

# The Great Simplification

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Nate Hagens (00:00:02):

You are listening to the Great Simplification with Nate Hagens. That's me. On this show, we try to explore and simplify what's happening with energy, the economy, the environment, and our society. Together with scientists, experts, and leaders, this show is about understanding the bird's eye view of how everything fits together, where we go from here and what we can do about it as a society and as individuals. For many of you, Dennis Meadows needs no introduction. He was a professor of systems management at MIT and the former director of the Institute for Policy and Social Science Research at the University of New Hampshire. Most famously, or infamously, 50 years ago this month, Dennis led the team which developed the Limits to Growth research and book. They used the World3 model to simulate the consequence of interactions between earth and human systems, which spawned both awareness and criticism on its forecast for the coming century.

(00:01:12):

The Limits to Growth study influenced many researchers and activists, including me, to better imagine how all the various inputs to our economy and environment fit together. Dennis is a no-nonsense fellow. This conversation was hard-hitting with no fluff. I hope you enjoy it and learn from it. For context, it was recorded just a few days before Russia invaded Ukraine. Hello, Dennis.

Dennis Meadows (00:01:53):

Good day, Nate.

Nate Hagens (00:01:54):

It's been 12 years since I saw you at some energy conference in Europe, if I recall.

Dennis Meadows (00:02:00):

Well, probably, that was in Vienna where I suppose you and I were both at, unfortunately, one of the last meetings of the Association for Peak Oil.

Nate Hagens (00:02:11):

Right, right. I remember that. What a complex story the peak oil one is. And now, just like many other things, the cried wolf has been tackled by complexity. And now, people aren't worried about oil at all when that wolf is one of many on our doorsteps. I have

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a lot of questions for you, Dennis. Let's get right into it because I know you have a lot to say. Probably half of my listeners are extremely familiar with you and your work, and *Limits to Growth*. And probably half of my listeners have never heard of you or the book you wrote and the work that you've done. Can you start by giving us a very brief summary of the results of *World3*, *Club of Rome*, *Limits to Growth*, and where we stand 50 years on for those who are unfamiliar?

Dennis Meadows (00:03:05):

The period of 1970-1972, I was on the faculty at MIT. I came into a relationship with an international group called The Club of Rome, which was worried about global problems. With their political and their financial support, I created a research team which had 17 people on it. And over the course of about two years, we built a computer model using methods that had been developed at MIT to understand the causes and consequences of physical growth on a finite planet. That led to many papers and three books. First book to appear was called *The Limits to Growth*, it was a popular text, which much to our surprise, went on to be translated in about 35 languages and fairly widely discussed and disseminated around the world. Its principal conclusion was to point out the obvious, at least obvious to us. Physical growth, expansion of population, of all the things associated with GDP, like energy consumption, food production, and so forth, can't go on forever on a finite planet.

(00:04:22):

And that, it seemed to us, was obvious. But much less clear was how long it could go on, "What would be the mechanisms for slowing it down, and what would be the consequences if we didn't?" And again, simplifying substantially, we said that there were really two choices back in '72. We could begin immediately to start slowing down expansion, hoping to stay within the carrying capacity of the planet. Or we could just sit back, enjoy the benefits of growth for another maybe 50 years. At which point, we would be far beyond the carrying capacity of the earth. And then there would be a decline. Our analysis only went out to the peak. The factors which cause growth are extremely different than the ones that will be involved in decline, and we didn't imagine we had anything to say about that. But our computer plots all went out to the year 2100. And in that sense, they all encompassed a period of decline for the global society. I suppose that's what attracted the most attention.

Nate Hagens (00:05:31):

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And there were several scenarios. And on the commonly shown graphs, there aren't dates on the bottom except for the beginning and the end date of 2100. But the standard model, if you look at it now in 2022, it's tracking pretty closely. Yes?

Dennis Meadows (00:05:49):

Yes, of course, the computer does print out all the dates, but we didn't consider them to be significant. So, in publishing the book, we blotted them out. We removed them. Nonetheless, you can stand back, realizing that the timescale is 200 years, and get some impression for when the different curves are unfolding. And if you do that with our so-called standard run, one of the, I think, 13 scenarios that we created, it showed that many of the major variables, food per capita and so forth, industrial output per capita, would reach their maximum about now in the period 2020 to 2030, and then begin a decline.

Nate Hagens (00:06:36):

Just a quick side question on that. I was looking at the graphs this morning, which anyone can find on Google under Limits to Growth or World3. And in the standard run, industrial production peaks right around now, early 2020s. But population increases for another 30 years or so. Can you briefly explain the dynamics of that?

Dennis Meadows (00:07:00):

Let me once again state that we produced 13 scenarios because we knew it was impossible and probably also not very useful to make a single prediction. That so-called standard run happened to be the one which was generated by our initial set of assumptions. If you change those assumptions, you get other results. In some of them, population begins to decline well before industrial output per capita. But in the standard run, the behavior you see is what is commonly observed in nature. A sort of classic ecological overshoot and collapse case study is known by the name, the Kaibab Plateau. It refers to a flat land out in, I think, Colorado where deer were introduced. The population grew rapidly after the wolves were killed off. You saw there what you could expect to see also on the planet, that the population tends to grow beyond the point of the carrying capacity. And for quite a long time, there is a declining standard of living without an actual reduction in the physical numbers.

Nate Hagens (00:08:17):

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This is a question that I've always had, that *Limits to Growth*, especially in ecology, environmental, energy, biophysical economic circles, is incredibly famous and continues to be referenced today. But it was written 50 years ago. In the intervening decades, computers, technology have become way more powerful, and scientific understanding has improved. Why do you think the book is still constantly referenced and referred to, and revered by some people, and ostracized and ignored by many others? Given how much technology we have today, aren't there similar things out there? What do you think about that?

Dennis Meadows (00:08:56):

First of all, let me note that, although I thank you very much for your compliments, the vast majority of mankind never heard of the book and could care less. Of those who have heard it and who hold it in high esteem, my guess is that they are influenced by one of our objectives. We weren't in our book, trying to tell what was going to happen. It's impossible to do that. Indeed, in the book, I think eight different places we used the term, prediction. Except the one time that it appears on a graph we used from somebody else's material, every single one of those is to disclaim or deny the idea or the goal of prediction. Rather, we were trying to give people a framework within which they could understand what's going on and form their own opinions.

(00:09:52):

As a teacher, I was always painfully aware of the fact that most of the so-called facts I would teach my students would turn out to be false or obsolete within a decade or two. But if you can give someone a conceptual framework within which they can integrate a lot of very different kinds of data and form their own opinions about the things that are important to them, that has lasting value. And I think the book does that.

Nate Hagens (00:10:20):

One of the other authors of the book, Donella Meadows, famously said that systems dynamics models weren't used to make predictions, but to better help human minds understand interactions. And so I think that is what the book probably tried to do is ... When I teach my students about a new concept, it's not that I'm trying to predict something. I'm trying to trigger different neurons and different connections in their brain to understand our world better. And that's what systems dynamics and ecology attempts to do. Yes?

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Dennis Meadows (00:10:50):

Yes.

Nate Hagens (00:10:52):

Taking a step back, why don't more people think like this? As a person, as a young professor in the '60s and early '70s, how did you get interested in systems thinking, and how has your thinking about systems changed over the years?

Dennis Meadows (00:11:10):

Those are good questions. Before I get into them, let me point out something that's obvious, but often unsaid. Already and probably in the course of this interview, we're going to cover a very wide diversity of issues and questions. On some of those, I actually have scientific expertise because I have devoted my time to studying them, to learning about the data, maybe to making models of them, and so forth. In other cases, actually, my opinion is really not much better than most of the people who are listening to this podcast. I may have intuition or in some cases, merely hopes about the things you're asking about.

Nate Hagens (00:11:54):

Dennis, isn't that at the absolute core of our problem? Because a lot of other people out there are ... The YouTube algorithms are up-voting them because of extreme opinions on this or that, when you as a scientist just doesn't even want to voice his opinion unless he has some data to back it up. Isn't that at the core of our problem?

Dennis Meadows (00:12:14):

Well, there are many things at the core of our problem. That's one of the things that make it more difficult. You asked me how my thoughts about systems have changed. Well, I'm a scientist, and it's essential. That means that when the data no longer support my conclusions, I'll change my conclusions. The vast majority of humanity operates in a different way. When the data no longer support their conclusions, they change their data. You see this, for example, in those who deny climate. There's the famous dialogue where the climate denialist says, "Well, I don't believe in climate because the glaciers are getting bigger." And then the scientists go out and spend a year or two studying the glaciers and come back, and say, "No, actually, the glaciers are getting smaller." At which point, instead of changing his opinion, the climate denier says, "Well, actually, I don't believe in climate for a different reason. I don't

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actually care that much about the glaciers. I don't believe in climate because the polar bears are doing just fine."

(00:13:22):

So, the scientists go out for a couple years and look at polar bears, and come back and say, "No, actually, they're in desperate straits." And of course, the climate denialist says, "Well, actually, I don't really care that much about polar bears." And gives some other reason.

Nate Hagens (00:13:34):

We only care about truth if it helps our self-interest?

Dennis Meadows (00:13:37):

Well, of course, it's the whole nature of, "What is really truth?" But I think a famous concept in psychology is the so-called cognitive dissonance. If what you see doesn't support what you want to see or what you expect to see, rather than changing your expectations, often, you will change what you look at. And that's a natural consequence of our evolution, I think, and unfortunately, characterizes a very large number of people.

Nate Hagens (00:14:05):

Well, just on that, would it have mattered if Limits to Growth study that you did came out in 1920 or 1970, or 2022?

Dennis Meadows (00:14:13):

No. Of course, our forecast would've been different. The nature of the model would've been somewhat different. But the main relationships in the model were formulated in an attempt to capture some sort of invariant socioeconomic, physical principles. For example, in the 1920s, food production depended on the amount of soil, on fertilizer, and the amount of inputs. The technology changed by '60. And so you got more than you did before. But still, if you didn't have soil in 1920, you didn't produce food. And if you don't have it now, you're not going to support the country. So, the physical relations had changed somewhat. But more important, I think, is an invariant social factor. For literally as far as we have any record of history, there have been a stratification of society into those who have power and in most cases, resources, and

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those who don't. And those who have it always resist change. In the old days, they may have been priests. These days, the heads of oil companies.

Nate Hagens (00:15:25):

Or economists.

Dennis Meadows (00:15:26):

Or well, a lot of economists don't actually have that much power except, of course, within their discipline. And that would be threatened by change. That hasn't changed. And as a consequence, for us to have come out in 1920 and say that we need to change policy probably would evoke more or less the same kind of negative response as it did when it came out in 1972.

Nate Hagens (00:15:49):

Imagine you have a time machine and plenty of funding and staff, and could return to MIT in 1970, using today's technology and knowledge, would you have done anything differently? What might you have done differently?

Dennis Meadows (00:16:06):

I've thought about variants of your question. Obviously, computer power has progressed enormously since we did our initial work in 1972. I still remember sitting for hours over a electric typewriter as it painfully pecked out each little character in our graphs. And physical science has advanced significantly. We know much more about the universe, about climate and so forth. So, those things have advanced. What hasn't advanced very much is our understanding about social, psychological, political dynamics. And those are the factors which have a major influence on the future options of society. So, since our model was predicated on the assumption that it did little good to take a stupid statement and replicate it a hundred times just to make it more complicated, we were simple, and we tried to stay with the things we knew. The things we know now fundamentally about long-term social, political economics and dynamics unfortunately are not much different than they were 50 years ago. And we may come to this later in our conversation. I would add a few components to the model where I think we compromised our ability to talk about the physical dynamics. But generally speaking, the model has stood up for what it was intended to do, which was help us understand that period after 1970 when there was still some opportunity to moderate population and economic growth.

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Nate Hagens (00:17:47):

Did you ever personally hold a great hope or some hope that your efforts actually would change the trajectory of decision makers and economic growth?

Dennis Meadows (00:17:58):

You're asking me now about things that took place 50 years ago, and I'll just counsel you to be very skeptical. I was naive. I directed the Limits to Growth project in my late 20s. I had grown up in a very non-diverse social and economic society. I had never been outside the country. I had a very, very, very naive understanding about how things work. I'm sure that I imagined our work would have some influence on decision makers. Looking back on it, I can see how really unrealistic that was. It was at that time, what I would term doorstep implementation. You independently identify a problem you think is important. You do analysis on it. You write it up. Then you take your report in the dead of night, lay it on the doorstep of an important decision maker and imagine that in the morning, they will come out, find your report, the scales will fall from their eyes, and everything will be just fine. Well, of course, obviously, that's enormously different than reality. If I did have the privilege of going back to 1972 and doing it all over again, I wouldn't change the model that much.

(00:19:20):

Obviously, I'd use my laptop instead of the IBM mainframe, but the model would be more or less the same. But the process would be very different. Instead of clustering 16 scientists together in a room up on the second floor of an MIT lab, I would have engaged in a process which brought a large number of concerned, more farsighted people together. At the early stages, models are implemented not because the results convince somebody else, but because somebody participates in the process and educates themselves through that process, and then comes to understand reality differently. In the old days, I used to teach people how to build computer models. Now, I teach them how to play games. Computer models are elitist. I stand up in front of you and tell you what my model tells you to do. Games are participatory. I give you the rules of the game, you play it, and in the course of playing it, hopefully, learn some constructive rules for how to be more successful. So, in building systems games, you're starting to give people some systems insights they'll never get by standing up and presenting a bunch of PowerPoint slides with scenarios.

Nate Hagens (00:20:39):

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Could there be a game modeled on the core principles of Limits to Growth that would set some light bulbs off in people's minds that that would result in change?

Dennis Meadows (00:20:50):

Well, now, you've asked three different questions. Could you build a model that incorporates some of the basic relationships of World3? Yes, you could do that. I did. It's called Stratagem. And it was used widely. The World Bank bought a bunch of them for training people how to develop countries. So, you can do that. Does it set off light bulbs? Yes, some light bulbs in some people. I often after playing the game, observe people standing around the game board, moving pieces as a way of trying to express what they saw going on in real life. Did it make actual change? No, I don't think so and for the reasons I mentioned before. A few people with new systems insight are a fairly feeble force in the face of a vast established bureaucracy of people who are, for good or ill, principally focused on their own short term welfare.

Nate Hagens (00:21:48):

Yeah, thank you. That was an excellent answer, which leads me to one of the questions that I've got prepared for you. We can both agree there's been very little concrete response to your 1970s descriptions of overshoot and prescriptions for avoiding it. How much do you think that this is attributable to ignorance or the education system, and how much to leaders, politicians, business people wishing to avoid the status risks that comes from speaking uncomfortable truths? As an aside, I got a call today from someone I won't mention, very well known person, who has a podcast. We've become friends. And he wants to have me on his podcast, but he won't do that until he's sure that there's a way that I can give a message that is popular and acceptable because right now, my message about the Great Simplification is too painful for his audience to listen to. Is that another part at the core, that the people in power were self-selected to get there, and they're afraid of integrating and voicing these hard truths?

Dennis Meadows (00:23:03):

Of course, once again, you've gone across quite a number of topics. Of course, all the things you mentioned are at work. There is ignorance, ignorance in a sense of a systems ignorance. There are people at the top who are afraid of currying the wrath of their voters or their donors by speaking the truth. The educational system is deficient in important ways. All those things are important, but there are other things

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at work. We are enmeshed in a large set of institutions, corporate and governmental institutions, led by people who rose to the top by doing certain things. A, it's what they know how to do. And B, a need for their policies is a reaffirmation of their worth.

There's a Japanese saying, "If your only tool is a hammer, everything looks like a nail."

(00:24:02):

And for the leaders, the problems they confront seem to be a call for and an opportunity for them to do those things, which they're good at, which they know. People don't behave inappropriately only through ignorance, but also through habit and through affirmation. We tend to cluster around us people we value and who value us, and it becomes a self-perpetuating clique. There are many things at work. Let me say incidentally, don't hold your breath for your interview. I can't imagine how someone with your point of view is ever going to be able, honestly, to speak a message that will make your blog colleague's audience feel happy.

Nate Hagens (00:24:49):

I'm trying to act as a conduit here and get all the experts of the various disciplines that come to bear on the human predicament together so that we can have a cohesive ... Maybe society or at least part of society is ready to hear about ecology and systems because there are so many people out there that feel that something is horribly wrong. I agree it's a long shot, Dennis, but I'm trying. You're trying. You've spent your whole life trying, actually. And for that, I'm grateful. I talked to Paul Ehrlich a couple weeks ago, and the founders of Greenpeace are friends of mine. It's unfortunately that if you think about the fable of the tortoise and the hare, the tortoise is the ecologists, and the hare is the businessmen. And our society is approaching a phase shift. I agree with you that my internal mental model and your scientific models ... I don't know what's going to happen, but I'm quite confident about what won't happen, and that is continued growth for much longer.

(00:26:00):

Let's jump into some more technical questions. I think, and I would assume you would agree, that people look at the world and the future through various lenses. And the biggest, most popular lenses in our culture are the technology lens, "Technology will save it." Or the market lens would be, "Via innovation and incentives, the market will come up with a solution. It always has." These lenses are largely blind to energy and ecology consequences. So, in the best case, referencing your modeling work, how might

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technology evolve to change the conclusions of the Limits to Growth model? What role could technology play?

Dennis Meadows (00:26:46):

Technology, of course, is a simple term that covers a phenomenal diversity of different kinds of things. A hammer is a piece of technology, as is my laptop, as is the blockchain. So, probably, there's no simple answer to your question, but there are some principles that I think are relevant. Take my hammer example. If someone were coming at you with a hammer, intent on doing you damage, my guess is you wouldn't focus on how to give them a different kind of hammer. You would understand that the damage is a result not of the technology, but of the goals or the ethics of the person who's wielding it. And as long as our society doesn't place much emphasis on external environmental costs, remains preoccupied with the near term, considers it acceptable to have wide gap between the rich and the poor, and so forth and so on, so long as that's true, there's no technology which is going to give us a fundamental solution. At best, different technologies will buy us time to make the changes that we need to make socially and institutionally, and culturally.

(00:28:12):

It's frustrating because, in fact globally, we have today, all the technology we need to deal with these issues insofar as they are subject to solution. We don't need a new kind of agricultural technology in order to feed people. We need, rather, ways of distributing food better, avoiding the kind of conspicuous consumption that converts cassava fields over to the production of roses for export and so forth. Having said all that, where do I see interesting technologies? Well, each of these is just trivial, but batteries. The storage of energy is still in a primitive state. I believe that even within 10 years, we will see phenomenally better, cheaper, less damaging ways of storing energy, which of course, opens up many alternatives for coping with the fossil crisis. Despite that I am a technologist ... I studied at MIT. I was a professor of engineering for decades. I've been on the board of a number of technical startups. I just don't see technology as the place to start. As I said, it's a way to buy time conceivably. But if you're not making the changes, having a little bit more time isn't going to make much difference.

Nate Hagens (00:29:35):

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Well, I agree with that. I've always said it's not a technology problem. It's a human problem with our goals and our system. There are a lot of people in my sphere that truly believe technology will overcome the financial and economic, and ultimately ecological limits we face. Let me run this by you. These are four points that I've been trying out this week, but I've never tried them out with someone like you. First point, there's an extremely tight link between energy and GDP. Every good and service in the world economy that results in GDP requires energy somewhere. Point number two, our human economy uses a hundred billion barrels of oil equivalent, of coal, oil, and gas per year. Each of those has roughly the labor potential of five years of human work. So, we have this giant army of fossil helpers, 500 billion human workers strong. Point number three, that army has been growing during yours and my lifetime at roughly 2% a year.

(00:30:45):

Point number four, humans use technology and innovation. We use and energy more efficiently, and we figure out ways to get the same benefits from using less energy. And that trend has been 1% a year. 1% a year, we've increased our efficiency of using energy globally. But all of the "technology will save us" in that fourth category. And we've looked at this entire system without considering that this giant army of fossil helpers has been supporting us. And at some point soon, we're going to have to use technology in a declining environment when those fossil armies retire and aren't woken. Did what I just say make sense? Does that resonate with your understanding, or do I have something wrong there?

Dennis Meadows (00:31:41):

No. At the level you're speaking, I agree with you. The link is an empirical fact. Every study of the relationship between GDP and energy consumption shows it is, and it's actually a very high correlation. Depletion of energy is, as you know well, a complex issue. It's not only the amount of physical availability, but the net energy that you get out of the materials you make available. And actually, the physical quantities of our energy stock continue to decline. We've only increased fossil fuel production by shifting to more and more expensive and alternative sources, offshore oil, fracking, and so forth. But also, the energy return on investment is declining from ... Well, you know the numbers. So, I won't repeat them. But together, those two are going to reduce the number of effective slaves we have. That will have profound consequences. I found it interesting. I went back to look. In ancient Rome, rich people tended to have about

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5,000 slaves, really rich people, and the emperor had about 20,000. So, it's no mistake that many of us today in the West can live a life in many ways, like that of the rich Romans. I asked myself, "Where are we going to get the slaves we need or want when the oil starts to go away?"

Nate Hagens (00:33:14):

Yeah. Basically, there's 5 billion real human workers and 500 billion fossil workers every year. No, it's a core issue. Bringing it back to your work, the original Limits to Growth analysis was robust, but it was simple, relative to certain models today. But there were several factors excluded that I could argue would impact the shape of the down-slope. One, you just mentioned, net energy, how much energy we have to devote to the energy sector and how much is left for the rest of society. Another factor is credit because when you wrote this, we had not even started using credit en masse in the United States and globally to pull resources from the future to the present moment in order to boost consumption. And then another third and fourth, I would say, is geopolitics and complexity. We currently have a six-continent supply chain that we've built a really efficient, just-in-time system. Do you expect these factors to influence the declines projected by your model?

Dennis Meadows (00:34:24):

Oh, of course. They're all important. We left out other important things. There's no warfare, no military in our model. Epidemics don't show up in our model despite the fact that they've had a really profound influence. Climate change is mentioned once in Limits to Growth. We increased our attention to it in later editions as it became clear how important it was going to be. But no, we excluded many things. Our goal was to look at what we said in the title, limits to growth, none of the factors that we've discussed now, not credit, not war. None of these increase the limits to growth. They only reduce our options. We weren't trying to understand the dynamics of decline. Anyway, it's a fascinating topic and certainly very important, but that wasn't our focus. And so I agree with you absolutely that those factors will influence decline, but that doesn't imply that we should have put them in the model.

Nate Hagens (00:35:25):

The Cassandra legend, maybe one of the earliest recorded human narratives about the basic contradiction between prediction and choice, if people had believed her, Cassandra wouldn't actually have been able to foretell the future because the actions

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taken would've been taken to avoid the foreseen or predicted disasters. In other words, a predictable world has no room for choice, and a choosable world is not predictable. Can you comment on this line of thinking?

Dennis Meadows (00:35:58):

Well, I certainly agree with it, but to say that prediction may lead to choice which alters the predicted outcome is true, in many cases, it's not always true. When you predict that a physical law is going to continue to remain valid ... For example, the law of gravity will continue at its current value or that the melting point of ice is going to continue to be 32 degrees Fahrenheit, making that prediction doesn't set up the conditions for nullifying it. We were trying to focus on things that we knew couldn't happen. And in that way, we kind of finessed the Cassandra complex. If we predicted one outcome, we would've been on the hook because then exactly the factor you're mentioning could have come into play. But remember, we laid out 13 scenarios.

(00:36:59):

And I think within them, you will find a possibility for almost any kind of social choice that you would like to make, ranging from complete ignorance of the situation over to a very active intervention in a successful attempt to produce some sort of sustainable development. I used to say in jest, I hoped we would be self-defeating prophets. I hoped that our more negative scenarios would prompt exactly the kind of action we call for and which would see a better result. I haven't noticed that happening, incidentally.

Nate Hagens (00:37:34):

Yeah, I feel you. 30 years less experience than you have, but I feel you. I was four years old when you wrote this report. I've got quite a few more questions, and the harder questions are yet to come. Here's a technical question for you. The integrated assessment reports of the International Panel for Climate Change, they are not systems models like World3. And so they have no projections of overshoot and collapse, only growth, all of them. Reflect on the differences in model approaches and what implications this has for some of the greenhouse gas emission scenarios.

Dennis Meadows (00:38:14):

I know personally, as friends and professional colleague, many of the people engaged in climate modeling. I enormously respect the work they do, the challenges they're

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confronting, and the expertise they bring to bear on it. It's of interest to me intellectually because I am fascinated by the way modeling is evolving to help us understand the world. And I'm interested in it personally because I always like to know what the weather's going to be like today. Nonetheless, we need to recognize that the two models, the goals, phenomenally different. It's almost as comparing a microscope with a telescope. We were trying to think about the longterm general dynamics of the social economic system. Whereas, climate change models are focused very narrowly on a set of climate variables. It's, I think, not an oversimplification to say that climate modelers because of the way the IPCC is set up, find out what's politically acceptable, and then trace it out, and then build models on the basis of that. Whereas, we found out what was scientifically valid, and then traced out the political implications or the social consequences of that.

(00:39:34):

You're just coming at it from different directions. One of the consequences of that was that many of the politically sensitive variables like population or food per capita, or economic growth are endogenous in our model. That is to say they change over time in response to things going on inside the model. For the IPCC, those politically sensitive variables are exogenous. They're fed in from out outside. You have to make assumptions about what's going to happen to the population or what's going to happen to the GDP, feed those assumptions into the model, and then trace out the implications for emissions, temperature change, and so forth. That's what's to say about it. The computer language is different. The demands on a computer are different. I can now easily run World3 in seconds on my laptop. The most advanced climate models requires supercomputers cranking out over hours. Our model has, I don't know, 150, 180 variables in it. The most advanced climate models have literally millions of variables in it. We're not particularly sensitive to coefficient values because we're focusing on the structure of the feedback, adaptive feedback structure. But when you have a model which is driven in large part by exogenous inputs, you need to be very concerned about the coefficients. So, it's just a totally different discipline.

Nate Hagens (00:41:10):

My view, briefly, is that the climate models are energy blind. I saw the International Energy Agency this week has a forecast out to 2050, that GDP is going to increase at 3% a year globally, and we're going to use 27% less energy between now and then, which is just divorced from a biophysical worldview. I personally think that the fossil

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reserves and the access to fossil fuels to burn for emissions is wildly overstated, how much fossil fuels we have that are affordable to extract. At the same time, the biological feedbacks, which were already starting, methane, permafrost, et cetera, are probably grossly underestimated. And at some point, one of my biggest worries is that the biological feedbacks will become a stronger forcing than the human emission ones.

Dennis Meadows (00:42:10):

Well, I agree generally with your views and your concerns, but that doesn't mean I think the models are blind to energy. The factors you mentioned, GDP per capita, remember those are fed in exogenously. It's the process which is energy blind. If you were to feed into those models more realistic assumptions you would get different results.

Nate Hagens (00:42:36):

You would get results that would not be politically palatable.

Dennis Meadows (00:42:39):

Well, actually, we're already getting results that are not politically palatable, but even the inputs would not be politically palatable. So-called turning points that you mentioned, one example of methane emissions, raise all sorts of political flags. And so it's difficult for the scientists to put those into the model. And we have also a problem. There are areas like these which we, in fact, don't understand physically very well yet. And the IPCC scientists need to have some foundation of theory when they're formulating the equations that go into their models. So, we may omit some of these turning points not only because they're politically unacceptable, but because we just don't know how to do it. But the models themselves are not making value judgements about this. They reflect the value judgements of the political process that's been created to produce them.

Nate Hagens (00:43:34):

That's a good answer. I understand that. I agree with that. Let's stay on that topic. Let's assume the political unpalatability aside and the political status risk aside. If you were somehow able to magically advise high level politicians today, given what you know, given, that it's 50 years after your research, which has largely held up on the model runs, what would you say? What would be the advice?

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Dennis Meadows (00:44:07):

I haven't had much time to think about that or a reason because by and large, leaders don't come to me asking for advice. And so let me just offer a few reflections about what you've just said. First of all, it's not magically possible to get rid of some of these problems. Over the past couple century, we have put enough greenhouse gases, CO<sub>2</sub> and others, into the atmosphere to eliminate the kind of society which we have come to think is going to go on forever. The last time CO<sub>2</sub> was at this level in the atmosphere was 4 million years ago. During the Pliocene, the sea was 20 meters higher than it is today. We have absolutely no reason to believe that isn't going to happen again. Indeed, we see it happening. The Antarctic ice shelf's melting is accelerating. And when it's gone, that in itself is enough to raise sea levels by 190 feet.

Nate Hagens (00:45:10):

We're already 400 feet higher than we were like 20 or 30,000 years ago, right? It's just a slow moving--

Dennis Meadows (00:45:16):

No. Well, here again, it's the difference between ordinal and qualitative data. Of course, these things are subject to debate, but I think the consensus is about 12,000 years ago at the peak of the Ice Age, enough water had been absorbed into the ice to lower sea levels by about 120 feet. At least, we know it was taken down far enough the people could walk back and forth between the mainland of Europe and the British Islands. What's a practical difference between 120 feet and 400 in my mind, it's not interesting. It is significant that our species was around and presumably getting on with life in those days. And it gives me some hope that with the kinds of precipitous changes that are coming, homo sapiens will have the capacity to see it through.

Nate Hagens (00:46:09):

My core message is I think there is no way out for our current way of living and our cultural expectations. That doesn't mean there's no way out. There's lots of viable future paths for lots of humans and other species. It's just our current expectations, there's a bill coming due on that. But getting back to your advice, if a politician were to take your advice, what would be some of the directions of suggestions you might give him or her?

Dennis Meadows (00:46:37):

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Well, of course, it depends on what the politician is trying to achieve.

Nate Hagens (00:46:41):

Better futures than the default.

Dennis Meadows (00:46:43):

Well, for whom and over what time period, and measured by what indicators? One thing I've learned is that most people are not going to stop doing what they're doing in order to do what I tell them to do, unless I can cause them to believe that it's going to serve their purposes better. Now, fortunately, there's a wide diversity of purposes at work. If somebody is trying just to get rich over the short term for themselves, I, by and large, don't spend my time trying to persuade them to do something different. I'm looking for people who have a concern, who are thinking longer term, and who recognize that there are other things in life than simply accumulating digital indicators of wealth.

Nate Hagens (00:47:31):

By the way, I think there are a lot more people that are recognizing what you just said. There's a gut check. There are people that are recognizing the truth of what you just said.

Dennis Meadows (00:47:41):

I hope you're right. What would I tell them? One of the profound constraints today on evolving in a more constructive direction is that virtually all of our research, all of our historical experience, all of our psychological yearning has revolved around the notion of growth. And when you pose the possibility ... I won't say the inevitability, but the possibility that that growth is going to slow down, the instinctive reaction is horror. I have recently gotten a small amount of perverse humor by sending out my standard run, the one we produced back in 1972, to half a dozen of the people who were its most severe critics back then, economists and others. And on that diagram, I simply put a little arrow at the peak and say, "You are here." Without further comment. One of the more thoughtful economists that I sent it to recently wrote back and said, "Well, you mean we're heading back to the Stone Age?" And I said, "No, I mean that the current level of material consumption is not going to continue." I said, "But that certainly doesn't mean the Stone Age." I said, "I actually can imagine myself a society

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which is quite advanced and uses half as much energy as that we use today per capita."

Nate Hagens (00:49:21):

Well, Spain uses half as much as the United States, as one example.

Dennis Meadows (00:49:25):

Well, and I said, "And the reason I can imagine that is because it's how I grew up." In the '50s in the United States, which was a relatively sophisticated and advanced society for the time, energy consumption was half current levels. But the notion of going back down is so horrifying, it introduces so many questions that are not well understood, that it just evokes a kind of visceral response to ignore the message. So, one of the first things I'd say to political leaders is, "Start systematically to support efforts to understand realistic options in a system where the population is declining, and we're shifting the nature of consumption and achieving hopefully some other goals like equality and liberty, and so forth." I've been on the lookout for stuff like this. Not much exists. I read recently, a fascinating book by a Japanese economist called *Shrinking Population Economics*. It's a systematic effort looking at the data of Japan, where this is a real problem, to understand what's going to happen with the productivity of industry, with export income, with the capacity of the society to afford social supports to staff its prisons and its hospitals, and its schools, and so forth.

(00:50:49):

There are a large number of extraordinarily interesting challenging questions to research. We need to get started doing that. Leave aside whether we'll choose to follow any of them or not. At the moment, we don't have that option because we don't even know what they are. So, that's the first thing I'd say. Second thing I would say to a politician is ... Let's assume the politician is open to suggestions. Look around at the factors in your society that enforce a short term time horizon. They're easy to find. Frequent election cycles, high interest rates, or high rates of desired payback, the daily stock market reports, et cetera, et cetera. Just look around and begin trying to understand how we could put in place alternatives, which would reduce to some extent the intense pressure to focus on the short term and on the current locality.

(00:51:48):

I would offer one third suggestion to a politician, and I'm not speaking academically now. I've actually done this. Start identifying some new indicators of success, which will

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look good if we start doing the right things. Now, unfortunately, if we start doing the right things, most of the indicators of success that we use start to broadcast failure, which is a serious problem for the politicians and corporate leaders who are pursuing the policies.

Nate Hagens (00:52:16):

Like GDP and quarterly earnings.

Dennis Meadows (00:52:19):

For example. Just to make this concrete, I live near a relatively large city. And a friend of mine who lives there was so proud the other evening, proclaiming that his group had managed to elect a set of city council members who were going to be very much more progressive and environmentally-concerned, and so forth. I said, "That's great. That's wonderful. But tell them instantly to start identifying and implementing some indicators that will show people why they should be happy at the results of their policies because now, the feedback they're going to get will be mainly negative."

Nate Hagens (00:53:00):

A couple weeks ago when you and I were emailing, I sent you a document that I had been presenting to former politicians called Advance Policy, which is recognizing that the things we need to do in the coming decade or so are not currently culturally or politically acceptable. So, we need, like you said, to get people thinking about the questions and researching them. One thing that I didn't send you is another project called How Are We, which is developing a complimentary metric to our societal success based on how people are doing in their real lives on a battery of categories. And we're in the early stages of that. It's amazing how low having luxury and convenience things ranks to people. The things that rank highest are their health, is number one. And their social fabric and job security are also very high up there. But yeah, we're in this mousetrap of ... Or monkey trap, as it were, of, "GDP is our goal. And if we're not growing, we're not successful." Are humans hardwired for growth? Is that part of our genome, or is that just a cultural construct, currently?

Dennis Meadows (00:54:15):

I would say no. I base that on the observation that genetically, we are the result of three or 400,000 years of evolution. And during the vast majority of that time, there was no growth. As recently as a thousand years ago, it was the norm that you would

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die in the house where you were born, that you would pursue the occupation of your father, that your standard of living would be the one of your parents. There wasn't this expectation of growth, but our behavior is a function of two things, our genetic endowment and our social infrastructure. While genetically, I don't think we're hardwired for growth, it is for sure the case that the social institutions which have evolved, corporate, governmental and others, are hardwired for growth. And that's not because it's innately necessary, but because the ones which grow survive and displace those which don't grow, by and large, in our society. It doesn't need to be that way, but it is the way it is now. That's where you see this incessant requirement for more.

Nate Hagens (00:55:37):

I actually totally agree with that. Okay. Dennis, what are the best examples, or are there examples, of how systems thinking solved a major societal problem?

Dennis Meadows (00:55:49):

I've always had trouble with the term, systems thinking, because it encompasses such an enormous array of different kinds of cognitive activity, ranging on the one hand from a two or three year effort to build an elaborate mathematical model and simulate it on a computer, which I have done, down to somebody simply looking out their window and drawing some observations about cause and consequence.

Nate Hagens (00:56:18):

Are we natural systems thinkers? Can we be?

Dennis Meadows (00:56:21):

We grew up in a family of systems. We were hunter-gatherers. It's a system which produces the lifecycle of our prey. We became agriculturalists. It's a system which produces food. Yes, in order to succeed, we did need to be systems thinkers. The conundrum is that the nature of our systems has changed faster than the nature of our thinking. It used to be that a great empire could rise and fall, more or less, in isolation from the vast majority of mankind. The Phoenicians rose and fell over many centuries without much impact either on the Chinese or the Aztecs. Well, the Aztecs didn't exist at that time, but the Indian societies of the North American, South American continents. Now, because of many things, we're so intertwined that even somebody entering a mathematical mistake on a Hong Kong financial computer can instantly cause a havoc in Eastern Europe through the bank system.

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(00:57:39):

So, the scale has changed. The speed has changed. We used to double our population over centuries. Now, we're doubling it over decades. Climate is changing at a rate ... It's always changed. Climate change is a constant, but not at this speed. And our capacity for coping with systems thinking has simply not adapted to the new characteristics of the system.

Nate Hagens (00:58:09):

Is there a concrete example of how a systems dynamics model or systems thinking suddenly changed a societal problem, even if it was at a city or a county, or something?

Dennis Meadows (00:58:21):

Of course. You can trace analysis to many changes. You and I both know that change doesn't come simply by running a computer model. At best, doing system analysis generates new insights. That insight has to be communicated to people who are in a position to act on it and who have the resources and the incentive to do so. They need to be convinced that it's legitimate. And once they're ready to go, typically, they have to bring a lot of other people, maybe even some institutions, along with them. So, it's a slow process, and it's a very diverse process. It's very hard to work your way back and say that some particular piece of analysis had the decisive impact. But just take a couple of examples. The one success that we pointed to in *Limits to Growth* was the ozone layer, the analysis of what was happening after we came to understand the chemistry and the projection of what it was going to do in the future to the ozone, and what consequences that would have for radiation on the earth, and what consequences that would have for the cancer rate prompted action.

(00:59:41):

There were a number of international meetings to work out a protocol. But even there, the analysis itself wasn't the only factor. It turns out that if DuPont, which had developed an alternative to chlorofluorocarbons, hadn't done that in time to expect that they would benefit commercially from a change in the law and hadn't communicated that to our president, probably the United States wouldn't have supported that convention. So, it wouldn't have happened without the analysis, but the analysis itself wasn't enough to make it happen. Or more recently, look at COVID. COVID has been the focus of a phenomenal systems modeling effort at all levels,

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national, global, et cetera. And those models, for good or worse, have had an impact on policy, but the policy is also influenced by political considerations and resources, and so forth. So, the simple answer to your question is you can't point to any piece of systems analysis which really has a major impact all by itself. On the other hand, almost every significant change that occurs can trace itself back partly, at least, to the fact that somebody had an insight about something that they didn't have before.

(01:01:03):

Sometimes, it's relatively simple and profound. Nuclear winter was an interesting example. There was an analysis, I think, probably involving computer models which projected that a widespread nuclear exchange would cause really catastrophic climate consequences. And the belief in that combined with the fact that there wasn't a huge vested interest in a generalized nuclear exchange prompted significant changes.

Nate Hagens (01:01:33):

Systems thinking or systems dynamics tries to uncover leverage points that can alter trajectories through some interventions. I don't like the word, collapse, because I think collapse is binary, and there are various shades of collapse. And as we were saying before, we're not headed back to the Stone Age. There's lots of gradients after growth ends. But in your opinion, what are the available leverage points to avoid the worst types of collapse at this stage?

Dennis Meadows (01:02:06):

I'm sure your definition of the worst types of collapse would be different from my definition. However, if I had a magic button that I could push to change things, probably, I would link it to the time horizon of decision making, the time period within which one evaluates the cost and the benefits of alternative actions. Today, the time horizon is rather short for a variety of reasons, genetic, economic, political, et cetera. And as a consequence, there's a tendency to do things which will make the situation look better now and to ignore or be unconcerned about what it's going to do later. It's in the nature of our problems that they tend to be of what we call the dynamic character better before worse/worse before better. A profound solution, let's say to the energy crisis or to the climate problem requires actions, which at least over the short term, would make things look, in some places, a lot worse.

(01:03:15):

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And it's only if you increase your time horizon enough to encompass the full scope of what you're going to do that, you might begin to pick the right action. So, one leverage point definitely is time horizon. And time horizon, of course, has the twin, spatial horizon. Clearly, as we were dealing with the COVID, the concerns of the West, principally let's say in the United States, was here and not, let's say, in Africa because over the short term, you could make things better in the United States by focusing all your vaccines here. Over the longer term, we have every reason to believe that by denying vaccines to those in Africa, we're setting up the condition for the evolution of more mutant varieties later that we're going to have to cope with. So, short-term, better. Long-term, worse.

(01:04:08):

Other leverage points would be, for example, indicators. It's a truism. You pay attention to the things you have information about. And we have in our society evolved a very complex system for generating information about short-term results. So, that's what we pay attention to. If we want a different behavior, we're going to need some new indicators. When my students would go into a corporate consulting relationship, after they'd done the analysis to understand why things behaved the way they did, one of the first things they would turn to is to identify new indicators that could be created, measured, transmitted, reported to the top leaders so that they would have a different understanding of the consequences of what they're doing because if they just keep looking at the old indicators, they're more likely going to keep doing what they've been doing.

Nate Hagens (01:05:06):

Thank you. A question for you, me, and all who theoretically understands the Limits to Growth prognosis, at what point are we personally ready to de-grow, downscale, simplify, become more frugal while the metaphorical candy store is still open? Is it at the core, a collective action problem where austerity and consuming less is a cost to me and a virtually unmeasurable benefit to the whole? I talk, as I'm sure you do, lots of people that are very concerned about climate change, limits to growth, over-consumption. And yet we're still kind of living like rich people in Rome did with our fossil armies.

Dennis Meadows (01:05:53):

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I don't think there will be a point in the evolution of the system where everybody switches over and simplifies, not willingly. Obviously, as the decline progresses and resources become more constrained, people are going to do with less, but not because they choose to do so, but rather, because they're accommodating to the realities. Where simplification does occur ... And of course, it does. It's not because of an external prompt, I don't think, but rather because people reexamine their own ethics and their own aspirations. You said earlier that you had engaged in an exercise where people listed what was really important to them. You mentioned health being a principal one. That's a very important thing to do. Everybody should sit down and make a list. I've done that for myself and for my students as well. And as you said, at least for those of us in our society, the survival items, food, clothing, shelter, and so forth, are pretty far down on the list. Maslow portrayed this so-called hierarchy of needs with the basic survival activities being in the bottom, and then coming up to social status and self-realization, and so forth. And when people look at those things, understand how their current life is working for them, they often will find that there might be an alternative, which would in most cases be a simplification, but it's going to come from within, not from without.

Nate Hagens (01:07:32):

I totally agree with that. Just as an aside, there's an author who's friends with a friend of mine. I want to have him on this show. His name is Scott Berry Kaufman, and he did an analysis of Abraham Maslow's unpublished works near the end of his life. He actually retracted that self-realization was the top of the pyramid, that the top goal is to be involved with some goal, some project, something that was larger than their own life, some collective ... A human goal. And I feel that now. I feel that in the comradery with you, who I've only met once in my life, because we care deeply about the future of the planet and humans and just talking about these difficult projects ... And prognosis has meaning to me. So, I do think more humans share that, and that's one of the things that gives me some hope. Dennis, what kind of advice would you give to young people who would today discover and understand the Limits to Growth analysis? As most of them, many of them, can already perceive in their own lives, the effects of humanity rushing straight into limits, how can they live meaningful lives in this world with the knowledge and understanding of the broad Limits to Growth picture?

Dennis Meadows (01:08:54):

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If I felt I understood the answer to that question, I would be out talking to them and exhorting them. I don't, quite frankly. I'm 80 years old. I lived my life. I grew up in a time phenomenally different than the current one. You said earlier that people need an ultimate goal, and you mentioned saving the planet. I'll just remark in passing, we don't need to save the planet. It will save itself. It's done that many times in the past, and it'll do it many times in the future, just unfortunately, over a time span outside the duration of our civilization. The planet's ... What? 4 billion years old and has still quite a run to go. So, don't worry about the planet, but do think about your society, about your network of social friends and so forth. I actually quit teaching and have even really quit lecturing about Limits to Growth because I don't know how to be honest about the things I know in that area and at the same time, encouraging and optimistic for young people.

(01:10:01):

The implications of what I know for anyone, for young people, are either non-existent or trivial. Well, there's no fundamental solution to climate change. It is now embarking on a drastic phase shift in into a regime that we can only dimly perceive and which will unfold over many lifetimes. And I don't know if it's possible, but I, for sure, have not managed to think what to say constructive about that. At the trivial level, it's things like grow a garden. It's a wonderfully educational experience to nurture life forms through their full cycle. Learn a practical skill. We know in times of crisis, those who do best are the ones who aren't purely intellectuals like you and me maybe, but plumbers and electricians, and farmers, and people who have the capacity to do things of practical value. Over and over again, we have learned the value of social networks, of acquiring a group of people about whom you care, whom you understand, who care about you. It makes you more resilient. It makes you psychologically healthier. It makes you physically healthier.

(01:11:31):

And social networks are not just people that you can use to accomplish your goals, but who are willing to rely on you to help them accomplish their goals as well. That's a reciprocity there that you need to acknowledge. And it takes time. It's not very efficient to have friends. They just take up a lot of time. And they don't, in general, add to your bank account or your resume. Think about happiness. What is happiness? Happiness is getting what you want. There's two ways to do that. If you don't have as much as you want, you can either get more or you can want less. In the past, getting more has been a dominant mode. It's becoming less available. So, it means we need to reexamine

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what we really want and to shift our wants over into the non-material sphere where resources are not so much limited. And it's easy to say this. I'm only going to be around for another 10 years. I don't expect to see the culmination of these trends. But at every moment in time, there are many possible actions for any of us. Some of them will make the situation better, and some of them will make the situation worse. Prefer the better. Although it may not sustain our society at its current level, but it will make you feel good.

Nate Hagens (01:13:03):

Those recommendations are very similar to what I tell my students at the University of Minnesota. But I've struggled with the exact same dichotomy that you have, which is I'm a scientist, I want to be honest, and I also want to be helpful and inspiring to people. And I've had to do that for the last 20 years. You've had to do it for a very long time. What do you do for fun? How do you cope with the burden of the work during your whole life, if I might ask?

Dennis Meadows (01:13:35):

I asked Paul Ehrlich a similar question. This was just after Population Bomb came out, and I said, "How do you keep from going crazy? You see what's coming and you tell people, and they just deny it or don't pay attention to it." And he told me something, which has actually remained in my mind and been a significant asset in my behavior. He said, "I have different spheres of activity." So, have a sphere of professional activity where you can be honest, but also have a different sphere where people don't criticize you, where they acknowledge the work you'd done. In those days, at least, that for him was the field of butterflies. He was a renowned butterfly specialist and acknowledged for the contributions he's made.

(01:14:23):

It didn't threaten anybody, and people acknowledged the quality of the work he'd done. For me, well, there are many things, but I enjoy gardening. I have created community gardens. I have built gardens in my backyard. I spend time gardening. It is a relationship with a complex exosystem that contains many lessons and many satisfactions. And people think I'm a good gardener. When I'm gardening, nobody comes up and tells me that I'm a prophet of doom or that I'm threatening their livelihood. So, I have maintained these two different spheres.

Nate Hagens (01:15:01):

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Do you grow flowers and such, or vegetables and--

Dennis Meadows (01:15:03):

No. Well, flowers are nice to have on the periphery, but I'm growing food.

Nate Hagens (01:15:10):

Dennis, I'm just going to ask you a few closing questions that I ask all my guests. What do you care most about in the world?

Dennis Meadows (01:15:19):

Well, things are interconnected. So, we know that it's not very useful to focus on one thing and care about it, and then not care about other things. I care about my friends. I care about my personal living situation, I care about my personal health. I want to remain physically healthy and mentally productive. I care about the natural world. It was here before we were, and it will be here after we were. I care about wisdom, which is embedded in our current genetic diversity. I care about beauty. I happen to live in a very beautiful area. And almost every window I look out gives me a reason to admire nature. I care about those things.

Nate Hagens (01:16:08):

Given this is a question I ask everyone, and it's kind of odd that I'll be asking you this, but given all the things we've talked about in the models and everything, what issue or what thing are you most worry about in the coming decade or so?

Dennis Meadows (01:16:23):

The thing that concerns me most is violence, the use of force and the threat or the implementation of damage to enforce an opinion. As I said at the beginning, I'm a scientist. I relish facts. I'm interested in ideas. I'm curious about relationships. Violence is just the opposite of that. Violence is the way to gain power without ideas, and it reduces your resources. It stifles dissent and experimentation, which we desperately need. So, I worry about that. At the personal level with the proliferation of guns, for example, in our society, which I think is just horrifying, over to what we see currently with Putin amassing his troops on the border of Ukraine, not, I don't think, to invade, but rather to secure attention to his demands and his goals, that's the thing that most concerns me.

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Nate Hagens (01:17:30):

And in contrast, what are you most hopeful about in the coming decade or so?

Dennis Meadows (01:17:35):

Well, I don't spend a lot of time on hope. Hope is not a strategy for achieving change. It's useful correlate, but in itself, it's a fairly pitiful thing. My mother was a very practical woman, and one of the lessons she taught me was that you should spend your time playing the cards you're dealt rather than wishing that you had a different set of cards. And I consider that to be a very useful piece of advice. So, I'm not sitting here hoping for something, certainly not at the larger level. I have personal hopes. I've mentioned them. I hope to remain physically healthy and intellectually active. I hope my friends will share that with me. I hope we'll remain in communication. I hope my town doesn't do a couple of really stupid development projects that are currently being proposed. I have that kind of hope. But at the international or the global level, I find that actually, the planet doesn't care much about my hopes. So, my hopes haven't spent much time caring about the planet.

Nate Hagens (01:18:44):

Well, Dennis, this has been a wild ride here for the last 90 minutes. Thank you for your time today. And thank you for your lifelong work on being a Cassandra on the systems of the human enterprise, and I appreciate it.

Dennis Meadows (01:19:00):

Well, it's been fun talking to you. It's given me an opportunity to think about some things I haven't thought about recently, and I admire your work. I think the series you're creating is a really unique asset. I wish you success in bringing it very widespread attention. Thanks a lot.

Nate Hagens (01:19:17):

Thanks so much, Dennis. If you enjoyed or learned from this episode of the Great Simplification, please subscribe to us on your favorite podcast platform and visit the [greatsimplification.com](https://greatsimplification.com) for more information on future releases.