The Great Simplification

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[00:00:00] **Johan Rockström:** We're deep in the climate crisis. We're deep in the red on the climate boundary, but what the Planetary Boundary Science shows clearly is that even if we were successful in phasing out fossil fuels, we would still breach the 1. 5 degree Celsius boundary if we do not come back into the safe space on the biosphere boundaries.

[00:00:17] It's so few people who really recognize that 30, 3 0, 30 percent of the carbon dioxide that we emit from fossil fuel burning is actually absorbed by intact nature on land. It's thanks to the biodiversity and the intact forest systems in particular that are buffering this. And if you don't have a healthy planet, that capacity of buffering that stress is reduced.

[00:00:44] So my fear is that we're shooting ourselves in the foot by emitting greenhouse gases and causing the climate crisis, and at the same time making the planet in her weakest state to deal with that crisis.

[00:01:01] **Nate Hagens:** I would like to welcome Professor Johan Rockström to the program. Johan is the co director of the Potsdam Institute for Climate Impact Research in Potsdam, Germany, which is a suburb of Berlin, where he leads an international staff of over 400 scientists and researchers, including the team of scientists that presented the Planetary Boundaries Framework first in 2009.

[00:01:26] Potsdam updated last year in 2023, these nine planetary boundaries presented in this framework of which climate change is but one are thought to be fundamental for humans to maintain a safe operating space of the Anthropocene. This is incredibly important work. It goes way beyond just global heating and climate change, though that is a biggie Johan and his team continue to forge new ground in understanding the natural system.

[00:01:58] And humans impact on them. I hope to have more conversations with his colleague. Stefan Romoff is on deck. I already talked with Lev Kiss Caesar on the Amoc. Please welcome Professor Johann Strom. Johann Strom, welcome. Thank you

for taking the time today. Thanks so much and great to have you here at the Potsdam Institute.

[00:02:22] I have so many questions. Let me just start with an obvious one. Can you give us an update on the planetary health? Where are we today? Well, I can tell you that in my

[00:02:31] **Johan Rockström:** professional life and in all my scientific work, there's never been reason for such deep concern as today. All the, you know, curves are still pointing in the wrong direction.

[00:02:44] We've been mapping for 15 years the Earth system processes that regulates the stability, the resilience, and the life support capacity of the Earth system, the nine planetary boundaries. Six of the nine are outside of the safe operating space. And if you just lift out one of them on climate, we're seeing that we are not only continuing to increase emissions, temperatures are not only rising, to actually accelerating.

[00:03:11] And we don't even understand that fully, but very likely it is because the planet is losing resilience, the health of the planet, the capacity of the planet to buffer is reducing. And we've already reached the warmest temperature on Earth over the past 100, 000 years. So we are rapidly deviating away from the last 12, 000 years that enabled civilizations to develop since we left the last ice age.

[00:03:36] So we are in a, you know, in a deep crisis situation with regards to the, overall health

[00:03:42] **Nate Hagens:** of the planet. I have a lot of questions on that, but my, first one is, how can a vast majority of humans alive today not know what you just said?

[00:03:52] **Johan Rockström:** Well, I, you know, to be honest, that, that is one of the big disappointments.

[00:03:57] I'm quite self critical here as well. I think that we in the scientific community, the environmental movement over decades, how can we not have been able to communicate? the most important message of them all, that we are

threatening the very branch upon which life depends, planet Earth. And, it's it's, one of these reasons why we see more and more scientists stepping out of our comfort zones and, trying to reach out more broadly with our science.

[00:04:33] It's no longer possible to just do science for science. We're doing science for change and science for bridging to society. But there's also, of course something we have to recognize, which is that, you know, for 200 years, we've been moving into this industrial globalized economy powered by fossil fuels based on linear system for overextraction and, and resource use, which has now come.

[00:05:03] to the end of the road. And we are at this point where science shows clear that we have to transform the entire logic and structure of the whole global economy and all societies. And that is a big step. and as a, fundamental human feature, we are resisting change. and there are so many vested interests in, in, in status quo.

[00:05:31] So it's not so surprising that, it's, for many quite uncomfortable to, to recognize that we are in this massive transformation phase. the beauty though, which, I hope we can come back to is that not only is science showing that we're heading towards unmanageable, potentially catastrophic risks.

[00:05:53] We also have more and more empirical evidence, I mean, from the ground, real evidence in the real economy that we have the solutions, they are scalable, and the outcome in the end makes us all winners. That actually a sustainable future within a safe, stable planet is actually a future that is more attractive and more advanced and more peaceful and healthier and more secure.

[00:06:19] It's just that this transformation, this transition phase is like a gauntlet. It's very jumpy, it's very turbulent, you have winners and losers. How do we do? Do we leave the internal combustion engine? do we go hydrogen? Do we go electric? Do we go biofuels? how do we scale renewable energies? Is it nuclear power?

[00:06:39] It's very messy right now. We don't have the policies, we don't have the financial institutions, they don't know where to put their money the oil industry is still very wealthy, so it's a, It's typically what you experience in big transitions, and that's exactly where we are right now.

[00:06:56] **Nate Hagens:** So you are known for a lot of things, but one of the things that I think you developed 15 years ago was the concept of planetary boundaries.

[00:07:05] You did a report in 2009, again in 2015, and then there was one last year in 2023. What broadly are the planetary boundaries, and what gave you the idea to originate that concept and framework? In short, the planetary

[00:07:21] **Johan Rockström:** boundaries are all the environmental systems, what we call the Earth system, that regulates the stability, the functions, and the resilience of the planet.

[00:07:35] where does this originate from? Well, it's Because we've had such enormous scientific advancements over the past 30 years in, in climate science and earth system science and resilience theory, but also in understanding that the planet is a complex self-regulating system where all the spheres, so you think of the biosphere all nature.

[00:07:57] You have the ocean system, the hydrosphere, the hydrological cycle, the atmosphere, the cryosphere, all the ice sheets, the geosphere, so. Basically, all the soils and rocks, all these spheres are interconnected and interact to regulate the state of the planet. And when you combine this with the phenomenal advancements in ice core data, which now date back to Back.

[00:08:22] You know, first we had 1 million years, but we can now date it back. We understand the journey of planet Earth for the past 3 million years. We see very clearly that over the past 12,000 years since we left the last ice age, we've had this remarkable stability of the planetary system. And when you package all that together, the stability of the planet since we left the last ice age, this understanding of all the interconnections of the biology, the chemistry, and the physics of the earth, and.

[00:08:53] the evidence that we have this hockey stick pressures of human increased, unsustainable pressure on the planet to the point where we can, you know, already in 2006, so three years before we published the first Planet Bounty paper the, the report came out showing that we've reached a great acceleration,

that we have all these exponential pressures that led to the conclusion that we've even entered the Anthropocene Anthropocene.

[00:09:22] being anthros, Greek for humans, that we're now in a whole new geological epoch where we, anthros, are the dominating force of change on planet Earth. When you put that all together, the risk of tipping points, the hollow sea in the last 12, 000 years being uniquely stable, and the exponential rise of pressures, that led us in the scientific community to ask two questions.

[00:09:46] One is, what are the environmental processes that regulate the stability of the planet? Because we're now putting pressures on the planet at an unprecedented rate in the Anthropocene. But secondly, which was the breakthrough in the planetary boundary theory, Can we, for each of those environmental processes that regulates the stability of the planet, identify a control variable, a parameter that functions as an indicator of the state of that boundary process, and can we quantify a safe boundary level beyond which, if you exceed that point, you risk starting to slide in a direction where the livability, the life support, the resilience, is at risk?

[00:10:27] is reduced, you might even trigger tipping points, but stay within them, that we have a good chance, a high likelihood, of keeping the planet as close as possible to the Holocene state, the state that has enabled civilizations to develop. And That science is what is now the planetary boundary framework.

[00:10:49] But it was only possible to, advance it, thanks to the fact that we knew so much about the Holocene and its stability. We knew about the Anthropocene and the pressures, and we knew that the planet is this complex self regulating system with tipping points. And With all that evidence, we could use the Holocene as a reference point, and we could use tipping point science, you know, to put it simple, you put a safe boundary to avoid crossing tipping points, so you could use science to say, at what pressure points are we at risk of crossing a tipping point?

[00:11:23] So all that evidence was maturing. And in 2009, when we put all these pieces together, I was able to convene you know, a broad group of scientists from oceanography, ecology, ice sheet experts, tipping point scientists, climate scientists. So we had a series of workshops basically saying that the question was very simple.

[00:11:49] What are the Earth system processes that regulates the stability of the planet, number one? Turn every stone we have, just try to gather the list of what is it that keeps the planet in a healthy state, and then question two, once we've identified those, can we find a control variable and start quantifying a safe boundary level?

[00:12:09] To be honest, the big surprise to all of us when we were working through this for three years, between 2007 2009, was that the list was not 50 plus systems, and it wasn't only climate. As often is given, you know, as the impression is often that's the only parameter that matters for the planet, we could only find nine.

[00:12:30] Nine planetary boundary systems. And that's what we put out in this first publication in 2009. We were only able to quantify, at that point, you know, reasonably with science six of the nine. And so we have major gaps still, and that was published actually deliberately as a call for action in the scientific community.

[00:12:57] It was a challenge to the scientific community to say, we feel that we now have all this evidence gathered together on the Great Acceleration, the Anthropocene, the Tipping Points, the Resilience Theories, the Complex Dynamics of the Earth System, and here we're putting out a new framework coming out of all that evidence.

[00:13:15] Help us. please to, critically scrutinize this. And and that is what then six years later in 2015 gave us the second publication of Planetary Boundary Science, which was based on all the papers and scientific scrutiny that this triggered the first publication, and that confirmed the nine.

[00:13:37] It was quite interesting. there were many suggestions back and forth of adding a boundary or deducting a boundary, but there was no scientific evidence that convincingly said that you should add one or deduct one. So, so in 2015, in the publication there, we, I would argue that we scientifically confirmed the nine.

[00:13:59] And that to me is a, very, that, that gives confidence. If we can be stewards of the nine planetary boundaries, we have a good chance of handing over a healthy, livable planet to all future generations. I found that to be, that is quite a line in the sand, scientific advancement. And then, even in 2015, we could still just

quantify seven of the nine, and we showed that four of them were outside of the safe space.

[00:14:25] We advanced the methodology, and it's only in 2023, it's only last year, that we for the first time quantify all the nine, and show that six of the nine are outside of the safe space. So the science continues, the quantifying safe boundaries is really complicated, that we need to be stewards of these nine is now, I would argue, scientifically quite well

[00:14:47] **Nate Hagens:** established.

[00:14:48] You mentioned the Holocene. What was the year, the years of the Holocene again? The Holocene

[00:14:54] **Johan Rockström:** is the geological epoch that geologists still consider that we are in. It starts 12, 000 years ago and has gone up until present. It's a geological epoch. It's a warm, so called interglacial state of the planet.

[00:15:11] So when you look at the ice core data, we have superb ice core data now from both Greenland Ice Sheet and from Antarctica, shows that over the past one million years, we've been, you know, oscillating between 100, 000 years roughly of ice ages. So that's minus six degrees colder, Global mean surface temperature on planet Earth.

[00:15:34] And then we have 15 to 30, 000 years shorter warm interglacials. So we've had roughly 6 to 8 warm interglacials. And the last one is we leave the last ice age, start leaving the last ice age 18, 000 years ago, and then we come into the warm Holocene period, 12, 000 years. And the interesting thing is that we've been We, as homo sapiens, have been modern humans on planet Earth just for the past two ice ages.

[00:15:59] We've only been on planet Earth for twenty fifty thousand years, so we've lived through two ice ages and two interglacials. The Eemian, one interglacial some hundred thousand years ago, and the Holocene. But you know, during these 250, 000 years, as fully modern humans, I mean, basically, with the physical intellectual capacity you and I have, we, lived as, you know, hunters and gatherers, we were a few million people on planet Earth, we had a very variable environment, jumping

up and down in temperatures it was a rough time, to put it simple, until we leave the last ice age, and we come into this extraordinarily stable, interglacial, 12, 000 year phase, the Holocene, and we barely enter it.

[00:16:41] We're just 2, 000 years into it, and we go through the most important revolution of all revolutions for human existence on planet Earth. We shift over from being hunters and gatherers to domesticating animals and plants. We become farmers, and we become sedentary. And, that happens. across all continents on planet earth, more or less simultaneously, which of course is a proof of the stability of the

[00:17:08] **Nate Hagens:** Holocene.

[00:17:09] So in a way you could say that climate change caused humans to expand.

[00:17:15] **Johan Rockström:** Yes, caused civilizations and, and development of societies as we know it. So the world as we know it is, a result. of

[00:17:27] **Nate Hagens:** the stability and the Holocene. So how many times in the past do you have any knowledge or speculation on what you're claiming as planetary boundaries today?

[00:17:38] Would those be the same looking backward in time or would the planetary boundary threshold been different a million years ago or whatever? I mean, we didn't have one of them as novel entities like chemical pollution, endocrine disruption. I mean, that didn't exist back then. So obviously that wouldn't have been, but.

[00:17:58] I guess my question is, are planetary boundaries an absolute or relative to recent past sort of phenomenon? I would argue that if you

[00:18:09] **Johan Rockström:** take the perspective just one million years back, or you could even take three million years back, three million years, then you're in the quaternary. As far as we know today, during the entire quaternary period, well, why is the quaternary relevant to start with?

[00:18:27] Well, it's because it's only during the past three million years that we have a planet that, that resembles the planet we know today. I mean, in terms of the configuration of continents, the oceans, the ice sheets, the hydrological cycle, the chemistry in the atmosphere. the planet we know has only been around.

[00:18:49] during the quaternary. If you go deeper into geology, you have a different planet, chemically, biologically, physically. So, the planet of relevance for us is the past 3 million years. As far as we know today, The planet during these entire 3 million years has never been beyond 2 degrees Celsius warming. Can you imagine?

[00:19:10] The warmest temperature on Earth over the past 3 million years is probably never exceeding 2 degrees Celsius of global mean surface temperature rise and it's never been colder than minus 6 as deep ice ages. So I would argue that the planetary boundaries in that sense are absolute because during that entire period we would basically, scientifically, always land at the same boundary definitions to keep the planet in a safe state.

[00:19:39] But you could argue that three million years is a unnecessarily long period because it's only in the last one million years, so in the so called Pleistocene, the latter part of the Quaternary, that the planet starts oscillating between ice ages and interglacials, ice ages and interglacials, the so called Milankovic cycles, which are driven naturally, and they are a result of Earth's elliptic journey around the Sun, and the wobbling of the Earth's axis.

[00:20:09] So they're very well mathematically defined in the Milankovic equations, and so we can show quite exactly the length of interglacials, not exact, but at least predict them reasonably well, and also reproduce long ice ages. So it's only in the last one million years that Earth has been dancing, according to this logic, And during that entire period, I would argue that the planetary boundaries, as we define them today, are applicable.

[00:20:38] Definitely. Because we do not set the safe boundaries to match human demands, or human wishes, or human needs. We set the boundaries only to keep the planet safe. as close as possible to a healthy resilient state, as close as possible to the Holocene reference point, and we are now in a warm interglacial, and what,

the question is, what is required in our management of nature, of oceans, of ice sheets, of the atmosphere, to keep the planet safe.

[00:21:14] in that stable interglacial Holocene state.

[00:21:17] **Nate Hagens:** When I used to teach college on evolution, I marveled at the fact that we evolved and the fact that we figured out that we evolved. And hearing you describe this, it's just amazing to me that scientists have been able to piece together this history of the quaternary and the different ice cores, and it's truly amazing what you all have been able to figure out, but it's still a tiny percentage of humans that are working on this, right?

[00:21:49] And, you're all working together and speaking the same language, yet it seems to me the broad swaths of humanity are just, have no concept of, what we're, I mean, is this too complex for a human brain to understand? I would. You know,

[00:22:06] **Johan Rockström:** adamantly, with full of my heart, say no, it's not too complex. I mean, admittedly, it is complex, but we have to learn many complex things in life.

[00:22:17] I mean, just tax regulations in any country is quite a complex matter, and we have laws and regulations we have to learn and, and, you know, try to follow. so I would say that understanding that the fundamentals of why, for example, the oceans and the land systems and the ice sheets function as cooling systems on planet Earth that can buffer stress and help us to keep temperatures at a livable level, I think everyone should know that.

[00:22:48] **Nate Hagens:** It's like knowing about our home. It's like

[00:22:52] **Johan Rockström:** knowing about our body and our health. You want to know something about how do you avoid a heart attack. And everyone has interest in kind of understanding how your lungs and your liver and your heart and your, you know, your, just your weight and your health levels.

[00:23:10] Well, think of planet Earth as the organs of your body. And you want to have a sense. I mean, I tried to convey in all my lectures that, you know, we've come so far in our science today that we're even suggesting that the green and ice sheet,

the Amazon rainforest, the permafrost in Siberia, the temperate forest in Canada, should actually be redefined as global commons.

[00:23:33] They should be seen Even though they are inside national jurisdictions, and of course are the responsibility of those countries citizens, they are actually systems that we all depend on. they are systems that every human being should feel, even if we're sitting in Potsdam as we are right now, I must be concerned.

[00:23:55] of the health of the Green and Ice Sheet. Because the Green and Ice Sheet regulates the temperature where I live here in Potsdam. So, so it's like, how can I not be interested in that? I cannot just

[00:24:07] **Nate Hagens:** shove it away. So said differently, there are certain countries that have a lot of natural resources, like oil or copper or lithium, but then there are other countries that have a lot of ecological resources that affect all of us, and we don't really think about.

[00:24:23] it that way, like Brazil, that the, if the whole Amazon becomes a source of carbon instead of a sink, that would be bad.

[00:24:33] **Johan Rockström:** We would be bad, and not only would it be bad, it would affect all of us, irrespective of where you live on planet Earth. So the Amazon rainforest, therefore, is a global commons, and if I was President Lula da Silva, I would say, Dear humanity, I'm willing to provide this service to humanity of keeping the Amazon rainforest intact.

[00:24:53] That is a service, is a global commons, it's a service to humanity and therefore you should compensate me for this. so you know, you, can actually have a quite a powerful policy position as well of that service that you provide to humanity because it is a true service.

[00:25:10] **Nate Hagens:** Building on what you just said, what's the sequence that gets us there?

[00:25:16] I, think, It's awareness and education. Then there's caring. Then there's being willing to play a role. And then there's action and policy and behavior change. And we're still in the awareness stage. There's so many people that are not

even aware, but we need all those things. Do you think there's a possibility that we could get to a planetary commons or someone like the president of Brazil being recognized internationally for how important the lungs of the planet are?

[00:25:48] **Johan Rockström:** Well, I think you're putting the finger on something really important that I think we have to act on all fronts, but I don't think it can be acted upon in a production sequence. You cannot start by awareness creation and then get policy framework and then get the action. I think you have to work because of the urgency on all these fronts.

[00:26:12] in parallel, because we've learned the hard way, actually, over the past 50 years, that we don't solve sustainability problems by only raising awareness. It's not enough. Yeah. You also need some some, some top down influence on what I call keystone actors to get key players in the economy or, key decision makers to move.

[00:26:35] And we know that we've succeeded in the past. I mean, one of the nine planetary boundaries is the stratospheric ozone layer, which science identified, you know, in the early 1980s that we were actually at an existential threat of depleting the stratospheric ozone layer because of the emissions of our chlorofluorocarbons, the freons, from air coolants and refrigerators and air conditioners and spray bottles.

[00:26:59] And science came out and policy listened, and industry listened, and it took us to a point where the Montreal Protocol was signed in 1987, quite a top down regulatory framework, the U. S. was very, a Republican U. S. government was quite driving in this process, and we got a solution which then benefited humanity.

[00:27:25] There was awareness as well, in parallel, but it was certainly not the global There were not demonstrations on the street that got us to the Montreal Protocol. It was in the end an elaborate effort of science policy interface, but also with industry dialogues that brought us to that point. So I think one has to act on multiple fronts.

[00:27:46] **Nate Hagens:** So you mentioned um, the ozone layer, and you mentioned climate. what are the rest of the the nine planetary boundaries?

[00:27:54] **Johan Rockström:** For the simplicity, and see, people can, remember them by heart, categorize them in three categories. So, so, the first category are the obvious ones, which I call the big three, because they operate at a global level, they're globally mixed, they are kind of, obvious planetary boundaries.

[00:28:11] And number one is, of course, the climate system, a stable climate system. Number two is the ocean, a stable ocean system, and we use ocean acidification here as the parameter. And number three, the stratospheric ozone layer. So these are global systems, connecting the entire planet. Second category is what I call the biosphere boundaries.

[00:28:32] Think of them as the nature boundaries. They don't have scientific evidence of global tipping points, they don't operate at the global level, but they work under the hood of the planetary machinery to keep the system intact. And the number one is biodiversity. All the species, you hear all the bird outside of the window here.

[00:28:51] So basically, we now scientifically know that, the richness of nature and the diversity in nature gives resilience and strength for it. carbon uptake, for moisture recycling, for the whole turnover of materials in, in, in the organic system on planet Earth. The second is, of course, the bloodstream of the whole planet, the hydrological cycle.

[00:29:12] Without fresh water, there is simply no, no stream. no health in the whole system. The third one is land system configurations. we understand today that we do depend disproportionately on certain big land systems. The rainforests, the temperate forests, the boreal forests. These are fundamental regulating systems in the whole And the final one is, so the climate system has one global cycle, the carbon cycle, but there are two additional global cycles in the biosphere, which is the nutrient cycles, and we are particularly singled out nitrogen and phosphorus.

[00:29:50] So the nature boundaries are the four you know, workhorses under the hood of the machine of the earth system. Biodiversity, land, fresh water and nutrients. And then finally, the final category are what I've a bit sloppily called the aliens. I mean, you mentioned that before, Nathan, that they have nothing to do on the planet.

[00:30:14] They're created by us humans, and number one is the novel entities, and they're novel because nuclear waste, microplastics, persistent organic pollutants, endocrine disruptors are simple compounds that we're loading into the biosphere that have never existed and they're just accumulating, and that they could threaten life on Earth.

[00:30:35] And the final one is aerosol loading. We see more and more evidence that pollutants, polluting the air at the lower atmosphere. Think of the smog in cities. Creates a dimming of the whole Earth system, which changes the energy balance because it becomes a reflector of incoming solar radiation. It changes the monsoon systems.

[00:30:57] It's actually, paradoxically, a cooling factor on planet Earth. It's a huge environmental problem because it's having massive human health implications. We don't use human health to measure as a boundary. We're only Defining aerosol loading, air pollution as a planetary boundary because it affects the functioning of the Earth's system.

[00:31:18] So there you have the nine. Climate, ocean, stratospheric ozone, the big three. The four biosphere boundaries, biodiversity, freshwater, land, and nutrients, nitrogen, phosphorus. And then the two aliens, the air pollution and novel entities. And, as I mentioned earlier, these nine, they've been scrutinized back and forth, and there's been turning you know, so many publications, trying to, you know, critically assess these, and we can today, with quite a high degree of confidence, say that if we can be stewards of these nine, we have a good chance of keeping the planet in, this, desirable

[00:31:58] **Nate Hagens:** state for us humans.

[00:32:00] So you first wrote about those in 2009 and then two subsequent reports, but there seems to be an alarming change in the most recent one in 2023. What, happened? Did you have better data or you understood things better or did things actually get significantly worse?

[00:32:16] **Johan Rockström:** It's a combination of both. we have better data, we've made major advancements and actually, that's quite important to mention.

[00:32:25] I say we've made major advancements, but what I mean by that is different research groups have been working and publishing research, for example, quantifying the novel entities. Boundary was done by independent chemical experts, and we brought in that science into the update for 2023. So that was scientific advancements.

[00:32:43] The second is that we have better data and unfortunately that data shows that we are deeper into the red. So we've been able to add new science enabling us to quantify, for example, the novel entities boundary, but those boundaries that we had quantified previously are deeper into the risk zone. So, so it's a combination of both.

[00:33:06] And today We conclude, which is really worrying, that six of the nine boundaries are outside of the safe space. and to me, that leads, of course, to many conclusions. I mean, the fundamental one is that, that proves the point that we are starting to see the planet sending invoices that are hitting human well being across the entire world.

[00:33:29] I mean, immediate effects of livelihoods for those who depend on coral reef systems or fisheries and coastal zones or food insecurity, but at a higher level, the deepest worry for me is the following. We're deep in the climate crisis. We're deep in the red on the climate boundary, and that's the only environmental challenge in general that is recognized in the broader policy scheme, and we are struggling with that one and focusing in only on fossil fuels, basically phasing out fossil fuels, and that is absolutely necessary.

[00:34:03] But what the Planetary Boundaries science shows clearly is that even if we were successful in phasing out fossil fuels, we would still fail. on the climate boundary. We would still breach the 1. 5 degree Celsius boundary if we do not come back into the safe space on the biosphere boundaries. Because biodiversity, freshwater, land, and nutrients will determine the ability of the planet to buffer, you know, it's so few people who really recognize that 30, 30, 30 percent of the carbon dioxide that we emit from fossil fuel burning is actually not in the atmosphere causing the 1.

[00:34:39] 2 degrees Celsius warming so far and all the extreme events and the crisis we're in right now on climate, 30 percent is actually absorbed by intact nature

on land. it's thanks to the biodiversity and the intact forest systems in particular that are buffering this. and why are they buffering it?

[00:35:00] Well, it's a stress response. It's actually a planet that biogeochemically applies the processes to try and stay in the Holocene. It's quite interesting that the Holocene is an equilibrium state which has resilience to cope with stress. And, you know, geologically that stress has been natural. It's been basically solar forcing or earthquakes or volcanic eruptions that the Earth system has had to biogeochemically deal with.

[00:35:31] And now the planet has to deal with us humans. And that stress is unprecedented. You know, the stress we're causing with the energy imbalance is something we haven't seen for the past four million years in terms of loading so much energy in balance. And if you don't have a healthy planet, that capacity of buffering that stress is reduced.

[00:35:53] So my fear is that, you know, we have a double whammy here. We're shooting ourselves in the foot by emitting greenhouse gases and causing the climate crisis, and at the same time making the planet in her weakest state, to deal with that crisis. That's what makes the planet, you could put it in the following way, we cannot succeed in delivery on the Paris Climate Agreement unless we take a full planetary boundary framework.

[00:36:20] We need to come back into the, safe space on planetary boundaries, even if we care only about solving the climate crisis, and it won't be enough to just phase out coal, oil, and gas.

[00:36:31] **Nate Hagens:** How has that narrative changed, and how has that been received in the broader political and scientific community? Because there does seem to be awareness now that climate change is a serious issue, but it often just stops there, and it doesn't go to these other issues.

[00:36:47] Is it changing?

[00:36:48] **Johan Rockström:** It is changing, but it's changing much too slowly. But, there are two factors that are starting to be increasingly understood. I mean, one is that three things actually. Number one is, and now I'm quoting Secretary General

António Guterres in his speech just two weeks ago when he said based on the science that 1.

[00:37:07] 5 degrees Celsius in the Paris Agreement is not a goal, it's not a target, it's a physical limit. and that is. basically coming directly out of our Planetary Boundary Science, because, as I mentioned to you earlier, we, one of the most important pieces of evidence we use to quantify the safe boundaries is the science on tipping points, and when we map the tipping points, we can today show clearly that several of climate tipping point systems are likely to cross their thresholds already at 1.

[00:37:37] 5 degrees Celsius. That is what informs the safe climate boundary, to stay away from that risk. And, therefore, we have so much proof today in the, even in the climate policy scheme, that 1. 5 degrees Celsius is a real limit. It's not something you can negotiate and play with. It's, it is a planetary boundary, and you don't negotiate with planetary boundaries because they are.

[00:38:00] They're hard wired. They're hard wired in the planetary fabric. But the second thing that is increasingly being understood in the climate regime is that, yes, to keep within that limit of 1. 5, it won't be enough to just phase out fossil fuels, we also need to keep the buffering capacity in the ocean and on land intact.

[00:38:19] It's, getting there, but I can tell you that, for example, right now, Many of us in the scientific community and in the policy community as well focusing already on what is called COP30, which is when Brazil hosts the climate negotiations, not this year, but next year in 2025, in Belen, in the Amazon rainforest.

[00:38:44] Brazil. The country hosting Earth's richest terrestrial ecosystem is leading the climate negotiations and is also now chairing the G20. And we foresee, and we have quite good signs that is going to happen, that this will be the climate negotiating moment where nature and climate gets fully integrated.

[00:39:06] I mean, we are already moving in that direction. but, we're seeing a very clear trend towards, let's call it that, that, the planetary boundary framework is increasingly understood as being central also to the climate action.

[00:39:20] **Nate Hagens:** You mentioned that six of the nine are already transgressing. is that measured in 2023 or the most recent data or does that take into account?

[00:39:30] what's built in the pipeline already because some of these things like CO2 and methane have longer term residence periods. So can we anticipate that these boundaries will be even further exceeded or more than six of the nine will be exceeded because of the momentum of what's been built in our economic civilization?

[00:39:52] **Johan Rockström:** No, that's a really important question. And unfortunately, the answer is that it's based only on the current state. So you're right for climate, we know that it will get worse before it potentially gets better. I mean, we know today that we are heading towards overshoot, meaning that we will be transgressing the climate boundary deeply.

[00:40:14] past 1. 5 and at best having a 30 40 year overshoot before we may come back to 1. 5 by the end of the century. By the way, the only reason why the climate models can take us back to 1. 5 is this assumption in the models that we won't cross any tipping points, that all the land systems remain intact, that the ocean remains intact.

[00:40:36] So, so the, climate models have indirect, already built in assumptions. that we will come back into the safe space. What would be the

[00:40:43] **Nate Hagens:** mechanism that we overshoot and come back?

[00:40:46] **Johan Rockström:** Well, the mechanisms is that once we stop pumping out greenhouse gases from fossil fuel burning. So, so it means we phase out fossil fuels according to the agreements we have signed on to in the Paris agreement to cut emissions by half by 2030 and reach a net zero world economy by 2050.

[00:41:04] Once we do that, then the, supply line, is, reduced, and when that happens, and if the planet continues to be healthy, then we know over, a long period of time, actually over centuries, the ocean and intact nature on land will continue to absorb carbon, because the, stress does not disappear immediately, the, planet will continue to try and buffer.

[00:41:30] And, That capacity is only, is determined by whether the forest systems on land remain intact and the ocean system remains healthy. So we, so that's why I'm saying that you need, a healthy set of biosphere boundaries to be able for that return to work. I should say also, of course, that the models also assume a very optimistic scaling of carbon dioxide removal technologies.

[00:41:55] So, so, so the models depend on both nature. Yeah. And this assumption that we'll be able to have direct air capture and different

[00:42:04] **Nate Hagens:** forms of carbon capture. Yeah, I'm pretty skeptical about that. But now what about oceans? Because it seems to me in the current planetary boundaries set up that ocean acidification is the metric, but there's, tons of ocean risks.

[00:42:18] There's sea level rise. There's lack of oxygen. There's your organization here just did a major paper on the AMOC and the currents, and there's lots of different aspects of the ocean. do you just parse that into one or what are your thoughts there?

[00:42:36] **Johan Rockström:** Said earlier, the planet boundary science is not finished in any way, there are gaps, and I would argue that today the biggest gap is that we are not able to represent fully with the control variables we use today, the ocean, because ocean acidification is actually only a physics and chemical indicator for the ocean.

[00:42:57] We don't have a control variable for ocean biology, and we don't have a control variable for the big ocean conveyor belt system, which holds the big potential tipping point systems like the AMOC, the overturning of heat in the North Atlantic, which more and more science shows we cannot exclude a risk of collapse, that it has a tipping point behavior.

[00:43:19] And if, by the way, if the AMOC would tip, which would then change fundamentally the whole heat exchange in the North Atlantic and the exchange between the North Atlantic and the Southern Ocean in Antarctica. It would impact the monsoon systems, sea level rise, catastrophic impacts on, livability in the Northern Hemisphere.

[00:43:40] It would have a global, impact. So, so yes, we are definitely in need to advance more planetary bounded science on the oceans, and I foresee that we are looking for a control variable on ocean biology, because that's, you know, the whole, on land, we use net primary production as an indicator for biodiversity, so basically, the richness of all biomass on land, but the ocean is also a control variable.

[00:44:09] a massive food web of net primary production from phytoplankton to the, you know, the big sharks and whales. And, we, we, need to be able to, represent scientifically what are the, minimum levels of keeping intact food webs in the ocean to keep the ocean functioning. Oxygen levels, as you mentioned as well,

[00:44:34] **Nate Hagens:** that's ongoing work right now.

[00:44:36] What if you had unlimited funding, not just you, but all the earth scientists in the world, like unlimited funding to hire the necessary scientists? What are the, like, most critical questions that you're curious about that need to be answered? They just don't have the manpower, computer power resources applied to them now?

[00:44:57] Yeah, that, that's

[00:44:59] **Johan Rockström:** that's a really important question. And there are many answers to that, Number one, which actually is something that we are embarking on right now, which is that, you know, as you mentioned, we've been publishing three iterations of the Planetary Boundary Science with, with with a cycle of seven years in between each one.

[00:45:19] So we actually, it's been taking more or less like an IPCC cycle for each of the Planetary Boundary Cycles. we're now setting out to update this every year and to connect that with the satellite data. across all the planetary boundaries, so we can produce what you can think of as a control room for the whole planet, like a situation room for planet Earth, with nine global numbers and nine high resolution maps based on satellite data, mapping all, basically measuring the planet, and measuring against the safe boundaries.

[00:45:54] And that is urgently needed. We have the technologies, And we are aiming to do that now. So, so we're, calling this the Planeter Boundary Health Check, and that requires not only massive funding, but also partnerships around, around the world. The second is something that I feel still, you know, quite uncomfortable about the fact that we have such uncertainty ranges on tipping point risks.

[00:46:22] I mean, as you know, for the AMOC, for example, you have one set of scientists saying that, you know, the AMOC is likely to collapse within the next 70 years, I mean, before the year 2100. And you have other Great scientists saying that is exaggerated. We have no evidence of a risk of a collapse of the AMOC in this century.

[00:46:42] So it's huge uncertainties here, and we need to reduce and get better precision

[00:46:49] **Nate Hagens:** on the risk assessment. The problem is, once we have much smaller uncertainties, the events will already have happened. That's right. I mean, there's definitely

[00:46:59] **Johan Rockström:** a risk that our predictive power comes too late.

[00:47:03] definitely, but I still think that science needs to continue working on, reducing the uncertainty ranges. And just to give you one, one story of, a very unsatisfactory uncertainty range, the Amazon Rainforest. So, in the latest paper and work that we've been leading from Exeter University and the Potsdam Institute, we show that the risk of a collapse of the Amazon Rainforest, which we know can happen, and what happens is that the Amazon tips over and becomes a savannah, releasing massive carbon and losing biodiversity and changing hydrology.

[00:47:36] So that is well known. We put the risk at three to five degrees Celsius of global mean surface temperature rise. So basically a temperature that we're not even likely to reach actually, that would be a complete disaster if we would come to those kind of disastrous levels of heating. When we then discuss this with our colleagues in Brazil, ecologists in Brazil, they tell us, you're wrong.

[00:48:01] This is not likely to be correct, because what can tip the Amazon rainforest is not only heat, and heat causes changes in rainfall and more fire, and that is what could trigger a tipping point. They say deforestation is a fundamental factor that would combined with temperature, lower the threshold dramatically.

[00:48:26] So they say basically that if, we cut down more than 20 to 25 percent of the force cover, which opens up so much force that the whole system just dries out because of the opening, then it could tip already between 1. 5 and 2 degrees Celsius of warming. And we simply don't know. We don't have the scientific evidence fully.

[00:48:48] what's the combination that could tip the force? But you should know, we are at 1. 2 degrees Celsius warming now, and we've cut down 17 percent of force. So, you know, we're moving very close to that, that potentially catastrophic combination. Certainly within the air bands. Yes, so that requires more scientific assessment to really get the, again, it's different boundaries interacting and unfortunately disciplines have been looking too much separately and not into the combinations of how biodiversity, freshwater, deforestation and climate interacts and that's what we also need.

[00:49:26] Just

[00:49:27] **Nate Hagens:** personally, how do you carry all this with you? Are you fun at parties? Do you crack jokes and do normal things? Cause I'm a, podcaster on these same topics. So I mean, there's so much and it's so intense and scary. We didn't evolve to carry this amount of, heavy stuff with us every day.

[00:49:46] Can you separate it from your personal life and, enjoy yourself? Or is this always with you 24 seven?

[00:49:54] **Johan Rockström:** I have difficulties in separating it, to be honest. But it's not, it's certainly not, um depressing me on the contrary, I'm, more of the kind of person who gets angry and and, and get more adrenaline from, this evidence and uh, feel the strong urge to be out there and really change things.

[00:50:21] But I don't go to parties and give lectures, I can promise you. But, but but, but it's, so I can of course separate in that sense. but I'm, very convinced today

that um, sitting on the risk assessment and having all this very dire diagnostic, that is not the problem. that's not the issue that should make us despair.

[00:50:45] What should make us really concerned is the lack of leadership, is the lack of efforts of acting on that evidence. So if there's anything that all this leads for me personally, is, more, you know, the wish to be even, more active in, in, in reaching up with the science and engaging with policymakers and, and uh, you know, shaking up the system and saying, look here, come on guys, you know, we, and as I mentioned earlier, what makes me doubly frustrated is that not only do we have all this evidence of, you know, potentially unmanageable risks.

[00:51:27] But we also have so much evidence that solving them is not a sacrifice. You know, it's a, it's actually a more modern, attractive, healthier, more secure, more peaceful, more stable future. It's even better for the economy. It's even better for jobs. And, you know, this is, this makes me just actually, to me, it just gives me even more wish to, to continue working along these, along with this, work.

[00:51:54] So it's it's, it's not easy to deal with, but it's at least not, it's not like like a

[00:52:01] **Nate Hagens:** black wall. Let me ask a follow up question to that. So I know that John Holdren, who was Obama's science advisor, made him a weekly report that was like 10 pages long on the science and Obama read it, but you're dealing with climate and endocrine disruptors and oceans and biosphere and ozone and everything.

[00:52:21] Do you get? like a weekly report as the director of this institute to give you updates on all these different things. And how do you stay on top of it all?

[00:52:31] **Johan Rockström:** It doesn't work really that way. but I'm really privileged to have a fantastic team of research analysts working, actually helping only me. And then we have a very close communication between my senior scientists at the institute here at the Potsdam Institute.

[00:52:51] But then you have the Planetary Boundary Science community, which is quite a, tight knit community. And I'm today co chairing something called the Earth Commission, which is the first attempt of creating a a global science mechanism to,

to synthesize the planetary boundary science and to introduce the social sciences as well.

[00:53:10] So not only safe boundaries, but also just boundaries. And this community interacts very regularly to update each other and we advance research together. So, you know, this is really an international community effort. And so that's the way I can keep reasonably, you know, on top of things. And as I mentioned earlier, The Planetary Boundary Framework has now become so mainstream that you have different independent research groups that, you know, I can get surprised one Monday morning I suddenly get informed, Yeah, so now you have a new publication of an update on the freshwater boundary, and I was not even aware of it perhaps, but it's fantastic as a way of, as an input, and we then synthesize that in our Planetary Boundary work.

[00:54:00] **Nate Hagens:** Yesterday I was with someone who earlier in the week was with Bill Gates at a conference. And he said that Bill Gates just picks up the phone and says, get this professor, get this scientist on the line. And in five minutes they're talking, wouldn't it be amazing if we could turn the tables and the earth scientists like you that are dedicated their whole career to this could get this politician on our billionaire on the line.

[00:54:25] Cause we need to talk about the Amazon today. Like it, do you feel like it's a David and Goliath situation with science versus the rest of the world on these really critical issues for our home planet? Well,

[00:54:39] **Johan Rockström:** I have felt that for a long time and of course I would find it very useful to be able to do exactly what Bill Gates is able to do, but I must admit that I think the tables aren't Turning, not fully, but I would say that today, we in the earth science and climate science community, we, actually should not complain at our access to decision makers, business leaders it's, it's, it's, really quite a big deal.

[00:55:12] You know, not easy access, but at least quite, quite a straightforward way of, of interaction, and particularly the private sector in the world has shown, you know, since the Paris Agreement, quite a, significant commitment to, to start moving forward. I mean, admittedly, it's still very climate centered, but it is at least moving in the right direction.

[00:55:34] I mean, just take one example, the World Business Council for Sustainable Development, the world's largest association of big multinational companies, they have just adopted a new action plan to 2050, and it's framed around planetary boundaries. and that is quite significant. The World Economic Forum, we're working very closely.

[00:55:54] They're also integrating planetary boundaries in, their global economy kind of policy agenda. so we, we see things, you know, it's, not as if we are shut out of these dialogues, but of course, again, we are at an urgency point. I mean, we know we need to cut global emissions by half within the next five years, by 2030, and we're not near to that.

[00:56:18] We're still increasing emissions, so we need, you know, we need to intensify scientific communication into the policy regime even

[00:56:27] **Nate Hagens:** further. So we have a mutual friend Jeremy Grantham. He was on my podcast and as worried as he is about climate change and has been for a long time, he actually thinks that endocrine disrupting chemicals may be a bigger risk to human futures and other animals than climate, which is a pretty strong statement.

[00:56:49] Do you have any opinion on that? And what is your, what is the state of the, novel entities more broadly?

[00:56:57] **Johan Rockström:** You know, I mean, one cannot exclude that he's right the challenge is that the science is, really not is very inconclusive on, the cocktail risks of chemicals in the biosphere, but that is why we have it as one of the planetary boundaries, that we have enough evidence to say that the loading of, for example, endocrine disruptors PFAS, persistent organic pollutants all forms of, of um, chemical long lasting chemical products.

[00:57:32] Many of them are persistent in the environment. We simply do not know what are the risks for our own genome, for example, is a risk of getting permanent damage on the configuration of our human species. And, of course these are factors that. that can, could even be equal to or even exceed the risks of many other planetary boundary breaching processes.

[00:58:02] So I would say that's why we have a very strong focus on novel entities. And just to take another one which we don't know is the interactions between biodiversity, land, And climate, which we increasingly know increases risks of zoonotic viral disease outbreaks. So we know that there is a hockey stick, which is that every pandemic over the past 100 years are all zoonotic viral disease outbreaks.

[00:58:30] And these are viruses that spill over from wildlife. often via domestic animals to humans. And we know that increasingly evidence shows that the risk increases when we breach the biodiversity boundary because it increases the penetration of humans into natural habitats, but it also changes the configuration of species.

[00:58:49] So you get more generalist species that can carry more viruses moving into urban habitats. And you know, if we get a bird flu mutation causing a human to human viral mutation that, that could cause also a catastrophic outbreak of a pandemic that would exceed, you know, by far what we experienced with COVID 19.

[00:59:15] So there are elements here of risk that we really need to be, you know, have a very strong focus on beyond just the climate

[00:59:24] **Nate Hagens:** and biodiversity risks. to add to the complexity of, what you're already describing, how do the tipping points and planetary boundaries. interrelate with each other. Are there tipping points within tipping points?

[00:59:37] Like I would assume that climate is probably the most important one, but I don't even know if I can say that really because they're also important, but that one seems like if we go, like you said, three to five degrees, then Brazil forest would become a savanna, which would disrupt all kinds of other things in turn.

[00:59:56] Do the different planetary boundaries, influence the other planetary boundaries and, or is that just too large of an error band to, to know? No, they do. I mean,

[01:00:09] **Johan Rockström:** as a starting point, the simple way of describing this is that the planetary boundaries are, quantified, are set to avoid crossing tipping points.

[01:00:21] Okay. Simple as that. So we, we know that if, we keep the tipping points on the right side of the fence the Holocene side of the fence where a green and ice sheet reflects 90 percent of incoming heat back to space because it's a permanent white surface, where the AMOC has a capacity to keep the ocean conveyor belt in a stable ocean state, where the Amazon rainforest is planet Earth's largest carbon sink on terrestrial land.

[01:00:49] As long as we keep the tipping point systems in this Holocene side of the fence, we are safe. Secondly, you're absolutely right that the risk of these 16 tipping point systems that we have mapped, that they would cross a tipping point, we've so far analyzed that risk predominantly based on climate, based on temperature rise.

[01:01:15] We need to work much more closely on. If we change the hydrological cycle, drying out landscapes, if we change biodiversity, change land, what are then the risks of these tipping points being crossed? But then there's a second dimension to this, which is also in the scientific frontier in a way, which is that we've only mapped the climate tipping point systems, that the tipping point system that, that we know regulates the climate stability, but there are other tipping points, like for example, lakes.

[01:01:43] that can flip over from, you know, oxygen rich, fish rich, clear water lakes into these murky, algal bloom dominated, anoxic states, dead states, based on nutrient loading and overfishing, and that is a Oh, not

[01:02:01] **Nate Hagens:** from climate

[01:02:02] **Johan Rockström:** or temperature. Not anything, no, has nothing to do with climate or temperature, it's just a, mismanagement, you know.

[01:02:08] overfishing, sediment inflow because of mismanaged tillage systems in agriculture, and leaching of fertilizers. And that leads to dead zones, and of course if you have one dead lake, that may not impact the planet, but if you have thousand dead lakes, Still perhaps may not impact the planet, but if you have 10, 000 dead lakes, or 100, 000 dead lakes, you know, when you start to accumulate these ecological regime shifts, as they're often defined, rather than big climate tipping points, then you can also have an impact on boundary, right?

[01:02:45] breaching of the stability of the planet. And we are actually using that evidence as well when setting the, biosphere boundaries. So, so we work with tipping points on several levels here to, give ourselves that scientific evidence.

[01:02:58] **Nate Hagens:** So there's something in chemistry, I'm sure you're familiar with Liebig's law of the minimum that says there's some input that constrains the growth of a plant.

[01:03:09] given your vast knowledge on all these different, boundaries and tipping points. Could you speculate what is the most likely thing that's gonna trip us up? Like, what are you most concerned about that would cascade into other systems?

[01:03:27] **Johan Rockström:** Well, right now, I think the evidence shows that the ground zero on planet Earth is actually the Arctic.

[01:03:34] For two reasons. One is that is warming up three times faster than the planet on average. So we are already at three degrees Celsius in the Arctic, which is in itself very dramatic. But secondly, when you look carefully at the data, you have six of the 16 tipping point systems in the Arctic region. So we're talking about the Greenland ice sheet, the AMOC, the overturning of heat in the North Atlantic, you have the permafrost systems sitting there with all the methane and carbon, you have the barren sea ice, and the Labrador current, and then you also have the Arctic sea ice, which is not considered as a global tipping point, but it is a tipping point system, because this is the white chapeau on planet Earth that cools the planet, and we do have increasing evidence, so now I'm at the, again, on the scientific frontier, not in the IPCC, that if these tipping points are crossed in the Arctic, then they can cascade through domino effects and hit the Amazon, and then Rainforest and Hit Antarctica.

[01:04:39] How can that be? Well, the conveyor there is the AMOC, so if the Greenland ice sheet and the Arctic ice systems continue melting faster and releasing fresh water into the North Atlantic, we know that is what slows down the AMOC, the overturning of heat in the North Atlantic, and when the AMOC slows down, because the AMOC is driven through a thermohaline engine.

[01:05:06] which is driven by the fact that you have saline, warm surface water flowing from the Southern Ocean up into the North Atlantic. When it reaches the

tip of Greenland, it releases heat to the atmosphere, making it possible to live where I come from, in the Nordic region. But that heavy salt water, has high density, it sinks.

[01:05:26] And that is what drives the whole ocean conveyor belt, this thermohaline engine. Now, when that is diluted by melting ice from Greenland in particular, it gets less salty, so it gets less heavy, so it sinks slower, so it slows down. And that slowing down, we increasingly know, pushes the whole monsoon system further south, which can explain why you get more droughts, and fire over the Amazon rainforest.

[01:05:56] So we cannot exclude that what's happening in the Arctic can actually push the Amazon closer to a tipping point via the AMOC. But not only that, you can just imagine that when you have less heavy salt water, warm saline water coming from the Southern Ocean, that water gets stuck in the Southern Ocean, more, has a larger, percentage of the year, which can explain why the West Antarctic Ice Sheet is melting faster than we had expected.

[01:06:25] So, and the West Antarctic Ice Sheet is very close to a tipping point. So that's another three meters sea level rise. The Greenland Ice Sheet is seven meters sea level rise. So today, our understanding is that what's happening in the Arctic is actually connecting via cascades via the AMOC all the way down to Antarctica.

[01:06:46] So. You know, again, we're all interconnected, and even these tipping point systems seem to be interconnected. So, so I would say, on your question, the Arctic is, in my view, where we have to have a particular attention right now.

[01:06:59] **Nate Hagens:** This is also fascinating. Do you struggle, like I do managing this podcast and talking to scientists of all different stripes navigating the difference between being accurate and being helpful?

[01:07:17] because you're a scientist and this is a puzzle that you and all your colleagues are putting together to best describe and understand Earth's systems. But you are also, like I am, incredibly worried and want to spend our time on this planet defending the sacredness of life. and so we want to do more than just describe it.

[01:07:40] We want to influence it, but sometimes those things can, You know, have a squishy boundary. Do you ever struggle with that? No,

[01:07:50] **Johan Rockström:** definitely. And, you know, the struggle is it's quite interesting because, you know, as we discussed earlier, this is really complex science and, we academics pride ourselves to stay true to our data.

[01:08:06] And and it means that if you try to simplify the story and, kind of step out of the academic jargon to kind of communicate things in in, yeah, you, you tend to, kind of turn corners a little bit. That means that I personally often experience that I can get stabbed both in the front from climate skeptics and in the back from academic colleagues because of taking a little bit too high degrees of freedom.

[01:08:40] and of course, to me, that's very healthy getting stabs in the back also from peers, because it's important that we stay very carefully on within the evidence we have scientifically. On the other hand, to put it a bit provocatively, I sometimes or quite often feel that if I get stabbed in both the front and the back, I probably do something right, at least, because it means that, you know, it is actually having a message that means something.

[01:09:12] It's clearly threatening those who deny that we have any problem at all, but it's also something That is challenging, and I think we need to be challenged as well. I think that is one of the dilemmas we have in society at large, but certainly in the scientific community, that we tend to be so nervous and so scared of actually being clear about, for example, talking of, you know, I don't think we have scientifically any reason to hesitate at all to say, not only do we have a climate crisis, we are in a planetary emergency.

[01:09:51] This is a planetary emergency. How can I say that being a scientist? Well, it's because emergencies is when you have unacceptable risks and running out of time. That's a combination. Unacceptable risk and time is running out. Emergency means time is short. That's what is the definition of an emergency. How do we define risk?

[01:10:13] Well, risk is equal to probability times impact, okay? So if you have an impact, which is Catastrophic. I mean, the impact is actually infinite. You cannot

even measure it economically. I mean, if we lose the Green and Ice Sheet, or the AMOC, it would be a complete disaster. So, you cannot measure it economically, it's an infinite parameter.

[01:10:36] So then, if the probability, even if the probability is low, if you multiply a low probability with an infinite impact, then risks are also infinitely high. So, I can say with very high degree of scientific certainty, even if the, even if uncertainties are high and probabilities are low, because we're talking about unacceptable impacts, it means that risks are high, and time is running out, I mean, we're in this decisive decade, we need to cut emissions by half in the next five years.

[01:11:04] So, time is running out, multiplied by very high risk, equals So, you know, it's a, but when I say emergency, my peers will say, we cannot really say we're in an emergency. but I would say today that I think we have to be clear. I have to, I think we have to challenge the world to understand that we are in this generation, Us, in charge today, sitting in the cockpit of planet Earth, putting the entire stability of the planet at risk in this generation.

[01:11:39] What happens over the next 10 20 years will determine the outcome for the next hundreds of years. Or longer. Or longer. Yeah. I mean, that is what is on our plate today. And, we have the responsibility to, to solve this.

[01:11:56] **Nate Hagens:** The challenge and the problem is that emergency to our neural ancestral wiring meant a saber toothed tiger or something like that.

[01:12:06] And these risks are complex. They're in the future. They're abstract. There are no easy solutions. the famous people on TV aren't talking about them. so it's, really difficult. And the other thing is, there's no problem. There's no problem. There's no problem. I listened to Johan Roxum. Oh my God, I don't think there's anything we can do.

[01:12:25] And then apathy. It was like, we go from not understanding it to apathy in the span of an afternoon which is another issue. Um, so so what should we do? What would be a couple policy responses that you would recommend knowing what you know? Yeah, well, the

[01:12:45] **Johan Rockström:** policy responses, I would argue, are quite clear.

[01:12:49] Today, to begin with, we need global governance, and that might sound very, utopian, but it actually isn't because we talked earlier about the Montreal Protocol, which is an example of a global governance regime. The climate regime is a global governance regime. Biodiversity has a global governance regime.

[01:13:09] So it's a question of implementing global, legally binding agreements that we have agreed upon. So that's number one. I mean, just deliver on the Paris Agreement. I mean, we have agreed to accelerate the phase out of fossil fuels and reach a net zero world economy by 2050. Just get on with it. But secondly, I mean, and we do a lot of research here at the Potsdam Institute on this, and my colleague Ottma Adenhofer leads on this, that, you know, we simply have to do what economists call internalizing externalities, put a price on carbon, and the European Union has a price on carbon.

[01:13:43] It's starting to get there at the levels that are required to get the incentives of accelerating the phase out of fossil fuels, but, you know, we have to come back to the, to, to the real discussion of implementing a global price on carbon. we're so close. to, to losing it on climate, that we now need at least a hundred US dollars per ton of carbon dioxide, global price on carbon, to, to rapidly start phasing out coal in particular.

[01:14:12] There's no excuse to invest in coal today, because it's more expensive, even without subsidies, more expensive than renewable energy transition work. And then, the third part, is equally quite straightforward, which is which, because we have an agreement at COP16 on biodiversity, which is to stop expanding our land use into intact nature.

[01:14:36] You know, we have, we've transformed grosso modo 50 percent of our land use. land, earth's land area into agriculture, cities and roads. So we still have almost 50 percent of nature that still functions, and we now have overwhelming evidence that we've come to the end of the road of that journey. We have to stop expanding into intact nature.

[01:15:03] And, you know, getting a moratorium or getting a global you know, agreement or treaty saying that we have to stop expanding in all rainforests, all temperate forests, all border forests, is not so magical because COP16 at the

Biodiversity Framework has this 30 by 30 decision, which is to protect 30 percent land areas by 2030 and 30 percent of ocean areas by 2030.

[01:15:28] And that is on a journey towards zero expansion. I mean, it's, this is a target for 2030, but you could say zero by 2050. So, you know, I think that is, these are a few of those big policy decisions that we need urgently and that we can

[01:15:45] **Nate Hagens:** implement. Does your research suggest how resilient nature is if we were to stop the land expansion and allowed nature to recover, or if we stopped fishing one of the major fisheries in the ocean?

[01:15:57] I mean, how resilient is nature if we were to leave it alone in spaces for a while?

[01:16:03] **Johan Rockström:** Yeah, so there's a lot of uncertainty here. and we are not experts on this particularly, but we have one of the biosphere models in the world called the LPJ model. That shows a high degree of resilience in both forest, wetland, aquatic systems, well we don't do so much on aquatic systems, but land based systems.

[01:16:26] the ability to regenerate if you apply the right conservation measures. But other ecologies, ecologists also confirm the, the, the remarkable strength, if you haven't pushed ecosystems too far so that you reach collapse or extinction of species, You still have a chance of regenerating back.

[01:16:49] There are uncertainties here, though. For example, on a rainforest system, you know, what would make a rainforest a rain forest, it's not a coincidence it's called a rainforest, is that 40 50 percent of the rain is self generated by this full canopy cover, this humid system that can hold its own hydrological dynamics intact, thanks to the canopy cover.

[01:17:13] If you'd open up the system and destroy that system so it moves into a savannah state and becomes self drying instead, it's not obvious that you can recreate all that moisture by simply planting, re replanting trees. So, some of these ecological transitions may be irreversible, others may be regenerative, and many of them may have irreversible effects.

[01:17:38] a positive solution, but you may not get the original system back. So, so, I would say that there is resilience in the system, but we have examples, I mean, the classic example is when the cod fisheries collapsed out of Newfoundland, which did not recuperate, it was basically permanent. collapse. The Baltic Sea right now is another example of a system that seems to have crossed the tipping point and permanently collapsed.

[01:18:08] So you have collapse of cod fisheries, eel, anoxic events, algal blooms, and can that system kind of regenerate itself? unclear. Yeah. Currently. So, and again, we come back to this discussion. So what does that imply? That message from science? Well, it certainly should not imply, Oh, the scientists are uncertain.

[01:18:35] So let's just continue as usual. I think that the conclusion must of course be, okay, so this is the risk assessment we have. Let's, then we have to apply precaution. Precautionary principle. Exactly. Uncertainty in science, which will always be there, should in my view, always be. connected with a risk assessment.

[01:18:55] And if the risks of what you may cause are unacceptably high, then even the probability of occurrence, even if that is low, means that you should act on that in terms of precaution. And, I think that's what applies in most ecosystems.

[01:19:11] **Nate Hagens:** I want to ask you one more personal question before I ask you closing questions that I ask all my guests.

[01:19:17] If you didn't have all the hundreds of scientists here and the funding tasks of supporting all this work and all your, deadlines, but you were just a scientist, what, would be the thing that you are personally most fascinated and curious about? If you weren't worried about the emergency, which you've so well described here, what like, what scientific question would you like to answer in your own research?

[01:19:43] Yeah, that's a wonderful

[01:19:45] **Johan Rockström:** question, actually. I'm, you know, my origins in this research is in global hydrology. So I've always been fascinated by the role of fresh water in sustaining life on Earth. And I think if I just had like a two year sabbatical

and could dive into a topic, it would probably be exploring how much What's the minimum wetness we need in landscapes to keep them healthy?

[01:20:20] what's the minimum levels of, moisture in the soil of groundwater levels, of freshwater levels to, to keep different ecosystems intact? That's a question that had been chasing me for a very long time that we don't really know. We don't have the measure. of, what's the minimum levels of freshwater to keep everything we love and depend on intact.

[01:20:43] So that would probably be one topic of exploration.

[01:20:48] **Nate Hagens:** The listeners of this program are quite scientifically aware of the challenges you've described. What sort of personal advice would you have to people who are aware of broader the human predicament but also the planetary boundaries and how close we are to various tipping points?

[01:21:04] as individual citizens, humans alive at this time. Number one

[01:21:10] **Johan Rockström:** is, to never despair, and to rather turn the concern and, and you know, the engagement in, in, in the science as, an asset, as something that gives you even better ability to be emotional and ethical and responsible for your co citizens on planet earth.

[01:21:38] So be proud that you're sitting so deep, entrenched in the risk understanding. Secondly, I would say, and that's the advice I give to all my students, they are, often I get the question, what should we do? And they expect me to talk about um, mobility and, um how to reduce flying and all forms of consumer choices.

[01:22:04] And they get surprised when I say that the number one issue is talk to your friends. Talk to your friends. Get the dialogue going. Speak to your, parents, your friends anytime you, you have a chance. Talk about the planet, talk about 1. 5. If you go out to the street here in Potsdam, nobody will know what you're talking about if you say 5 is the most important number we have in the world today.

[01:22:32] So I think it's really important to keep the buzz going. We need a momentum here. So that would be my second wish. And then the third one, which

we really need to help each other on. And I know that. Everyone can help here, which is that for 50 plus years, this whole topic of sustainability, environment, and climate has been about problems and sacrifice.

[01:22:59] It's been like, humans are causing a major problem and we need to back off. We need to you know, do less because it's damaging the environment and planet. And we now know that it's a completely new narrative. The narrative of sustainability is that if you apply your scientific understanding, if you put on sustainability glasses, if you apply planetary boundary thinking, what emerges is new innovations, new technologies, new advancements, much more attractive, much more.

[01:23:33] For young people, I mean, it's a cooler, more advanced, more attractive future, which also has well documented win outcomes when it comes to health, peace, security, jobs, economy. So, we're talking about the World 2. 0. We're talking about moving into a direction which is the story of the future, and we do know that if we continue on the path we're on, that's a dead end.

[01:24:02] So either you're back into the future in a dead end, and you hit the wall, and it gets dark. or you transition towards this more attractive future. And I think we need to start talking about that attractive future that, you know, what do we really care for? And what is it that gives us real happiness?

[01:24:21] And what is it I want to give to my children? And what is it that I, how would I, what would I qualify as modern? Is a coal mine modern or is a windmill modern? Is an electric Car modern or is an old diesel engine driven car modern? what is modernity? What is it? What is it I? kind of get attracted to.

[01:24:44] and I think we talk too less, we were polarizing this question too much politically. It's like, the greens in societies are still completely wrongly perceived as the leftist. You know, I interact more and more with CEOs across the world, and you know, even the most, CEOs tend to be liberals market oriented.

[01:25:07] they're lean more on the right side of politics than left side. But boy, are they onto the sustainability agenda. The car industry, the ikea's of the world, the h and s of the world, you know, they're all lined up for a journey where they want to

be winners in this sustainability race. And, why don't we have more of that narrative broadly in society?

[01:25:34] I love the environmental activists. I respect them so much, but, I don't think the way that environmental activism has over the decades scared away the vast majority by giving this impression that, you know, we're doing everything wrong, humans are all to blame, and the only way to solve this is basically to back off from everything that the vast majority considers being equal to, you know, a modern life.

[01:26:05] And I'm not saying that there are quick fixes in any way. We will need lifestyle changes. We will need that the rich minority in the world definitely changes traveling behaviors ridiculous, unnecessary consumption diets. I for sure, but, we, also know that this transition is not so painful.

[01:26:29] And we also know that the solutions that renewable green energy and consumption patterns provide us, gives us better life outcomes. So that is what I think we would, you know, we cannot shoulder that ourselves in science. we need help with that, and it's something that we can hold hands and do together.

[01:26:52] **Nate Hagens:** What do you care most about in the world?

[01:26:56] **Johan Rockström:** The planet. and my children. No, but definitely. I mean, I, tried to be very clear that you know, we talk of integrated world earth science here, people, planet science to, to, to truly, recognize that my, ultimate definition of justice is every human being's right to be born on a livable planet.

[01:27:22] And that sounds like that's a statement you could not make five years ago, but today we have to make it. That justice. is actually about the right to a livable planet. So in my

[01:27:33] **Nate Hagens:** view, the planet is like stakeholder number one. So, so then there's intergenerational justice becomes a serious thing.

[01:27:40] **Johan Rockström:** Absolutely.

[01:27:41] **Nate Hagens:** Because the carrying capacity and the tipping points and all the biogeochemical flows and everything in your work could arguably be much worse 30 years from now, 60 years from now, et cetera. So if you have a, right. to a healthy planet and you're born 60 years from now, that, that may be a different existence.

[01:28:02] **Johan Rockström:** Yeah. And remember, which is very painful to say, that it's you and I, it's our generation that have caused all this. You know, the Great Acceleration has only been ongoing for a bit more than 50 years. And I am, you know, approaching my 60th year. So, so it's in, it's on my watch that this has happened and it's what happens in the coming 50 years or less than that, that will determine the outcomes for the coming centuries.

[01:28:29] So, not only is it on our generation's watch that everything has occurred, it's on our generation's watch that we will determine the future. So, so it's, in our hands. to now determine the future for humanity on earth. So yes, it's an intergenerational justice, fundamentally.

[01:28:49] **Nate Hagens:** My closing question for all my guests is if you could wave a magic wand and you had no personal recourse to your status or situation, what is one thing you would do to change human and planetary futures?

[01:29:02] I think that the number one

[01:29:04] **Johan Rockström:** issue is to get world leaders immediately to sit down together and, recognize that we need to urgently get back into the safe space of planetary boundaries.

[01:29:20] **Nate Hagens:** Well said. Do you have any other closing comments for our viewers today, Johan?

[01:29:26] **Johan Rockström:** No, I think we've covered a lot of ground and I'm so glad that we were able to also talk about what's the narrative in the future.

[01:29:34] And I just want to close by saying that, you know, I, as you mentioned, I mean, I, live in this data every day. That's a dark room, but, I'm, really. privilege of

having, interacting as a scientist also with, change makers in the world. And, I can see the light in the tunnel from so many stakeholders in the world.

[01:29:57] So it's not, it, is not in any way a lost cause. And we know from previous large transitions in history that you never change the world by having everyone on board. You change the world by having large enough minorities that can tip quite inert majority to move in the right direction. and when you look at, you know, the world of sustainability.

[01:30:25] In many societies in the world, we are actually a double digit penetration on sustainable solutions, on people's awareness, on, on, willingness to even politically you know, vote for green or, sustainable options. So, you know, we're very, close to that positive tipping point as well.

[01:30:46] And that's why another reason why it's really worth now is not the moment to back down. Now is the moment to just increase momentum.

[01:30:55] **Nate Hagens:** Thank you for your time today and thank you for your lifetime of work and service of life, Johan Rockström. Thanks for inviting me. If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform.

[01:31:12] You can also visit thegreatsimplification. com. com for references and show notes from today's conversation and to connect with fellow listeners of this podcast, check out our discord channel. This show is hosted by me, Nate Hagens, edited by No Troublemakers Media and produced by Misty Stinnett, Leslie Batlutz, Brady Heine, and Lizzie Sirianni.