

Regards

Katherine Richardson: An oceanographer with a global outlook and a pioneer in Sustainability Science

Interview by Bernard Hubert and Niels Halberg

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Katherine Richardson is Professor in biological oceanography at the University of Copenhagen and leader of the Sustainability Science Centre at the same University.

The overall focus of her research is to better understanding of the role of biological processes and biodiversity in the cycling of carbon in the upper ocean and how this impacts food webs and the global carbon cycle. In addition, she has recently been working with an international research team focusing on identifying “planetary boundaries”, i.e. identifying a “safe operating space” for human societies in relation to anthropogenic impact on critical Earth System processes.

The Sustainability Science Centre

NSS: Natures Sciences Sociétés is a French scientific journal, established 21 years ago focusing on nature-society relations, environmental issues and interdisciplinary approaches. It is of huge interest to the different schools of thought involved in these issues, and Sustainability Science is definitely one of them. You are one of the initiators in relation to the establishment of the Sustainability Science Centre¹ at the University of Copenhagen and you chair its Steering Committee. Why did you take this initiative? How does it allow a renewal in academic curricula, taking into account the necessity of “combining

traditional disciplines to determine how to meet the needs of the present without adversely affecting future generations: i.e. bringing together social, natural, technical and health scientists as well as experts in the humanities...”? Did you design new educational pathways to fit these aims?

Katherine Richardson: We took this initiative because we see a need in society for an infrastructure that can channel a “systems perspective” into decision-making. Traditionally, we work in specific disciplines or sectors but the challenges facing society are multi-faceted and cannot be solved by “adding” sector solutions together. Agriculture is one of the best examples here – we need not

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only knowledge of agriculture but water systems, biodiversity, circular economy, resource efficiency, watershed ecology, etc. to make good decisions and find sustainable solutions. I regret in some ways that we called it a “centre” because people tend to think of centres at universities as being research centres – ours is simply a platform designed to do two things – 1) foster cooperation between the different faculties and institutes at the university on research and teaching that relates to sustainability and 2) be a “one-stop shop” where society’s decision makers from both the public and private sectors can access the competences from different disciplines that they need to address a particular problem. Traditionally, we have thought that the way that universities support societal development has been largely through technological development of “things” or “processes” that can be sold or make production process more efficient or cheaper. It was “easy” to find the researcher who worked on that specific problem. Nevertheless, there are lots of publicly financed infrastructures (technological institutes to bridge from “basic” to “applied” research, funds for supporting proof of concept, etc.). As the paradigm changes and we need “convergence” of disciplines (see MIT white book on convergence²), we need new forms of infrastructure and we believe the Sustainability Science Centre is a valid prototype. And, yes, at the university we have developed new forms of cross-institute/faculty teaching as a result of our having the centre.

Convergence of disciplines

NSS: “Convergence of disciplines” – what do you mean by that? Is it something like an interdisciplinary approach or is it something interfacing the different disciplines and building towards mergers with different disciplines or is it something completely different like building a new discipline?

Katherine Richardson: Interdisciplinarity and convergence are two very different things. In interdisciplinary research a researcher gets the idea of what he/she wants to do. He/she realizes that competences from other disciplines are needed to reach the goal and, therefore, invites researchers from other disciplines into the project. In convergence, the idea (vision) for the research is developed with equal input from the representatives from different disciplines and the product of the research is,

therefore, different than in the inter or “multidisciplinary” project. Convergence is an attempt to exploit the very fertile research ground that lies between disciplines. Thus, convergence requires that you learn the language of other disciplines than your own and really interact with those disciplines. It becomes part of your training or education to understand and to think like an economist even if you are a biologist. And obviously, it is a fine balance here. We need to be very good in our own disciplines to succeed but that does not preclude developing an understanding for other disciplines. I personally believe that what you learn in education is how to learn – what I actually use of the biology courses I had at university is very little because biology has changed so much since then, but I learned how to learn. So if you learn how to learn you can actually learn how to learn in different fields too. We all complain that it is difficult with the language between disciplines – it is a question of learning it from the bottom, I mean from the start – learning to think in two different disciplines.

NSS: Then the problem/question is how to convince people that you do not dilute your own competences and thereby devalue yourself as a scientist when you attempt to approach a research question from several different disciplinary angles.

Katherine Richardson: Yes – our traditional Humboldtian understanding of success as an academician is achieving the highest level of training/understanding within a single discipline. That results in many experts in many disciplines but very little understanding of how the systems that the different disciplines are components of actually work. With the challenges facing human society today, a systems understanding becomes paramount and we must find a way to bring the disciplines together. Spread your fingers and look at your hand. It can be used as an analogy here where your fingers represent different disciplines. We always build on the top of the disciplines, making the fingers longer and longer and the space between the fingers becomes greater and greater. Most of the great discoveries that have emerged in recent years have come at the interface between disciplines, i.e. the area between your fingers. We need to develop infrastructures and processes that can increase the probability of us exploiting those regions between your fingers.

NSS: And also we need two hands.

Katherine Richardson: Yeah exactly.

NSS: Your background is in oceanography and you are involved in research dealing with climate changes; why did you join the Sustainability Science community? What does it contribute to the development of your research area?

Katherine Richardson: In the late 1990s, I became a member of the IGBP (International Biosphere Geosphere Program) scientific steering committee. My research had

² Sharp, P.A., et al., 2011. *The third revolution: The convergence of the life sciences, physical sciences and engineering*, Report, MIT. See also Roco, M.C., Bainbridge, W.S., Tonn, B., Whitesides, G. (Eds), 2013. *Converging knowledge, technology, and society: Beyond convergence of nano-bio-info-cognitive technologies*, Dordrecht, Heidelberg, New York, London, Springer, <http://www.wtec.org/NBIC2/Docs/FinalReport/Pdf-secured/NBIC2-FinalReport-WTECversion--web.pdf>.

always been focused on carbon cycling in the ocean but, through the IGBP, I learned to see my carbon cycling in the ocean in an Earth system context – what does my phytoplankton mean in a global context instead of just an ocean context? I was “caught” and ended up being an author on a synthesis book *Global change and the Earth system: A planet under pressure*³. Later, I became part of the research team that has developed “Planetary Boundaries⁴” – an attempt to use science to define a safe operating space for humanity. How much of Earth’s resources and services can we deplete without seriously jeopardizing the stability of the Earth system? Through Sustainability Science, my research is set in a context that can be useful for the societal decision-making that can lead to sustainable development.

Sustainability Science Congress 2014

NSS: In your experience – has it been more challenging than expected to get key researchers onboard in this cross-disciplinary effort? Did the Centre produce the types of synthesis and output you had hoped?

Katherine Richardson: Actually, many of the really good researchers have jumped onto the idea and support the centre fully! So, I have been heartened by the enthusiasm which the researchers have shown. It has been harder to get the university administration to support the initiative as all of our administration is built up in “towers” associated with the different faculties and it can be exceedingly difficult to do anything that crosses between the towers. We have had some fantastic initiatives that have been coordinated by the centre. These include teaching initiatives (a new Masters in climate change), presentations for the general public and development of applications for research funding. At present we have a huge and exciting project. We are responsible for organizing on behalf of 10 leading universities (including Oxford, Cambridge, Yale, Berkeley, Peking, Tokyo, Singapore...) a Sustainability Science Congress from October 22-24, 2014⁵.

At the Sustainability Science Centre website there is a description of the meeting – it is a very high-level conference actually. The Prime Minister and the Climate Commissioner and the Crown Prince will participate, as well as Guido Schmidt Traub, the director of the United

Nations’ Sustainable Development Network. Also, other very high-level people are coming, among these Jane Lubchenco, who will be a speaker. In fact, the French research attaché in Copenhagen has asked me to identify people from France, who ought to come because they consider it as a build-up to the COP21 in Paris in 2015. There are many really, really relevant topics – also for agricultural science – there is a session on biomass as a natural resource, there is a session on feeding 9 billion people, there are sessions on moving from climate to sustainability. We also have a very constructive dialogue with the private sector, including financial support from both business and a philanthropic fund (Velux Foundations).

NSS: One thing is getting people together to talk, but will they actually cooperate?

Katherine Richardson: Well, if you take our Sustainability Science Congress as an example, each of the sessions is defined around a problem, and they are trying to find the solution. For example, the problem for biomass is that the Earth system scientists, like Steve Running (see his paper last year in *Science*⁶), say that it is light that limits everything in the terms of net primary production and we cannot really change that very much through agriculture. We can change the amount of material which is directly usable by humans, but we do not change net primary production per se very much. So he, and his school, estimates that there are about 5 gigatons more biomass that we can appropriate. That is about the equivalent of 40% of energy demand today so, clearly, if these analyses are right, then biomass cannot solve the energy challenge as many believe. On the other hand, the conventional agriculture people say: no, with agriculture we can greatly improve yields – the sky is the limit. The truth probably lies somewhere in the middle so for this session, we brought these two groups together and they address the question “What do we really think – how much more biomass is available out there”.

NSS: Do you see social sciences as a part of this new mixing, new crossing?

Katherine Richardson: Absolutely, and they are involved in several sessions at the congress, e.g. about governance in light of Planetary Boundaries. We have limits as to how much we can take out of the planet – what does that mean for governance systems. We have another session called “Reconciling the cultural differences in the understanding of human/Earth relationship”. We also have a really fantastic keynote speaker named Julian Agyeman from Tufts University, who deals with equity and ethics in all of this, so the social sciences are essential for achieving sustainable development and clearly constitute a component of Sustainability Science.

³ Steffen, W., Sanderson, A., Tyson, P.D., Jäger, J., Matson, P.A., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.J., Turner, B.L., Wasson, R.J., 2004. *Global change and the Earth system: A planet under pressure*, Berlin Heidelberg New York, Springer-Verlag.

⁴ Rockström, J. et al., 2009. A safe operating space for Humanity, *Nature*, 461, 472-475.

⁵ <http://sustainability.ku.dk/iarucongress2014/>.

⁶ Running, S.W., 2012. A measurable planetary boundary for the biosphere, *Science*, 337, 6101, 1458-1459.

Ecological Economics as a part of Sustainability Science

NSS: Last year the conference of the European Society for Ecological Economics was held in Lille, and the organizers received about 700 proposals! You know this community of Ecological Economics, and in your opinion – what are the differences between Sustainability Science and this community?

Katherine Richardson: I certainly consider Ecological Economics as a part of Sustainability Science. Sustainability Science is simply using the new knowledge that we create through research in order to be able to put, or maintain in some cases, human societal development on a sustainable track. And that means that the human demand for the Earth's resources and services must be held to within the actual supply of those resources/services. Part of our problem is the economic models that we use do not accurately reflect the cost of the Earth's resources and services and ecological economics might be able to supply better models but there are other schools of thought out there. Some people believe that the existing economic tools can be transitioned to promote sustainable development. All options must be considered. At our congress, there is a session called "Sustainable transition" or "Economic tools for sustainable transition". What I am trying to say about this meeting is that it is not the scientists who identify themselves as being economic or ecological economists, it is not the microbiologists and it is not the geologists – it is bringing all of these different people together, the different strains of thinking in economics and getting them working together to identify a vision for meeting the challenges society is facing.

Sustainable development and Sustainability Science

NSS: Do you think that this Sustainability Science community is at the forefront of research within sustainable development today? How do you feel the relevance of this 27 years after the Brundtland report and 22 years after the first World Summit in Rio? For scientists? policy makers? citizens and civil society?

Katherine Richardson: When the Brundtland report extended the traditional understanding of "sustainable development" to include not only economic sustainability but also environmental and social sustainability, we really couldn't quantify environmental sustainability. Today – thanks to research – we are in a much better position to define environmental sustainability, i.e. maintaining the human demand for Earth system resources and services to within the supply. In my opinion this is the core of the environmental part of Sustainability Science. Achieving sustainability is no less relevant today than it

was 27 years ago – it has always been a necessity if we want to ensure the possibility for future generations to thrive. The difference between then and now is that our backs are now up against the wall. The good news, however, is that we now can determine to what degree activities really are sustainable in an environmental context. This means that science is much better placed to propose potential solutions on how to achieve sustainability than before when we were confined to simply describing environmental degradation. It is not up to scientists to tell society what to do but if we accept the premise of Planetary Boundaries, i.e. that it is possible for scientists to define a level of resource use that greatly increases the probability of decreasing the ability of the Earth to support the development of human societies, then we can think of resources as a kind of "bank account". We know how much money we have in the bank and we can use it on any number of things but we cannot use more than we have. If science can define the safe level of resource use, then politicians, in effect, have a framework within which they can make decisions. We can use our resources in many different ways but we cannot use more than we have! Actually, politicians have already given themselves a resource framework with respect to climate change. Here, the resource is the atmospheric garbage dump for greenhouse gas refuse we share with all other people on Earth. If we are to hold human-caused climate change to within 2 °C, then science can tell us how large the garbage dump is (and that it is half filled). The political discussion then becomes who should get the rights to the last half of the resources. I also think the new scientific ability to begin to quantify environmental sustainability makes it easier for citizens at large to relate to sustainability. For too long, we have been arguing that our actions should be environmentally "friendly" for the sake of nature and the planet. However, whatever, we do, the planet will survive for a very very long time. People are most motivated to do something if there "is something in it for them". We do not pollute local lakes and streams because we know there are detrimental effects on our own health. We regulate pesticide use because there are human health implications. Science is now telling us that we need to manage resources at the global level in order to preserve the only habitat in which we know that human societies can thrive. We know that the survival of all other organisms becomes threatened when their habitats are destroyed. Why should we be any different? Maintenance of our own habitat is a much more powerful motivation to use resources wisely than "saving the planet"!

Planetary Boundaries

NSS: Do you consider Sustainability Science as being a discipline confined to the scientific community

or does it extend wider where it can build as a momentum in terms of an increased social or political interest for sustainability?

Katherine Richardson: Sustainability Science is definitely much wider than the scientific community alone. The Planetary Boundaries have been taken up, discussed and brought up in the OECD Environmental Outlook 2012, the Global Energy Assessment 2012, the UNEP (United Nations Environment Programme) 2012, the UN High-level Panel on Global Sustainability 2012, the UN Sustainable Development Solutions Network, the World Economic Forum 2013, the World Business Council for Sustainable Development, etc. This suggests that we have with Planetary Boundaries found a way to “package” scientific understanding in a way that societal decision makers find useful. In science, we have for years been saying: “here we have something that is interesting for you” and assuming that we are packaging it in a way that can be used, and then we complain that politicians and decision-makers do not take it up. Users of scientific research should never control what research should be done or the methods used but maybe they are better to define what packaging of results should look like. We talk so much of “stakeholder engagement” but it is often unclear what it really consists of. I believe we should be talking packaging of the research products we create with stakeholders. I think it is huge what’s been going on as a result of this way of thinking, because it seems to package science in a way that can be used by decision-makers instead of the economist standing over there saying “nah”, and the physicist standing there saying something else. It has never been integrated before, it has never been brought together to tell a story that can be useful in decision-making and that is what we are trying to do now.

NSS: What do you expect from this framework of Planetary Boundaries? How will it help strengthen research within sustainable development? I have understood from the Brundtland report that the limits are not in the resources themselves, as it was for the Club of Rome, but rather relate to our technologies and social organization which should be improved, aiming at a better management of the existing resources as well as the creation of new resources...

Katherine Richardson: The concept of Planetary Boundaries does not define absolute limits or thresholds for human development. It attempts to define a “safe operating space” within which there is any number of possible trajectories for society to develop. It’s rather like having a budget. You know how much money you have to spend – and there are lots of ways you can spend it – as long as you don’t use more than you have! I honestly believe that the Planetary Boundaries approach can ultimately provide a framework for societal decision-making that can lead to sustainability.

NSS: From the authors of *Blueprint for a green economy*⁷ came the notion of sustainability as maintaining and enhancing critical capital, where one of the key questions is to which extent natural and physical capital may be replaced by human and financial capital. This question divides researchers into two groups: followers of so-called strong vs weak sustainability. If you accept this idea, which seems to fit somehow with the notion of some of the Planetary Boundaries, then how do you see your centre contributing to determine for example the following questions: What is the critical natural capital within the concept of Planetary Boundaries? Which natural and physical capital assets cannot be substituted by other types of capital?

Katherine Richardson: There is not one critical natural capital – but many (biodiversity, water, a common atmospheric garbage dump for greenhouse gas waste, etc). Phosphorous cannot be substituted. Biodiversity cannot be substituted. Radiative forcing cannot be substituted, etc.

NSS: To return to the metaphor you used – the bank account – don’t you think there is a limit for this metaphor: my bank account does not allow me to buy my house, but anyway I ask for a loan and 15 years later I have my own house.

Katherine Richardson: But when you ask for that loan you know that you have the ability to pay it back. And that is what you have to look at in terms of some of these resources and services. Let us take the climate discussion. We might be able to “take a loan” by letting the temperature increase beyond 2 degrees but we are taking a huge risk because we do not know that we will ever be able to pay the loan back. In fact, science suggests that payback, if possible, will be much more expensive than the loan itself as the higher the temperature goes, the more probability that you initiate processes, i.e. melting all the ice in Greenland, that cannot be reversed. With water we might be able to pay a “loan” back through desalination of ocean water and so on. So, in making the political decision to exceed a planetary boundary, one must take into consideration our potential ability to pay a debt if we go above the safe level.

NSS: Maybe we can change the economy of water by modifying the ways in which the ecosystems function by changing the vegetation cover, e.g. with a set of layers from the ground to trees in order to be self-sufficient in water with water coming from the atmosphere and not only from rainfall. We can imagine different solutions not only by saving to take care of the limits, but designing different ways in using water cycles?

⁷ Pierce, D., Markandya, A., Barbier, E., 1989. *Blueprint for a green economy*, London, Earthscan.

Katherine Richardson: That is true. I would call that geo-engineering and a lot of people talk about that and geo-engineering is fine – if it is considered in a system context. Using geo-engineering to cool the planet by, for example, pumping particles into the atmosphere to reduce the amount of solar energy reaching the Earth might be a good way to reduce the temperature on Earth but the extra CO₂ in the atmosphere would still cause acidification of the ocean with huge ecological and geo-chemical consequences. The same would be true for your suggestion here. All of the system effects would need to be considered and, if they are considered to be acceptable then, yes that would be a potential course of action – although it really would only be treating symptoms and not the root cause of the problem. So you have to look at the system as a whole, but I agree with you that there are different things that society can do to keep itself within resource limits.

NSS: Some of these aspects, as you describe them, are more a question of resilience for instance; and this is exactly where some of the people behind this framework come from – resilience thinking. Some of the aspects you refer to here – biodiversity and so on – are about finding resilience systems, accepting how far we can go and what the irreversible changes are. Some of the other aspects fit with what you said about phosphorus, because these aspects might actually be understood better from a “natural capital” perspective. So perhaps it would be interesting to look at the different items that you have so appropriately included in the Planetary Boundaries from a slightly different angle. For instance, ecological economics could have a closer look at e.g. critical capital; and other disciplines supporting resilient thinking, both from a biological and a human-social system point of view, may actually be better at illuminating some of the other boundaries.

Katherine Richardson: That is true and, in fact, lots of papers have been following up on the original Planetary Boundaries paper where they argue things differently. Some people have argued that we should have net primary production as a planetary boundary, and ecological economics is also taking it up. The original Planetary Boundaries paper was just a start and, in fact, a follow-up paper will be coming soon where we change or at least modify some of our approaches. So this is just an attempt to bring Earth System Science, or Sustainability Science, together in a way that can be useful for society.

The 2015 climate change conference

NSS: You were particularly involved in the scientific contribution to the COP15 in Copenhagen in 2009 by chairing the Scientific Steering Committee of the scientific

conference “Climate change: Global risks, challenges and decisions” in March the same year. What advice would you give to scientists (French and others...) to prepare the COP21 in Paris next year and help it lead up to new encouraging perspectives?

Katherine Richardson: Avoid trench warfare! Communicate, communicate and communicate about the science but avoid getting into “believer”/ “non-believer” debates. The audience never gets wiser through that kind of debate. Be honest about what science cannot do (it does not provide “proof” and 100% certainty) and what it can do (it can provide observations and consensus about what the best explanation for those observations is). Remind people that anthropogenic climate change is not a “prediction problem” (is it happening or not?) as most media try to profile it as. It is a “risk” problem – do we dare as a society to take the risk that the 97-98% of climate researchers who are convinced that humans are responsible for a considerable proportion of the climate change, that we are observing, are wrong? The IPCC AR5 WG1⁸ concluded that there is >95% certainty that humans are a significant cause of the climate change we are witnessing. That is a shockingly high degree of certainty...

NSS: The Sustainability Science community aims to be organized into a strong international network. As you probably know this notion is not as well developed in France, where climate change research is strongly established but with quite few links to the other aspects of sustainable development. We do not commonly use the terms and the notions of Sustainability Science but it does not mean that we are not aware of it. What do you think about this situation in our country?

Katherine Richardson: I think that, in general, much of Europe is not well placed to take on the “convergence” of disciplines for societal problem solving that is being called for in the USA and in other areas because of our strong Humboldt tradition. We like to think that Sustainability Science is real science, even though the French maybe do not consider it as such. I would not single France out as being a “particular” problem in this respect. I do, however, think that the academic community (and the funding agencies) in every country need to examine and consider this international movement towards convergence and decide whether or not infrastructures need to be established within their countries to accommodate convergence and to stimulate this new way of thinking about research.

⁸ Intergovernmental Panel on Climate Change, 2013. *Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex V., Midgley, P.M. (Eds.)], Cambridge (UK)/New York, Cambridge University Press, <http://www.ipcc.ch/report/ar5/wg1/>.

Links between Sustainability Science and agriculture

NSS: You have been a board member in the International Centre for Research in Organic Food Systems (ICROFS⁹). What main links do you see between the Sustainability Science Centre and research in organic agriculture and agroecology?

Katherine Richardson: Environmental sustainability is – as noted above – in my opinion keeping the demand for natural resources within the Earth system supply. Organic farmers represent a sub-set of farmers who have placed upon themselves constraints with respect to certain resources (i.e. N and P). I honestly believe that some of the methods, techniques, and species developed in organic agriculture will be crucial in ultimately developing a form of agriculture that can feed 9 billion people without destroying the planet.

NSS: How do you see agriculture's role in the sustainability debate in general and how is it integrated in your Sustainability Science Centre?

Katherine Richardson: Agriculture is critical – we need it to feed the growing population but it needs to change radically if we shall have any hope of achieving sustainability and a situation where future generations can thrive on this planet. Business as usual within agriculture is not an option! Every faculty is represented in the steering committee of our centre – including the faculty housing all agricultural scientists and many participate in the projects we carry out. Planetary Boundaries provide a whole new “spec” for global agriculture. We need an agricultural revolution but we essentially need to do it without increasing the percentage of Earth surface that is dedicated to agriculture. We need to be more efficient with respect to water use in agriculture and we cannot continue to increase our release of reactive nitrogen and phosphorous into the environment. So, how are we going to produce food for 9 billion people and not destroy our own habitat? This is all Sustainability Science, and many people are involved in such an issue like for instance John Ingram at Oxford, John Foley at Minnesota, Johan Rockström from the Stockholm Resilience Centre.

The Anthropocene

NSS: What do you think about the notion of Anthropocene?

Katherine Richardson: I think it is absolutely correct. Our only problem is that we have never had a geological

era which has been identified while we were living in it; we have only done it in the past. Previously, different geological eras have been identified by digging through the strata. When you find sudden changes in geochemistry, i.e. oxygen in the atmosphere, temperature or atmospheric CO₂ content, it is argued that a new period has started. Looking through ice cores now, you see that an amazing change from the historical profiles begins to emerge about a 150 years ago. Suddenly entirely new (human-made) chemicals appear and there is evidence of the mobilization of some otherwise naturally occurring chemicals or elements, which basically had been relatively stable at low concentrations, elements like lead and mercury or nitrogen, for that matter. These changes are totally mediated by human activity, and in this respect, the recently formed layers of the earth/ice are totally different from all past history. Therefore, it is obvious in my mind that the period that we are living ought to be called the Anthropocene.

NSS: Do you think it would be useful for Sustainability Science to include this as one of the paradigms to help people get the measure of the complexity of the situation?

Katherine Richardson: Yes; and here's the reason why I think it is useful: Think back to our oldest ancestors – when they produced garbage, be it bodily waste or garbage from their activities, they just dropped it where it was produced. Then they realized that they were going to have to manage the environment at the local level, because this garbage was polluting their water, it was making them sick. They needed to do something there. So they began to manage at the local level. Then we began to manage at the regional level, because we could see that things actually were not just in our backyard; it was also in the water mass, in the ocean around us or whatever. What the Anthropocene is telling us is that we are now having an impact at the global level, which means we need to manage our use of the environment at the global level. And we need science to be able to help us find out how we manage at the global level, both with respect to what we need to do and also the mechanisms to do it. That is what Sustainability Science is all about! The challenge in all this is that we do not have a governance system that can operate at the global level, so managing global resources without global governance is really the whole challenge in terms of sustainability.

Actually, I believe that the simple fact that we have evidence that we should call the current era the Anthropocene because of the incredibly strong signal in the geological record that humans have left, in itself, tells us that it is necessary to manage resources at the global level. If we are having an effect at the global level, then we need to be managing at the global level as well.

⁹ <http://www.icrofs.org/>.