Use of Antibiotics in Animal Farming)*, Axfoundation Report, Sweden.
- » Troell, M., M. Jonell, and B. Crona. 2019. Scoping report: *The Role of Seafood in Sustainable and Healthy Diets, The EAT-Lancet Commission Report Through a Blue Lens*. Stockholm Resilience Centre, Beijer Institute, Global Economic Dynamics and the Biosphere, Stockholm, Sweden.

Conferences, workshops and presentations

- » Exploring factors influencing antimicrobial resistance in Europe, workshop, AMResilience Project, Stockholm Resilience Centre, September, 2019. Participant.
- » Agri4D 2019: zero hunger by 2030, our shared challenge, conference, Agricultural Research for Development Conference, Swedish University of Agricultural Sciences, Uppsala, September, 2019. Participant.
- » Dialogmöte - Behovsanalys inför havs- och fiskeriprogrammet 2021–2027 (Dialogue meeting – Needs analysis for the Seas and Fisheries Programme 2021–2027), Jordbruksverket (Swedish Board of Agriculture). Jönköping, November 2019. Participant.
- » Reference group meeting, Criteria for sustainable antibiotic use within Swedish

animal farming, workshop, Axfoundation, Stockholm, November 2019. Participant.

- » MASMA (Marine and Coastal Science for Management) Grantees Meeting, Mombasa, Kenya, November 2019. Participant.
- » Regional workshop on development of an integrated livelihoods approach for Pacific Island small-scale fishing communities, Townsville, Australia, November 2019. Participant.
- » Blue Economy, mini-symposium and workshop, University of Wollongong, Wollongong, Australia, December 2019. Participant.
- » 20-year retrospective Nature Paper, workshop, Center on Food Security and the Environment (FSE), Stanford University, Stanford, USA, January 2020. Participant.
- » Blue Food Assessment, Scientific Team Leadership Meeting, Stanford University, Stanford, USA, January 2020. Participant.
- » Aquaculture Environmental Impact and Nutrition Modeling, workshop, Harvard School of Public Health, Boston, USA, February 2020. Participant.
- » Genomförandet av den strategiska forskningsagendan för livsmedel: Vägen till ett hållbart och konkurrenskraftigt livsmedelssystem (Implementing the strategic research agenda for food: Pathways to a sustainable and competitive food system), workshop, FORMAS (Swedish government research council for sustainable development), Stockholm, January 2020. Participant.

Commissions

- » Member of MASMA (Marine and Coastal Science for Management) Programme Committee, Research reviews and programme support, Western Indian Ocean Marine Science Association, since 2007.
- » Lead researcher for joint work on Antibiotics, SeaBOS (Seafood Business for Ocean Stewardship).
- » Member of the Expert Group on Kriterier och frågebatteri för ansvarsfull användning av antibiotika till livsmedelsproducerande djur Version 2.0 (*Criteria and issues regarding responsible use of antibiotics in animal farming*), Axfoundation.
- » Internal committee member for PhD thesis evaluation of Jean-Baptiste Jouffray with title: *The Anthropocene Ocean*, Stockholm Resilience Centre, Stockholm University, November 2019.
- » Evaluation committee member for the PhD thesis of Richard Cottrell with title: *Bridging the Land-Sea Divide: Links, Interactions and Trade-Offs for Food Security and Sustainability*, University of Tasmania, New Zealand, 18 November 2019.
- » Journal review editor for *Aquaculture Environment Interactions* (AEI), *Frontiers in Marine Science*, and *Western Indian Ocean Journal of Marine Science*.

- » Journal Reviewer for *Nature Foods*, Marine Policy, and *Aquaculture Environment Interactions*.

Media coverage

- » Interviewed in Swedish Radio Science Programme (SR Vetenskapsradion) for a story with title: *Fiskodling ute till havs fortstärker att utvecklas* (Offshore marine aquaculture is developin), 17 Februray 2020. Available at: <https://sverigesradio.se/sida/artikel.aspx?programid=406&artikel=7408538>

Publications

Journal articles

- » Barrett, S., A. Dasgupta, P. Dasgupta, W. Neil Adger, J. Anderies, J. van den Bergh, C. Bledsoe, J. Bongaarts, S. Carpenter, F.S. Chapin, A.-S. Crépin, G. Daily, P. Ehrlich, C. Folke, N. Kautsky, E.F. Lambin, S.A. Levin, K.G. Mäler, R. Naylor, K. Nyborg, S. Polasky, M. Scheffer, J. Shogren, P. S. Jørgensen, B. Walker, and J. Wilen. 2020. Social dimensions of fertility behavior and consumption patterns in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America* 117(12):6300–6307.
- » Boltz, F., N. LeRoy Poff, C. Folke, N. Kete, C.M. Brown, S. St. George Freeman, J.H. Matthews, A. Martinez, and J. Rockström. 2019. Water is a master variable: Solving for resilience in the modern era. *Water Security* 8:100048.
- » Bratman, G.N., C.B. Anderson, M.G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J.J. Gross, T. Hartig, P.H. Kahn Jr., M. Kuo, J.J. Lawler, P.S. Levin, T. Lindahl, A. Meyer-Lindenberg, R. Mitchell, Z. Ouyang, J. Roe, L. Scarlett, J.R. Smith, M. van den Bosch, B.W. Wheeler, M.P. White, H. Zheng, and G.C. Daily. 2019. Nature and mental health: An ecosystem service perspective. *Science Advances* 5:eaax0903.
- » Causevic, A. and I. Al-Marashi. 2020. Can NATO evolve into a climate alliance treaty organization in the Middle East? *Bulletin of the Atomic Scientists* 76(2):97–101.
- » Colding, J., S. Barthel, and P. Sörqvist. 2019. Wicked problems of smart cities. *Smart Cities* 2(4):512–521.
- » Colding, J., M. Colding, and S. Barthel. 2020. Applying seven resilience principles on the vision of the Digital City. *Cities* 103:102761.
- » Colding, J., M. Giusti, A. Haga, M. Wallhagen, and S. Barthel. 2020. Enabling relationships with nature in cities. *Sustainability* 12(11):4394.
- » Colding, J., Å. Gren, and S. Barthel. 2020. The incremental demise of urban green spaces. *Land* 9(5):162.

- » Colding, J., M. Wallhagen, P. Sörqvist, L. Marcus, K. Hillman, K. Samuelsson, and S. Barthel. 2020. Applying a systems perspective on the notion of the Smart City. *Smart Cities* 3(2):420–429.
- » Folke, C., H. Österblom, J. B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2019. Transnational corporations and the challenge of biosphere stewardship. *Nature Ecology and Evolution* 3(10):1396–1403.
- » Folke, C., H. Österblom, J.-B. Jouffray, E.F. Lambin, W.N. Adger, M. Scheffer, B.I. Crona, M. Nyström, S.A. Levin, S.R. Carpenter, J.M. Anderies, S. Chapin, A.-S. Crépin, A. Dauriach, V. Galaz, L.J. Gordon, N. Kautsky, B.H. Walker, J.R. Watson, J. Wilen, and A. de Zeeuw. 2020. An invitation for more research on transnational corporations and the biosphere. *Nature Ecology and Evolution* 4:494.
- » Garcia, D., V. Galaz, and S. Daume. 2019. EATLancet vs yes2meat: the digital backlash to the planetary health diet. *The Lancet* 394:2153–2154.
- » Garmestani, A.S., J.B. Ruhl, B.C. Chaffin, R.K. Craig, H.F.M.W. van Rijswijk, D.G. Angeler, C. Folke, L.H. Gunderson, D.Twidwell, and C.R. Allen. 2019. Untapped capacity for resilience in environmental law. *Proceedings of the National Academy of Sciences of the United States of America* 116:19899–19904.
- » Gars, J. and C. Olovsson. 2019. Fuel for economic growth? *Journal of Economic Theory* 184:104941.
- » Gunderson, L., C. Folke, and M.A. Janssen. 2019. Remembering Buzz Holling. *Ecology and Society* 24(4):39.
- » Hallström, E., K. Bergman, K. Mifflin, R. Parker, P. Tyedmers, M. Troell, and F. Ziegler. 2019. Combined climate and nutritional performance of seafoods. *Journal of Cleaner Production* 230:402–411.
- » Heijungs, R., J.B. Guinée, A. Mendoza Beltrán, P.J.G. Henriksson, and E. Groen. 2019. Everything is relative and nothing is certain. Toward a theory and practice of comparative probabilistic LCA. *International Journal of Life Cycle Assessment* 24(9):1573–1579.
- » Henriksson, P.J.G., L.K. Banks, S.K. Suri, T.Y. Pratiwi, M.R. Fatan, and M. Troell. 2019. Indonesian aquaculture futures — identifying interventions for reducing environmental impacts. *Environmental Research Letters* 14:124062.
- » Herrfahrdt-Pähle, E., M. Schlüter, P. Olsson, C. Folke, S. Gelcich, and C. Pahl-Wostl. 2020. Sustainability transformations: socio-political shocks as opportunities for governance transitions. *Global Environmental Change* 63:102097.

- » Jørgensen, P.S., C. Folke, P.J.G. Henriksson, K. Malmros, M. Troell, A. Zorzet, and members of the Living with Resistance project. 2020. Coevolutionary governance of antibiotic and pesticide resistance. *Trends in Ecology and Evolution* 35(6):484–494.
- » Jørgensen, P.S., C. Folke, and S.C. Carroll. 2019. Evolution in the Anthropocene: Informing governance and policy. *Annual Review of Ecology, Evolution, and Systematics* 50:527–546.
- » Keys, P., V. Galaz, M. Dyer, N. Matthews, C. Folke, M. Nyström, and S. Cornell. 2019. Anthropocene risk. *Nature Sustainability* 2:667–673.
- » Krishnamurthy, C.K.B. and N. Ngo. 2020. The effects of smart-parking on transit and traffic: Evidence from SFpark. *Journal of Environmental Economics and Management* 99:102273.
- » Kummu, M., P. Kinnunen, E. Lehikoinen, M. Porkka, C. Queiroz, E. Röö, M. Troell, and C. Weil. 2020. Interplay of trade and food system resilience: Gains on supply diversity over time at the cost of trade interdependency. *Global Food Security* 24:100360.
- » Li, C.-Z., Wei, C., and Y. Yu. 2020. Income threshold, household appliance ownership and residential energy consumption in urban China. *China Economic Review* 60:1–12.
- » Metian, M., M. Troell, V. Christensen, J. Steenbeek, and S. Poui. 2019. Mapping diversity of species in global aquaculture. *Reviews in Aquaculture* 12(2):1090–1100.
- » Norström, A.V., C. Cvitanovic, M.F. Lóf, S. West, C. Wyborn, P. Balvanera, A.T. Bednarek, E.M. Bennett, R. Biggs, A. de Bremond, B.M. Campbell, J.G. Canadell, S.R. Carpenter, C. Folke, E.A. Fulton, O. Gaffney, S. Gelcich, J.B. Jouffray, M. Leach, M. Le Tissier, B. Martín-López, E. Louder, M.F. Loutre, A.M. Meadow, H. Nagendra, D. Payne, G.D. Peterson, B. Reyers, R. Scholes, C.I. Speranza, M. Spierenburg, M. Stafford-Smith, M. Tengö, S. van der Hel, I. van Putten, and H. Österblom. 2020. Principles for knowledge co-production in sustainability research. *Nature Sustainability* 3(3):182–190.
- » Nyström, M., J.-B. Jouffray, A. Norström, P. Sogaard-Jørgensen, V. Galaz, B.E. Crona, S.R. Carpenter, and C. Folke. 2019. Anatomy and resilience of the global production ecosystem. *Nature* 575:98–108.
- » Sanecka, J., S. Barthel, and J. Colding. 2020. Countryside within the city: A motivating vision behind civic green area stewardship in Warsaw, Poland. *Sustainability* 12(6):2313.
- » Schill, C., J.M. Anderies, T. Lindahl, C. Folke, S. Polasky, J.C. Cárdenas, A.-S. Crépin, M.A. Janssen, J. Norberg, and M. Schlüter. 2019. A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability* 2:1075–1082.

» Schlüter, M., L.J. Haider, S.J. Lade, E. Lindkvist, R. Martin, K. Orach, N. Wijermans, and C. Folke. 2019. Capturing emergent phenomena in social-ecological systems: An analytical framework. *Ecology and Society* 24(3):11.

» Shen, M., D. Mao, H. Xie, and C.-Z. Li. 2019. The social costs of marine litter along the East China Sea: Evidence from ten coastal scenic spots of Zhejiang province, China. *Sustainability* 11:1-15.

» Stoll, J.S., M. Bailey, and M. Jonell. 2019. Alternative pathways to sustainable seafood. *Conservation Letters* 13:e12683.

» Tlusty, M.F., P. Tyedmers, M. Bailey, F. Ziegler, P.J.G. Henriksson, C. Béné, S. Bush, R. Newton, F. Asche, D.C. Little, M. Troell, and M. Jonell. 2019. Reframing the sustainable seafood narrative. *Global Environmental Change* 59:101991.

» Wu, S., X. Zheng, J. Guo, C.-Z. Li, and C. Wei. 2020. Quantifying energy consumption in household surveys: An alternative device-based accounting approach. *Field Methods* 32:213-232.

» Yu, Y. and C.-Z. Li. 2020. Green certificate trading, renewable portfolio standard and tax burden reductions. *Chinese Journal of Population, Resources and Environment* 2:80-88 (in Chinese with an English abstract).

» Zipper, S.C., F. Jaramillo, L. Wang Erlandsson, S.E. Cornell, T. Gleeson, M. Porkka, T. Häyhä, A.-S. Crépin, I. Fetzer, D. Gerten, H. Hoff, N. Matthews, C. Ricarte-Villota, M. Kumm, Y. Wada, and L. Gordon. 2019. Integrating the water planetary boundary with water management from local to global scales. *Earth's Future* 8(2):e2019EF001377.

Books

» Galaz, V. (editor) 2019. *Global Challenges, Complexity, and Governance: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

» Hassler J., B. Carlén, J. Eliasson, F. Johnsson, P. Krusell, T. Lindahl, J. Nycander, Å. Romson, and T. Sterner. 2020. *Konjunkturrådets rapport 2020: Svensk politik för globalt klimat (The Economic Policy Council Report 2020: Swedish Policy for the Global Climate)*. SNS publisher, Stockholm, Sweden.

Book chapters

» Crépin, A.-S. 2019. Complexity, resilience and economics. Pages 166-187 in V. Galaz, editor: *Global Challenges, Governance, and Complexity: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

» Folke, C. 2019. Governing for emergence in social-ecological systems. Pages 24-37 in V. Galaz, editor: *Global Challenges, Governance, and Complexity: Applications and Frontiers*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA.

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Humanity is embedded in the Biosphere and shape it from local to global scales, from the past to the future. At the same time humanity is fundamentally dependent on the capacity of the Biosphere to sustain development.

The major objectives of the Beijer Institute are to carry out research and stimulate scientific cooperation to promote a deeper understanding of the interplay between ecological systems and social and economic development. Cooperation efforts include collaborative research between economists and ecologists and related disciplines on fundamental and applied problems in relation to sustainability, as well as teaching and training on those issues nationally and internationally.

The Beijer Institute's major activities are international research programmes, synthesis workshops, a broad set of research projects, teaching and training programmes, dissemination of results, the science-policy interface and collaborative communication.

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