

The Great Simplification

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[00:00:00] **Corey Bradshaw:** We're looking at a series of death by a thousand cuts and in many cases of the combination of a rapidly changing climate but just the expansion of humans and their needs. I mean, even if we live in a completely eco friendly way and have very low per capita consumption and we live, you know, not in this high consumption manner that we have today, we completely change the economic system or it's forced upon us by collapse.

[00:00:24] There's still so many of us and we still eat and we will still hunt and we will still take resources until they're gone and then subsequently we will be of lower density. I don't think humans are going to go extinct anytime soon but there will be a point when the earth's carrying capacity and I think we've surpassed that by several decades already will no longer be able to support the numbers that are there.

[00:00:51] **Nate Hagens:** I would like to welcome Australian Professor Corey Bradshaw to the program to discuss his latest research on the sixth mass extinction, as well as human population demographics. I would like to caution viewers. This is not an episode for the faint of heart. If I was still teaching, I would probably have to issue a trigger warning.

[00:01:12] It's very intense. Some of the. Topics on climate, mass extinctions, human population. You all show up here to learn about the world we face. So it's an excellent conversation and I hope you listen to it, but it's intense. Corey Bradshaw is a Matthew Flinders fan. He's a fellow in global ecology at Flinders University in Australia.

[00:01:35] He's published over 300 peer reviewed scientific articles. He's also the director of the Global Ecology Laboratory and a chief investigator in the R. C. Centre of Excellence for Australian Biodiversity and Heritage. Corey's research is mainly focused on global change ecology, how human endeavours and climate fluctuations have altered past, present and future ecosystems.

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[00:02:01] This episode is densely packed with information, and while it does paint a daunting picture of what we face, it's my continued belief that to address the situation we face, we have to understand what we face and all that it entails. That being said, I greatly enjoyed this conversation with Corey, and I've asked him to be the anchor on a population roundtable in the near future.

[00:02:25] This was one of our most potent episodes. Last but not least, I would like to remind listeners that we are not a monetized podcast. So one of the biggest ways you can support us is by following and subscribing on whatever platform you use to listen. Additionally, if you'd like to donate to our organization, please use the link in the description.

[00:02:45] All donations are tax deductible and go directly to our operating costs. And we appreciate your continued listenership and support with that. Please welcome. Corey Bradshaw, Professor Bradshaw. Good to see you. Good morning. Oh, good

[00:03:01] **Corey Bradshaw:** evening.

[00:03:02] **Nate Hagens:** It's good evening for me. Good good morning for you in Adelaide, Australia.

[00:03:07] So you lead a very busy academic life publishing. Papers, teaching articles, book chapters on a wide range of ecological topics. We have a lot of natural scientist colleagues as mutual friends. And today I'd like to focus on the topics of biodiversity, mass extinctions, as well as human population and human demographics which are among your specialties especially with regard to two recent recent papers of yours, which we will highlight in the show notes for people to look them.

[00:03:46] But before we dive into all that, maybe you could share with our viewers your background. What inspired you to be a research ecologist?

[00:03:57] **Corey Bradshaw:** Oh, I have a very weird background actually, in some ways I didn't go through the normal channels. I'm actually, which

[00:04:04] **Nate Hagens:** seems to be the case for almost all ecologists.

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[00:04:08] **Corey Bradshaw:** Yeah, I suppose, I guess it's probably normal from that group of people. But despite my accent, I actually grew up in Western Canada and my father was a fur trapper and I spent a lot of time in the bush as a kid. In fact, the first time I saw a city, I was 16 years old. Yes, I've spent most of my life in Australia, but that's how I started.

[00:04:31] And. Growing up with a trapper father puts you in contact in a rather consumptive way, but puts you in contact with a lot of the nature of nature. And I think that's where it started. I was interested in how animals behaved and how they adapted to their environments and I saw it the.

[00:04:49] the gritty end of that. But over time, I realized that even people like fur trappers, who, as again, are quite consumptive in their use of nature, in, in that time they were actually one of the largest lobbyist groups for reducing deforestation rates because you cut down the bush and there's no fur to trap, there's no fur animals to trap.

[00:05:15] So there was a conservation ethic underneath that. Had an ulterior motive, but it was actually quite efficient in convincing government that, that they shouldn't just cut everything down. So that was my introduction sort of the, into the deep end of conservation.

[00:05:34] **Nate Hagens:** But on that, just to pinpoint that they weren't trying to conserve.

[00:05:41] on behalf of nature, they were conserving because they wanted something for their own bottom line profits. So it was still in the name of profits and progress, et cetera.

[00:05:51] **Corey Bradshaw:** Absolutely. But you know, if you don't have a healthy ecosystem, you don't have animals to trap. And so they were very strongly vocal.

[00:06:00] About keeping those ecosystems in some form of balance and, you know, everything from bushfire prevention to logging to overhunting and, and even introduced species.

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[00:06:13] **Nate Hagens:** So not to age you, but I assume you were born in the late sixties, early seventies.

[00:06:18] **Corey Bradshaw:** 1970. Yes.

[00:06:19] **Nate Hagens:** So how does in British Columbia?

[00:06:23] **Corey Bradshaw:** Yes. Yeah. In the Rocky Mountains. So how does

[00:06:24] **Nate Hagens:** the megafauna today relative to the early seventies and the things that were trapped?

[00:06:30] **Corey Bradshaw:** Yeah. Not having lived in Canada for a long time, it's difficult for me to say exactly what's going on, but my understanding is that a lot of those animals are still doing relatively well.

[00:06:39] I mean, despite all of the other declines everywhere else, but a lot of those places that were trapped I, as far as I know, still have the tree cover, which is probably one of the main things. I mean, habitat loss being one of the principal drivers of biodiversity decline. Now, things have changed, obviously climate change, things are warming up, distributions are changing, so I can't speak with any authority about a lot of the species, but I haven't been aware of any, at least any extinctions in those regions.

[00:07:07] **Nate Hagens:** I was in Yukon territory a few years, and that's one of the few geographical areas in the world where the historic relationship of megafauna biomass to humans is still largely what it used to be. Yeah, I suspect it's very similar.

[00:07:23] **Corey Bradshaw:** I was actually just in Canada in Quebec, actually, the last few last month.

[00:07:28] And I was still quite surprised how much tree cover is there. And yes, a lot of that is secondary growth from over exploitation centuries ago, but, you know, it's still some very beautiful and very productive areas. So I'm still, I'm pleased to see that.

[00:07:46] **Nate Hagens:** So carry on with your story. Sorry to interrupt.

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[00:07:49] **Corey Bradshaw:** After that, I was lucky enough to get a scholarship to go to an international school on Vancouver Island. And that. Really sort of started my pathway on the academic side of things. I did the international baccalaureate, which is a kind of a bridging program and international curriculum that really focuses on developing your own capacities.

[00:08:11] And I was in a beautiful spot outside of Victoria on Lake Hove Island in this little bay. And we. We did scuba diving, we did sailing, we had, our lab was right on the water, so we had lots of marine components to the ecology courses I was taking. And I really sort of got hooked on the academic side of things and realized that a lot of my knowledge was actually applicable and perhaps I could even turn it into a career.

[00:08:39] So after that, I ended up going to do my undergraduate at the University of Montreal in Montreal, and that had a strong ecological stream. They're very well known for their, especially their plant ecology and a lot of entomology. And so I became very astute in the, in, in discovery and taxonomy of the Laurentian region around, sort of central Quebec.

[00:09:09] And that just sort of precipitated into a master's and eventually a PhD, and I decided I'd leave Canada permanently around then. So I went to New Zealand, I did my PhD at the University of Otago in Dunedin, and I saw some pretty amazing spots around New Zealand, got to some. Very remote areas. I was working on fur seals at the time, nothing terribly scientifically interesting in, in, in retrospect, but it got me to some really cool places and I'd sort of cut my teeth in the mathematical side of things.

[00:09:41] And I guess from there, that's where I really became probably more of a computational or a modeler, computational biologist or a modeler, and these days, I'm, you know, back in the day, I used to spend nine months of the year in the field, and now I'm mostly coding and listening to death metal when I do it.

[00:10:01] And that's my brief journey. Given the topic.

[00:10:04] **Nate Hagens:** Um, okay. So I had. Earlier this year a science journalist named Peter Brannan on, who talked about the five previous mass extinctions and

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many minor extinctions. Can you just give me a bird's eye view speculate where are we with respect to a sixth mass extinction event?

[00:10:32] What is the stance based on your lifetime of scholarship and research into that topic?

[00:10:38] **Corey Bradshaw:** Yeah, I've written about that quite a bit recently. And it, it's, it's good to understand the deep time aspect. In fact, I'm doing a lot of deep time paleontology these days, even back to the Ediacaran. So over 500 million years ago, been just working on a lot of Devonian stuff.

[00:10:53] So in the 360 to 400 million year range. And

[00:10:58] **Nate Hagens:** how do we know stuff from 360 million years ago, just from fossils?

[00:11:03] **Corey Bradshaw:** Yeah, pretty much. It's in the rocks. You've got to be a bit of a geologist to do good deep time paleontology all in the sedimentary material and the precision, I mean, the preservation and some of these Lagerstedter these amazing preservation sites are just gobsmacking.

[00:11:17] So you can really track the evolution. I'm working, I've just published my first paper coelacanths, for example, and the history of the record there is astounding. It goes back to over 400 million years ago and we can pinpoint Very minor evolutionary changes. And, you know, even stem tetrapods right up to the, you know, the emergence of the first reptiles and amphibians.

[00:11:39] **Nate Hagens:** So you can pinpoint the evolutionary trajectory of coelacanths when they had adaptations and were better swimmers or whatever else, just from using today's science.

[00:11:49] **Corey Bradshaw:** Yeah. And we know when things went. Extinct precipitously. And that's how we really track these mass extinction events. And a mass extinction event by itself is a little bit of an arbitrary designation.

[00:12:01] So it's at least 75 percent of species going extinct within about two and a half, three million years. Now, why that? Because those were the big ones that sort

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of stuck out. It is arbitrary. There are lots that are fewer or lower proportion 35, in that range and the, the time frame, you know, two and a half, three million years doesn't sound like it's a mass extinction that happened suddenly.

[00:12:27] It's not like the sort of the dinosaur bolide impact in the Cretaceous. But, you know, in geological speak, that's an iblic. So these are rapid extinction events. Yes, they can take millions of years. Now, so there's a lot of smaller extinctions, in fact, probably well between, somewhere between 20 and 40, depending on what sort of threshold you decide to use.

[00:12:49] And they occur quite regularly through, through the geological history.

[00:12:54] **Nate Hagens:** Regularly as in they're frequent or regularly as in they could be predicted time wise? Yeah,

[00:13:02] **Corey Bradshaw:** we can't predict them. That's the thing. It's it's a very people have looked for patterns and there are some suggestions, perhaps some sort of cyclicity in the orbital relationship in the solar system about our, you know, how far we are from the sun and various other things.

[00:13:17] But it's, if there is anything going on, it's, it's it's very minor. compared to the randomness of these events happening.

[00:13:25] **Nate Hagens:** But how many of those 20 to 40 minor extinctions and the five big ones were related to carbon pulses?

[00:13:34] **Corey Bradshaw:** Probably quite a few. I mean, a lot of the early ones, of course, were only marine, so these were lack of oxygen and even temperature related changes in, in chemistry of the ocean.

[00:13:46] And these are usually set shallow seas where most of the life was concentrated around the edges of continental masses. And so if you get these even subtle changes in atmospheric concentrations of different gases and or changes in the saturation point of oxygen in the water, you can precipitate these huge die offs that, that can span the entire globe.

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[00:14:07] And we see the evidence of that time and time again throughout the entire geological history.

[00:14:13] **Nate Hagens:** So with that caveat how likely is it that we're headed for a minor or mass extinction in coming hundreds of years given what's built in?

[00:14:25] **Corey Bradshaw:** Yeah, well, this is something our colleagues and I've argued quite strongly that we're actually in the sixth mass extinction now.

[00:14:30] Now, have we achieved a 75 percent reduction from some previous baseline, whether that was you know, the onset of the Anthropocene, and that isn't even really well understood, or at least there's no there's no agreement on when that might have happened. But if we go back even to the sort of the Fertile Crescent, the development of agriculture and humans 12, 000 years ago, give or take, if we took that time frame as a sort of a baseline, we haven't achieved a 75 percent reduction.

[00:15:00] in biodiversity, that is number of species or even other metrics of biodiversity. For example, the distinctiveness, the evolutionary distinctiveness of species. But if you look at the extinction rates that happen between these mass extinction events, and again, can, we can estimate those quite well from the fossil record. What we have, even just what we've recorded not taking into consideration the species that we miss, because many species, of course, have very small ranges, they're very tiny, they live in a very cryptic lifestyle, and most extinctions actually go unnoticed until well after they've occurred.

[00:15:39] So, even if we just look at the ones that we definitely know have gone extinct that we've observed, we're looking at an extinction rate that's about sort of on average of about a thousand times the rate that occurs between these mass extinction events. That's what we're in now. And everything that we look at points to the fact that it's perhaps even larger than that.

[00:15:59] So, while we're not, we haven't achieved that threshold yet, we're on the way. And even more strikingly is that it's not going to happen in two and a half million years. It's going to be a century scale event. So, this is potentially the largest mass extinction, or I'd say the most important or the highest magnitude mass extinction event that has ever occurred in the history of planet Earth.

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[00:16:23] It's happening now. We're in it. But it'll take some time to precipitate fully.

[00:16:28] **Nate Hagens:** For more reasons than one, it's also the high, before this mass extinction began, you know, let's just bookmark 20, 000 years ago, we were at the highest level of phylum genera species diversity ever from the scientific record, right?

[00:16:48] **Corey Bradshaw:** Yeah, if you look at just total number of species, that's true. If you look at phylogenetic diversity, so the uniqueness, the evolutionary uniqueness. Now actually we achieved that in the Cambrian. So going back 540 million years ago. So we call that disparity versus diversity. So there was more evolutionary uniqueness and evolution is this kind of weird Yeah.

[00:17:09] Yeah. Things pop out that, that work for a while and then they don't seem to work as well as some others and so they sort of drop off the scene and then other things come up. For example, the placoderms, the bone plated fish that are, you know, Dunkleosteus and the, you know, those massive, bony plated, armored fish that you see sometimes in museums or even in film they, they just were gone at the end of Devonian and they never reappeared.

[00:17:35] Whereas things like coelacanths, which are a very ancient fish, lobe finned fish, they managed to survive right through to today. So some things manage to work and other things don't. You know, a lot of people think that evolution is this process of constant. sort of perfection and adaptation to some pinnacle or optimum.

[00:17:54] It doesn't work like that. It's actually the opposite. It's, evolution is a penalty. So if it works, fine. Evolution's not going to really screw with it. But if it gives a slight disadvantage, that's when it gets knocked on the head. And it might, that form, that particular form might never reappear again, or it might form in another different way.

[00:18:12] For example, the evolution of eyes. That's happened in five or six different ways through different groups of species that have absolutely no relationship to one another.

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[00:18:21] **Nate Hagens:** Oh, so there wasn't an eye that evolved somewhere and then all the eyes after that came from that single ancestor?

[00:18:28] **Corey Bradshaw:** No, it happened about four or five different times.

[00:18:29] Yeah. That's kind of cool. So there's lots of examples of that through, through morphology. Now I'm not a paleontologist, so I'm thinking, I'm talking a little bit outside of my area of expertise, but I do work closely with a lot of paleontologists.

[00:18:42] **Nate Hagens:** I do know that blue eyes were epigenetic epigamic which means sexual selection preferred mutation, not that long ago.

[00:18:54] And all the people in the world that have blue eyes did come from one person who had blue eyes, not that long ago.

[00:19:00] **Corey Bradshaw:** I'm not sure if this is correct, but I was under the impression too, that there was a link to Neanderthal genes. Associated with that. Also ginger hair. So as it turns out, I had my DNA tested and I'm quite high on the Neanderthal scale.

[00:19:13] I am too. I am too.

[00:19:15] **Nate Hagens:** Neanderthal bros unite. Yeah. Well, it's

[00:19:18] **Corey Bradshaw:** funny. Corey actually means caveman in Scottish. So

[00:19:23] **Nate Hagens:** it works really well. Yeah. So I'm going to talk a lot about extinctions and biodiversity and such finishing this intro to the topic, of course, the measurement and the impact and the data on mass extinction and species, both their population sizes and the number of species, our system is going to impact them in a backloaded fashion, because while energy surplus has allowed us to expand around the planet, and like you said earlier the places in the world that have their forests removed, obviously are going to lose megafauna and insects and birds and other things.

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[00:20:10] But what happens on the downslope of the carbon pulse if we have to go back in an Easter Island sort of way and use forest for timber, et cetera? So, you know, we're impacting climate and habitat on the way up, but we're also going to impact it on the way down. So my fear is that, you know, the animals that are very remote from human habitations will have a reprieve, but the ones closer are not, especially the megafauna in Africa and places that are near economically poor areas.

[00:20:46] I don't see how they're going to survive. I'm going a little off tangent, but do you have any opinions on that?

[00:20:52] **Corey Bradshaw:** Yeah, no, I couldn't agree more that we were looking at a series of, you know, death by a thousand cuts in many cases of the combination of a rapidly changing climate. But just the expansion of humans and their needs, I mean, even if we live in a completely sort of eco friendly way, and have low, very low per capita consumption, and we live in, you know, not in this consumptive high consumption manner that we have today, we completely change the economic system, or it's forced upon us by collapse, then we're still, there's still so many of us, We still eat and we will still hunt and we will still take resources until they're gone.

[00:21:36] And then subsequently, we will be of lower density. I don't think humans are going to go extinct anytime soon, but there will be a point when there's the earth's carrying capacity. And I think we've surpassed that by several decades already, will no longer be able to support the numbers that are there.

[00:21:52] So there will be mass die offs, there'll be warfare there'll be natural disasters, and life per se, for a lot of people, will not be that pleasant. So we'll regress to those sort of, perhaps even neolithic kind of times. Um, that could be a century scale thing, but it's unlikely, just given our numerical dominance, that we'll go extinct right away.

[00:22:14] Humans are a flash in the pan in an evolutionary sense anyway. So, you know, we're not here for a long time.

[00:22:20] **Nate Hagens:** We're going to talk about some dark things, I suspect but let me throw in a little rainbow of sorts. You said that these mass extinctions

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happened in geological flashes of time over two or three million years, and there were 20 to 40 of them.

[00:22:39] So over 500 some million years there were these very two to three million year periods of mass extinction. And yet up to 20, 000 years ago, or the Neanderthals 40, 000 years ago, we had the most biological diversity ever on the planet. So things do recover on earth, including an abundance of flourishing of life.

[00:23:03] So whatever happens in this sixth mass extinction, well maybe not whatever happens, there could be nuclear war and a whole lot of confluence of events, but things will evolve and there will be new life maybe not complex life like dolphins, apes and humans. But can you give us a bright story before we talk about some of the other constraints?

[00:23:27] **Corey Bradshaw:** Yeah, just given the complexity of life and the fact that we've gone through these dips, these huge dips in diversity over many hundreds of millions of years. It gives me actually a lot of comfort ironically, and I will quote from Paul Ehrlich here who I just saw last week actually I passed through California on my way back back home, and he always says, you know the planets, fine.

[00:23:53] It's not in trouble. Life isn't in trouble. Humanity is, but life itself. So after a mass extinction, it opens up millions of new ecological niches that are exploited through basically the trial and error of evolutionary change. And so species extinction begets speciation. We always see the massive pulse and speciation, and even the rate of evolution increases after a mass extinction event.

[00:24:24] So life will persist until the sun explodes and wipes out Earth entirely from the solar system, and that's several billion years down the track, so we don't have to worry about in the immediate term. But life will pretty much always persist on the planet. Like you said, will another sentient species emerge from that.

[00:24:42] It's possible, but I tend to look at um, our big brains and our sentience as merely one of these disparity forms that have come out, provide an interesting chapter in the history of life, but aren't necessary for life to persist in any sense whatsoever. There's nothing of high value that we can attribute to sentience per se.

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[00:25:03] From a life perspective, it's just, it just happened and we're using it to our advantage, but ultimately to our disadvantage.

[00:25:10] **Nate Hagens:** Do you think there's other planets out there that have life and complex life and oceans and biodiversity?

[00:25:17] **Corey Bradshaw:** I think it's pretty much a statistical given that just the sheer immensity of our own galaxy, let alone the entire universe, that there's not some other form of life out there would be almost.

[00:25:29] infinitesimally small probability. And so being a numbers guy, I can't accept the fact that there wouldn't be life. Is it in a microbial form or something analogous to that? Is there complex ecosystems? Well I suspect there would be quite a, an array of different types of systems. I suspect probably the most common form of life in the universe would be microbial.

[00:25:52] And that probably in most cases wouldn't get much beyond that. In some cases, in the rare cases, you might actually getting. ecosystems established and some sort of trophic relationships between different species. Whether there's the opportunity for this weird sentience experiment that evolution can kick up is, is entirely an open question.

[00:26:11] I, I tend to think probably not, but you know, if you went just on the probability, I'd say that yes, plenty of life out there, but also on the same probability framework the, the massive distances preclude us ever from discovering it. So if we do discover life elsewhere it'll be a big fluke and it'll only be because it's next door in, in a galactic sense.

[00:26:34] Yes.

[00:26:35] **Nate Hagens:** Ethically, I think we have to treat this planet as the only place that harbors complex ascension. life. Because that is sacred. I mean, I'm getting beyond the science, but you know,

[00:26:50] **Corey Bradshaw:** well, we don't have any evidence to the alternative yet. So, I mean, if you're just playing the numbers, of course it makes sense, but we haven't assessed size of one and that's the planet.

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[00:27:00] Right.

[00:27:01] **Nate Hagens:** So let's dive into your work. You have a lot of your work looks at the impacts of coextinctions and the overall rate of extinction and biodiversity. I don't know what a coextinction is. Can you explain that and why it's important and relevant?

[00:27:19] **Corey Bradshaw:** Well, I'll take you back to 2017, working with a colleague of mine, Giovanni Strona, who's now at the Joint Research Center of the EU, he's based in Italy, obviously Italian name good friend, and one of the best computational ecologists I've ever met, well, we were sort of met.

[00:27:37] Discussing a paper that had come out saying that tardigrades, the little, you know water bears, the tiny they're multicellular, obviously, but if you've ever seen a photo of a tardigrade, they're the cutest little things, they've got little claws and little round bodies like the Michelin Man, and there's many different species and they exploit a lot of niches in the soil and in the litter layer and they are immensely resilient little little, little dudes.

[00:28:05] They, you can, Boil them, you can freeze them, you can shoot them into space and they just go into this little cocoon and they can survive all sorts of extremes. And so the point of this particular paper was that no matter what happens on Earth, you know, comet hits us or, you know, nuclear War, whatever.

[00:28:25] At least we're going to have tardigrades, because they, physiologically, they're little juggernauts. They're amazing little things. Second favorite creature on the planet for me. I have to ask

[00:28:37] **Nate Hagens:** what the first thing is then.

[00:28:38] **Corey Bradshaw:** Oh, well. Velvet worms. Platypus. velvet worms. Now they're the coolest. They are the bridge between the the, the true worms and arthropods.

[00:28:52] And they have the coolest hunting technique on the planet. What they do is they have two little siphons on the side of their mouths. And when they detect prey, they spit this kind of gluey mass. It's siphoned it all out and then just envelop

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their prey in this gooey mess. And then they just sort of suck it all in and eat the thing that's attached in the glue.

[00:29:12] There might, yeah, absolutely.

[00:29:14] **Nate Hagens:** I, I now see why you like death metal.

[00:29:18] **Corey Bradshaw:** Yes. Weird things. I like weird things, but you know, I'm a classic geek scientist. So there you go. Anyway. Okay. Waterbears. Tardigrades. Tardigrades. So we looked at this paper and went, and as ecologists, we said, well, that's all fine. you know, they are resilient.

[00:29:32] And if you take them out of the system and you can do stuff to them, fine. But that's not actually how ecology works. Ecology works in the relationship to other species in the system just as much as it does to the physical environment, the temperature, the water availability. So the food really is what drives ecological systems.

[00:29:51] Now you can be really resilient to extremes in temperature and precipitation and so on and so forth, but if you have nothing to eat you die, right? It's pretty clear. So. Everything eats something else, or everything is related to something else. Think of parasites and their hosts. Without the hosts, there's the parasites can't survive.

[00:30:10] You think of flowering plants and their pollinators, just a bee and a flower. You know, without the flower, the bee goes extinct. And without the bee, the flower goes extinct. Predators and prey. You know, you're, you let your cat out at night and it eats all the birds and the, and maybe some rodents without, you know, the prey, the predator dies.

[00:30:32] And so there's all these relationships that exist, and it gets more complex than that. There's a lot of different symbioses, you know, plants growing on other plants, and these hyper specialized relationships. So, if you look at a species in isolation, in vacuum, and you say, okay, it'll survive, yet you fail to take into consideration all of its neighbors, and all the species it interacts with, then you're going to vastly underestimate What the total extinction rate might be from some sort of disturbance.

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[00:31:03] So we call these dependencies in an extinction sense. If one goes extinct and then things depend on it and no longer have that thing to depend upon, then they will go extinct too. These are secondary or coextinctions. So you might have like a. Maybe this species was overexploited, maybe it was a prey species of something else, and the predator over here goes, oh, I've got no more food.

[00:31:31] If it's specialized on this species that no longer exists, It drops off the perch and that can cascade throughout an entire system. We have something called trophic webs. People call 'em food webs or food chains. It's is, that's a simplification. So you get thousands of species in a community and they'll interact either directly or through these.

[00:31:53] chains of relationships. So one might eat something and then that's being eaten by something else and that's being eaten by something else and so on and so forth. So you can actually get this key species down here that a lot of things depend on. If it drops out, then all of these things, some can rearrange, some can eat other things, but a lot of them are specialized.

[00:32:11] So they drop out. And then all the different relationships to all those other species that depend on it, will then also precipitate these changes. We use network analysis. We actually use the same computer techniques we do to analyze, you know, internet relationships. We do the same thing with ecological networks.

[00:32:31] **Nate Hagens:** So I'm sure you've seen this short animated video, which Lizzie will find and put in the show notes that I used at my class. which showed a relationship between ants and plants and how there were certain ants for certain plants. And sometimes they had seven or eight others. And then you saw if there was a little drop in the species of ants or plants, there was not much of an impact, but the more of a drop, then it cascaded through the ecosystem.

[00:33:00] **Corey Bradshaw:** Yeah. And that's another term we use extinction cascades, and that's been known for quite a long time. Well, we can't. Let's come back to tardigrades in this particular paper. So what we did is we actually developed these massive virtual worlds of interrelated, you know virtual species. So these, we're talking computer games essentially.

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[00:33:20] And we coded these large, again, it's models, so they're simplified systems, but we tried to get something as ecologically realistic as possible. And then we, then what we did is after we established all these different relationships, we then took out species. So, first we did it sort of at random, and then we looked at these cascading effects through its system.

[00:33:40] Then we tried to play God a little bit, and we went sort of all evil, and we took the most important species from those ecosystems, so those are the ones with the most connections. And then we took those out first. We, you know, the virtual extinction. I would assume those would be,

[00:33:52] **Nate Hagens:** those would be really low on the trophic pyramid, as in their food for a lot of other things.

[00:33:57] **Corey Bradshaw:** You can get predators that actually have many different prey and they keep different prey species numerically in check. So without the predator,

[00:34:07] **Nate Hagens:** the prey go on to overshoot and destroy the ecosystem.

[00:34:10] **Corey Bradshaw:** Exactly. And then all these other things that depend on that ecosystem will die out too. So it's not necessarily the lowest trophic levels.

[00:34:16] Or the, you know the ones that are being eaten by everything else. And it's true though, that plants are the key component of these systems. So we'll come back to plants later. But then we we also did things like we do, we, then we took the next most important and so on and so forth. And then we heated up this system and we looked at thermal tolerances.

[00:34:37] So how much could you heat a species up until it died? you know, some species a little bit above their temperature range and they like turtles, they die instantly. You

[00:34:46] **Nate Hagens:** weren't heating up the species, you were heating up the environment in which the species live. We

[00:34:51] **Corey Bradshaw:** were heating up our virtual earth, yes.

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[00:34:52] Yeah, okay. But we coded in all of these different thermal tolerances because actually there's huge databases on what species, what type of species can handle both in terms of upper range and lower range, so cold and hot ranges. And once they exceed that, You know, there can be behavioral adaptations.

[00:35:08] There can be changes to their distributions. You know, they can move latitudinally to get the most optimum range. That's actually what's happening. But if we heat the system up and say, okay, once you exceed this threshold you die. Or you know, we did a cooling one as well, just, just as, as a point of comparison and what struck us was two things.

[00:35:30] Okay. When you don't account for the secondary extinctions, if you just look at what's causing the primary extinctions from the exceeding the thermal tolerance compared to if you take into account the co extinctions, you can underestimate overall extinction rate by about 10 times. In other words you have 10 times more extinctions than you would otherwise have just from the primary extinctions.

[00:35:54] **Nate Hagens:** So, so most of our ecological climate system science is using too narrow of boundaries and not the precautionary principle. Everything is way more connected than the common narrative.

[00:36:07] **Corey Bradshaw:** Now, that was a very theoretical sort of heating the planet to 20 plus degrees or cooling it. minus 20 degrees and seeing these massive changes.

[00:36:15] But the other striking thing about that work was that when we took, when we played evil and tried to crash the system as quickly as possible, and it compared that to the heating trajectory, they were almost identical. So if you were to choose the disturbance that precipitated the most extinctions through extinction cascades, it would be heat.

[00:36:34] It's not cold. Yeah. So yeah it's quite depressing. Now that was a, there was a very big theoretical paper in terms of how we structured it, but we didn't do a subsequent work. And we looked at heating over the coming century and we took a very a much more ecologically realistic virtual earth.

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[00:36:54] And we created Yeah, it was geographically explicit, so we covered the entire planet and we only looked at terrestrial to start with, but we basically looked at within the timeframe of this century the, the underestimate from primary extinctions is about 50%. So just in that with the next, you know, 70, 80 years, what's been predicted to go extinct by the end of the century, we're probably going to be at least double that.

[00:37:23] **Nate Hagens:** Predicted by who?

[00:37:25] **Corey Bradshaw:** Well, predicted from the the thermal tolerances of just those primary extinctions. So it's quite a bit of work.

[00:37:31] **Nate Hagens:** Because of the coextinctions and the tardigrade effect that if that species is gone, then there's the food web implications. So is, is there such a thing as the inverse of that?

[00:37:45] A positive? A negative co extinction that a species disappears and it's better for the ecosystems?

[00:37:55] **Corey Bradshaw:** Well, that's probably an open question in a lot of respects because, well, there's been some work on the influence of invasive species. in potentially replacing ecological function in some of these systems.

[00:38:09] So what I mean ecological function, let's say you lose a key predator and then some other species comes in and takes that role in that ecosystem. It could potentially replace that and save the ecosystem. The community from that coextinction cascade. But in most senses, what we're seeing is quite the opposite.

[00:38:27] So you add in another species and even though it might replace some of the ecological function, it's different enough to actually cause more extinctions. So we haven't actually seen evidence of that yet.

[00:38:37] **Nate Hagens:** Let's talk about insects. I had a butterfly specialist, Nick Haddad from Michigan State on, and he gave some just horrifying statistics on insects.

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[00:38:49] So lay it on us Corey, what is the situation? My understanding is that we're losing insect biomass one to two percent a year. And does that at some point play into your co extinction thesis? Have you looked at that?

[00:39:05] **Corey Bradshaw:** Well, yes. And no. The yes part is that from, from an ecological perspective, once the insects go, you're looking at a bottom up effect.

[00:39:18] So when we're talking bottom from the trophic perspective, who feeds on whom, that you could precipitate a lot more extinctions quickly. Actually it's even below that. The plants are probably even more important because many of the, most insects are herbivorous, right? So they're eating the plants and then things eat those insects and so on and so forth.

[00:39:36] So. We, as ecologists, as the ecological community, probably never really expected that insects would be declining at the same rate as vertebrates. Simply because they have high reproductive rates. They, you know, one female can produce millions of eggs in one clutch. They have they have adapted to almost every single niche, you know, the highest diversity, 50 percent of all animal species are beetles.

[00:40:03] You know, that's those kinds of statistics that are just mind boggling. 50 percent of insect species or animals? 50 percent of all animal species are one order of insect, Coleoptera, which are the beetles. Yeah it's, I mean, most of the biomass terrestrial biomass on the planet is, well, plants, then bacteria, but then invertebrates.

[00:40:23] So most things are insects on the continental scale. If you're not, if you're just looking at animals.

[00:40:30] **Nate Hagens:** Well, insects, we take them for granted like 2 percent a year, if that number is even in the ballpark, you just, you're a numbers guy. That's 50 years and it's game over or less.

[00:40:44] **Corey Bradshaw:** And most of our ecological networks have pretty much ignored those lowest trophic levels, the plants and the insects.

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[00:40:53] So our 10 times overestimation or underestimation of extinction rate is probably being conservative because we haven't accounted for that. insect and plant biomass change. So it's much, much worse than even our worst case scenarios. That's kind of the point of this conversation. And we never expected the insects to be at the same sort of extinction rates that the invertebrates are because of those life history traits that allow them to exploit these niches quickly.

[00:41:23] But we're seeing that now, the problem is that we haven't been looking at insects as well as everything else. And the fact that They're so variable in time. You can get a, you know, an explosion of cicadas or something. And then, you know, the next year there's none to be able to determine trends with really variable data like that.

[00:41:39] You need a lot of time.

[00:41:41] **Nate Hagens:** And research money and bodies and equipment and all that.

[00:41:45] **Corey Bradshaw:** And globally, it's actually quite controversial. The extent to which insect. Changes and reductions are happening, but everywhere that people have looked well, and it's only a handful of places, we're seeing these precipitous drops.

[00:42:01] And you'll, you know, you hear a lot of anecdotal information, there's a lot of science still to be done in this area, but the signs are extremely worrying.

[00:42:09] **Nate Hagens:** Let me ask you this. Well, of course, where I live in the Midwest USA, I remember 40 years ago, growing up, you'd have to clean your windshields off driving around.

[00:42:18] Yeah, the

[00:42:18] **Corey Bradshaw:** windscreen analogy is quite commonly used. Yeah.

[00:42:21] **Nate Hagens:** Oh, well, it just, cause people remember it.

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[00:42:23] **Corey Bradshaw:** That, I mean, almost everyone you talk to notices that, and it, there might be a lot of truth in that. And it's just, unfortunately, we haven't actually got the numbers. Yeah, right. It's

[00:42:33] **Nate Hagens:** anecdotal. It's not science.

[00:42:36] But with the science, so the Living Planet Index I think was a few years ago, said that we've lost around 70 percent of the populations of animals since the year 1970 globally. But that was really different based on the area. Like North America is only like 25%, Latin America and South America and parts of Asia were 70 percent and some places 90%.

[00:43:04] What about insects? Does it follow the same sort of numbers or don't we know?

[00:43:08] **Corey Bradshaw:** Those are only vertebrates. The Living Planet Index only looks at vertebrates. And that's its major limitation. It's a very good index. But as you say, it's so highly spatial, spatially variable. We have nothing like that for insects.

[00:43:22] And people are doing a lot of work to try to get to something like that, but we just, that's a big unknown, unfortunately. It's probably in that same sort of category of in terms of reduction of individuals. And that's really what the Living Planet Index is. It's how many individuals in populations.

[00:43:39] **Nate Hagens:** So, so are you as a scientist who this isn't your core thing, but numbers are, do you feel confident that one to 2 percent loss in insect biomass annually recently is an adequate description of what's going on?

[00:43:55] **Corey Bradshaw:** I think that's, plausible. I think there would probably be high uncertainty around those numbers.

[00:44:01] And the other component about, because of that rapid life history of many insects, in many cases, they could potentially be driven to extremely low abundance and then rebound from those, whereas that would just knock out any vertebrate. We don't really know what inbreeding depression is. How that affects a lot of insect species.

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[00:44:19] Most of our work on genetics and inbreeding depression and that's basically if you have a very small population, the chances of, you know, having a sexual relationship with your neighbor increases the relationship between them because they, they're probably going to be kin and we know there's all sorts of jokes and movies and everything made about that Mutiny on the Bounty, same sort of thing post Mutiny on the Bounty, there's inbreeding it's not good for species, and we know what these inbreeding coefficients are for many vertebrate species, and some species are extremely susceptible to it, for example, mammals and humans.

[00:44:53] We, we don't deal well with inbreeding. Other things like sharks seem to be relatively resilient to them. A lot of plants they can happily reproduce vegetatively or clonally for a long time without no real observable impact. We don't know what happens with insects.

[00:45:12] **Nate Hagens:** I'm going to have you back because we haven't even gotten to the questions that I want to ask.

[00:45:17] So I'm still going to keep asking other ones. So there are other kinds of extinctions, right? There's something called ecological extinction, where a species no longer plays the functional role in its ecosystem. Even though we still have, you know, a few hundred of them, I think there's 390 right whales left as an example, but then I wonder if there's a functional extinction where there might be.

[00:45:42] 200 of these megafauna left. So the species exists, but it's so genetically inbred. I think cheetahs come to mind that at some point they don't become healthy and they're, there's not a viable enough gene pool. What is the science that, that's all called and is that relevant to our story?

[00:46:02] **Corey Bradshaw:** Yeah. So this comes back to our inbreeding discussion, but basically when you get down to very small numbers. The chance of inbreeding increases dramatically. And what that does is it tends to reduce your genetic diversity. So how variable your DNA is across the entire chromosome. And in itself, it usually isn't a direct problem.

[00:46:26] Yes, you can get the expression of, for example what we call homozygous alleles that have both a deleterious effect, and when they're expressed together, they can create all sorts of diseases, or they can, you know, you might not grow a

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particular component of your body properly, or you have a physiological you're missing an enzyme that's essential for example digesting proteins, or there's a million different ways that can precipitate.

[00:46:57] But more, more commonly, inbreeding depression doesn't have that direct, what we call deleterious or lethal effect. What it does is just by virtue of having reduced variability and you cross your genome, means that when things change, there's less of a template to or less or a smaller toolbox that you can then borrow from to, to adapt to that change.

[00:47:19] And I'm talking on a generational scale, not an individual lifespan. So if things change, for example, climate and you're heating up and you have. If you have a very healthy genome you're genetically diverse in your population, there's chances are that some of those individuals in there were going to have the genetic capability to adapt their enzymes, for example, to deal with increasing heat and maybe increase your thermal tolerance.

[00:47:44] But when the population size is small and therefore your genetic diversity is low, you have fewer tools in your toolbox to deal with change. And so that really is what drives these long term susceptibilities, is that you have, even though things are getting worse, you have less adaptability. It's a little bit like politics.

[00:48:02] You know, we have big, more and more problems to deal with, but in, across the world, we're seeing the rise of conservatism and reduction of capacity to deal with these mounting problems. It's the same thing in genetics.

[00:48:15] **Nate Hagens:** And the irony is in the word conservatism is the word conserve. So getting back to insects, how important are pollinators and what's the story there?

[00:48:25] **Corey Bradshaw:** Well, you know, there's been quite a bit of back of the envelope calculation of the value of pollinators just to our cropping systems. For example, 80 percent of all of our crops require some form of animal pollination. And it's about 70 percent for all flowering plants. And most of that is from insects.

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[00:48:46] And in fact, 50 percent of all of that pollination that occurs for our crops is provided by one species. *Apis mellifera*, the European honeybee. Without that species, we would probably lose at least a third of our food production.

[00:49:04] **Nate Hagens:** Couldn't we use drones or such?

[00:49:06] **Corey Bradshaw:** Well, they've actually tried that.

[00:49:08] And it's not very efficient as you can imagine, if you're dealing with small flowers on things it's, it's extremely difficult to pollinate properly. So there have been estimates of what the net value worth of pollination globally, and it's in the trillions of dollars annually, and that's probably an underestimate because we couldn't even do what.

[00:49:26] Insects actually do for us and mainly bees. So, you know, when you see things like hive syndromes where, you know, bees are being reduced to very small numbers you get mites, all sorts of things that compromise bee production, and, you know, in many parts of the world, including the US most, much of the cropping is due to the fact that people move around beehives and allow for that pollination to occur.

[00:49:54] Without that, you would get, you would reduce your total crop yields by massive amounts.

[00:50:00] **Nate Hagens:** Okay. That is an introduction. I'm sure we could have talked a lot longer on the details of the various unfolding extinctions or population declines in nature. But what's causing it? What are the biggest driving factors across the board on some of these issues that we've discussed?

[00:50:19] You mentioned habitat loss with forests. What else?

[00:50:23] **Corey Bradshaw:** Well, the legacy of habitat loss, basically from the expansion of, mainly from expansion of human agriculture. So yes we do also expand in terms of urbanization and just carving out a place to live. But most of the damage has occurred through the expansion of agriculture.

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[00:50:40] And much of that has happened since the 1950s, because that's been a massive pulse. We've gone from, you know, 2 billion to Over eight billion in that timeframe. And so just the increase in the amount of land required to feed us has caused most of those extinctions in the terrestrial realm, obviously.

[00:51:00] But we've also had, and that's probably the more proximate. Cause of most extinctions, but of course we have over exploitation that just basically over hunting, so you take your bison example, or your passenger pigeon, or your great orc, you know, there's many examples of massive over hunting.

[00:51:19] Ork? I didn't think those were real. No, the great Ork. Sorry, it's my accent. A U K. A

[00:51:26] **Nate Hagens:** U K. What is that? Like a big cow? No,

[00:51:29] **Corey Bradshaw:** it's, it was a large seabird that were populated most of the North Atlantic and it was over hunted for mainly for its eggs. And partially for the adult birds and its meat.

[00:51:41] And this is actually a really interesting story because while it was really widespread and not susceptible to, you know, small perturbations right here and there across its range, it got to such a small number. And the last colony was on a little islet off of Iceland. And that islet blew up in a volcanic explosion and that was the end of the species.

[00:52:00] That one explosion was the ultimate cause of its extinction, but the reason it went extinct is because its entire range had been reduced. So anyway, back to, we're saying the, these extinct, overexploitation, invasive species is probably one of the biggest contributors today. And that is via changing the dynamics of these systems.

[00:52:23] So they come in and they eat things. They also out compete things. They change soil chemistry. They completely restructure communities in, for example, lakes and rivers. Could you give an

[00:52:33] **Nate Hagens:** example, a modern example of an invasive species that had a deleterious effect on the existing species?

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[00:52:41] **Corey Bradshaw:** Well, I'll give you a great example from Australia.

[00:52:42] We introduced. Cats and foxes to Australia some 200 and so years ago, and cats, when they were released here, went sort of woohoo and spread to all parts of the continent, and they are the principal driver for the highest mammalian extinction rate of any country in the world. Yes, Australia is number one, we have the highest rate of mammal extinctions globally.

[00:53:09] And it was mainly because of cats.

[00:53:11] **Nate Hagens:** Are they, you mean they're living in people's houses or these are wildcats? No, these are feral

[00:53:15] **Corey Bradshaw:** cats. These are, yeah, cats that have gone feral. Also people in people's houses, but mainly they're wild, you know, what we call feral. So they've been released and they've gone wild.

[00:53:25] **Nate Hagens:** So they kill mammals as well as birds, presumably.

[00:53:29] **Corey Bradshaw:** Yep, birds as well. We have a lot of threatened birds because of, but the main effect has been small marsupials, small marsupial mammals foxes to a lesser extent, but then we also have things like rabbits that have destroyed soil chemistry and, and topsoil erosion across the country, have carp that have invaded our freshwater systems, and we don't have a lot of freshwater in Australia, and they've completely changed those ecosystems and, and precipitated extinctions of other fish species just by their sheer abundance, not just their predation.

[00:54:03] We have you know, weed species that have overtaken vast tracts of forest and they choke out native species. So they did, the list goes on and on.

[00:54:13] **Nate Hagens:** But this happened before humans. There were, I suppose, the speed at which new species could be introduced came on boats with humans. There were stowaway rats or whatever else.

[00:54:27] But these bursts of invasive species also happened before humans. Yes?

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[00:54:32] **Corey Bradshaw:** True. Yes. I mean, we call them tend to call them vagrants instead of invasive species per se, just that's, I guess, just the lexicon, but things would be blown off track, you know, a flying bird. and managed to establish a small population somewhere.

[00:54:46] It obviously takes more than one usually. Get back to that inbreeding conversation we had earlier. But most of it is through commerce. Most of the transplanted species are through commerce, through shipping, through airplanes, through just people walking driving. And you can get invasive species even within the same country.

[00:55:05] One side of the country will have a completely different biota than the other side. And people will exchange those and that can cause massive disruptions in those very delicate systems. Globally, invasive species cost our economies about 1.5 trillion annually. That's just the economics. We're not even talking about But how much do our economies

[00:55:27] **Nate Hagens:** cost the other species?

[00:55:29] **Corey Bradshaw:** Yeah, exactly. But just to show you that we also do a lot of work on the economics of invasive species and they are a massive drain on our global economic systems as well.

[00:55:38] **Nate Hagens:** Okay. Habitat loss, over exploitation, invasive species,

[00:55:43] **Corey Bradshaw:** and now climate change. And now climate change. And of all of those, and climate change is already precipitating extinctions climate change is overtaking all of that.

[00:55:52] So.

[00:55:52] **Nate Hagens:** Even at one and a half degrees Celsius only.

[00:55:56] **Corey Bradshaw:** Oh yeah. Well, one and a half is a pipe dream. Now we're looking at more like two to four by the end of the century. Now this is the most realistic projections. So at

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[00:56:05] **Nate Hagens:** four and I, well, we could pick a number because like, like you said on, on the co extinction and the vertical and horizontal relationships with everything, no one has a fricking clue.

[00:56:16] Let's just say that we stop at three degrees Celsius. What does that, just that number, let's speculate that's where it stops. Could be two, could be four. We don't know. Paint us a picture of what that means to the other non human species on the planet in a few minutes.

[00:56:34] **Corey Bradshaw:** Well, again, without trying to get too predictive about proportions or anything we're probably looking at least.

[00:56:41] half of species on the planet going extinct within the time frame that's affected by that change. If we limit it. Three

[00:56:47] **Nate Hagens:** degrees Celsius.

[00:56:48] **Corey Bradshaw:** Yeah. Yeah. In the past it was sort of predicted to be more like in the 10%, 15 percent range, but now given the understanding of coextinctions, it's probably well above that.

[00:56:59] So I, I would say 50 percent would probably be in the right.

[00:57:03] **Nate Hagens:** Do, does the average climate scientist who's looking at glacier melting and Arctic ice and other things, do they understand what you just told me?

[00:57:14] **Corey Bradshaw:** From an extinction perspective, probably not, but I think most climate scientists are shitting their dacks, basically that we, every time we come close to understanding a projection we exceed it.

[00:57:26] And so, if you look at the predictions back in the early 90s to where we are today, we've exceeded everything. We're seeing these increase in pulses, I mean, what was it Sunday was the hottest day on the planet ever this Sunday, and then Monday was the hottest thereafter. So, yeah, we're still being blown away by how conservative our models have been, and that's partially politics.

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[00:57:51] And we can get into that about, you know, the IPCC and the fact that we've downplayed the severity of this because it's not politically palatable for most people. Even the language that the IPCC uses in its reporting, it reduces the certainty with which we report these changes. So most scientists, you know, they have a hard time getting out of bed in the morning when they understand the gravity or the extent and the magnitude of these changes that are happening in their own lifetimes.

[00:58:21] So we, we're a depressed bunch.

[00:58:23] **Nate Hagens:** Yeah let me talk about that for a second, Corey. I host this podcast, so I know these things. You obviously are an ecological researcher. You work on this every day, but especially for lay people around the world listening to this podcast, this episode, this can be a fucking gut punch.

[00:58:45] I mean, It is a slow unfolding tragedy, horror movie. How do you put that in and keep your jovial attitude? And I mean, at some point, is this helpful to tell people what's going on? 50 percent of species, if we are at three degrees Celsius, plus a whole lot of asterisks and other unknowns, I think we have to communicate that.

[00:59:13] This is our world, our planet, and yet, to some people, this is almost too much to bear, and I'm borderline one of them, to be honest.

[00:59:21] **Corey Bradshaw:** Yeah, and it's a perfectly normal response and the ability to deal with change that you are incapable of altering. That's the other component. And there's actually an entire branch of psychology devoted to this.

[00:59:38] We can get into it in a little bit, but basically the idea is that it's, it comes back to. Ernst Becker's book back in the in the 1970s, it won the Booker Prize on the the basically the idea that people deny their death. It was called the denial of death and how, as an individual, you have aspirations, you have dreams, you have, you enjoy life you raise families, you have, most people have this positive outlook on and achieving something yet for all that to disappear because you die, because we all die.

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[01:00:13] And so we have this, we built in psychological denial of death, and that's why death is such a scary topic for most people. But now let's magnify that to planetary death, or at least death of life. So we can't even handle it on an individual level. So, so Our little brains really can't handle the severity of the loss of life at this scale.

[01:00:36] So we become even more denialist. And in fact,

[01:00:38] **Nate Hagens:** it's cognitive dissonance. It's

[01:00:40] **Corey Bradshaw:** a complete cognitive and it's for our mental health that we do this. So I don't blame people for, putting their head in the sand. And as a parent too, in fact, parents are the worst culprits because you know, no matter what you do, invest in your children you make sure that they eat well you invest in their education, you teach them about life.

[01:00:59] And for all that to mean nothing that they're going to still be facing these horrors. in their lifetime is almost inconceivable in the head of a parent that there's nothing you can do to give your kids a leg up. Yes, there's some buffering from wealth and from education, but everyone's susceptible. So that cognitive distance is even magnified from most parents perspective.

[01:01:23] So you translate that to an entire population, you can see why people are ignoring what's going on and don't want to hear the story, no matter how much we beat our drums and say, look, it's bad. We have to tell the story, but we also have to realize that people's reaction isn't going to be right. We best do something then, because that's not how people respond normally.

[01:01:45] And I guess that's given me a lot of, it's turned my frustration into at least an understanding of our own, behavioral responses to emergency. And yes, you can sugarcoat things and you can tell them that, you know, if we do X, it'll be maybe not as bad. And that's actually become my philosophy. If I can, if I get out of bed in the morning and the work I do even changes one small thing for the better.

[01:02:09] I say the future is going to be shitty, but maybe I can make it just a little less shitty. And that's kind of my philosophy of life now. And you have to accept

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that it's going to be catastrophic, but how big of a catastrophe are we talking? Maybe we can limit its damage to some extent. And once you accept that, it's actually easier to do your work and to be not depressed about it.

[01:02:32] I mean, it's still depressing, don't get me wrong. I've had a lot of therapy. I do a lot of exercise and martial arts to, you know, That's my yoga, you know, it's just yoga with violence. I listened to death metal. I mean, these are my escapisms. I make wine, you know, I have my, I, I enjoy my family. I have my little dogs, you know, I do enjoy life.

[01:02:51] So that keeps me functioning as a human being, but I have to face this every single day, regardless.

[01:02:59] **Nate Hagens:** Let me ask you this. You were interested in animals and biology and ecology. You told us your academic history. I'm sure when you started out at a, as a bright eyed, bushy tailed, non tattooed 20 year old that you were just interested in the science and the wonder and beauty of it all.

[01:03:19] But at some point between then and now you understood The sixth mass extinction and the, you know, three degrees Celsius plus or minus, even if it's two degrees it's a huge deal for other species, right? So you, so this is unfolded during your own intellectual and emotional journey.

[01:03:39] **Corey Bradshaw:** Yeah, actually, when I started out in academia, I really.

[01:03:43] did not like conservation biology or even conservation biologists. I thought they were sort of the fringe of science and that they these people were sort of worried for nothing and that the real science was more the empirical stuff. And, you know, I was very much involved in that, but the more I started looking into it, the more I realized how wrong I was.

[01:04:02] And that was more, probably one of the most important sciences that we could possibly do. And that's. Drew me into that. And then the more, I mean, yes, I'm applying the mathematics and I still enjoy the empirical aspects of it, the scientific components. That's really my passion, but you can't help but be affected by that mentally and emotionally.

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[01:04:19] It's impossible because we're like ambulance. you know, paramedics. We see death and destruction and maiming and injury and suffering every single day. And you talk to your average paramedic and, you know, they have a hard time mentally dealing with that every single day. Post traumatic stress disorder from military people, you know, it's, there's many different professions that have this kind of response.

[01:04:41] And we're just one of those.

[01:04:44] **Nate Hagens:** So we've talked about animal extinctions, some mass extinctions. I want to talk about human population levels and the impact of that and also policy, but let me ask you a difficult question put you on the spot just cause I'm curious as to your philosophy on this, if you could push a button and every human in the world could understand what you do about animal insect wild populations, and climate change, and what climate change is going to do to those.

[01:05:20] Would you push that button or not?

[01:05:24] **Corey Bradshaw:** Everyone would understand? That's what the button would do?

[01:05:27] **Nate Hagens:** Yeah, it would understand. You couldn't affect their caring, that would be another button, but everyone would understand it. Like, oh, I believe this is the case.

[01:05:35] **Corey Bradshaw:** Yeah, absolutely. I think in, you know, information is nothing but an advantage.

[01:05:41] It's how you deal with that information is comes the moral and ethical components. Education. I'm not sure

[01:05:46] **Nate Hagens:** I would press it. I would press it for those people that have levers of power. I don't know if the average person benefits from hearing this story. I'm open minded to it, but I'm not sure because people are already at wit's end with all their worries.

[01:06:00] And everything else going on in the world.

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[01:06:01] **Corey Bradshaw:** No, I do see your point, and I can certainly understand that some people wouldn't be mentally capable of dealing with that. But I think the advantages would outweigh the disadvantages overall, I think, if people actually understood. And especially their particular relationship, their lifestyle.

[01:06:18] Relationship to healthy ecosystems and why we can breathe and why we're happy, and why we can make money and why we can travel, and why we can see beautiful and appreciate beautiful things. Art being one of them. That's, you know, art, it comes from natural systems. That's why we em, em, embrace it. I, if that understanding was there that we could see the link to our own wellbeing, I think that would precipitate a lot more action.

[01:06:44] So I, yes, I agree. Some people would be. in desperation, but I think overall it would be a net benefit.

[01:06:52] **Nate Hagens:** So, so moving on to global human population, you've also written on this. You had a review paper come out in March of this year. And in that you looked at the United Nations model projections that said that human population is expected to peak at 10 billion people.

[01:07:12] Sometime this number a 25 percent increase from the current eight billion. Based on your systems ecology work, how likely do you think that is?

[01:07:24] **Corey Bradshaw:** Well, you know, even if you look at the, a lot of people have been working on this. If you look at the sort of demographic consensus, that really is right in the best.

[01:07:34] information that we have. And even if we went through, and I've done this as previous work, even if we go through a massive war, and even if we have child mortality double over the next century or so, even if there are three or four major pandemics that make COVID look like the common cold, it won't even affect the trajectory.

[01:07:57] And that's the thing. We have this massive. demographic momentum. Why is that? Well, there's just so many of us. And the fact that you, we were still increasing at the, our fertility rates. But our,

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[01:08:08] **Nate Hagens:** but our, you've our fertility rate peaked in 1965.

[01:08:13] **Corey Bradshaw:** It peaked in globally. Yes. But if you look at many other nations, like for example, Nigeria, where it's tracking at five to seven children per female and much of, yes, South America, South, Southern and sort of Latin America has reduced.

[01:08:29] South Asia has reduced a lot, but mainly that sort of Middle East Sub Saharan Africa area is still massively increasing. So globally we're, Again, it's changes by region, but globally we're locked into increases at least till the end of the century. I would say that the best case scenario is that I disagree with that.

[01:08:51] I disagree with that and I'll tell you why in a

[01:08:53] **Nate Hagens:** second, but go on.

[01:08:54] **Corey Bradshaw:** Okay. Well, I mean, all the models point to that. And regardless of what we the models

[01:09:00] **Nate Hagens:** include a proper accounting of the carbon pulse and how oil, especially, and natural gas underpin our actual food system? Do the models include many of the countries you mentioned?

[01:09:12] And here I'm arguing with an expert, I'm just throwing out some things. Yeah, no, I see what the models include the fact that the wide boundary implications of climate, which you just said at 3 degrees Celsius is going to change? going to eliminate 50 percent of the species. What about countries like Nigeria and Saudi Arabia that have high growth rates under a three?

[01:09:33] I mean, how are they going to, how's that going to work?

[01:09:36] **Corey Bradshaw:** Okay. Well, I'll give you, I'll give you a good response to that, but I think we'll explain this simply. The number one predictor of female fertility on the planet, and this is work where we've done. What do you think it is?

[01:09:50] **Nate Hagens:** I'm talking on a national scale.

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[01:09:52] Lack of education. Income,

[01:10:03] religion?

[01:10:04] **Corey Bradshaw:** Nope. Not even

[01:10:04] **Nate Hagens:** close.

[01:10:06] **Corey Bradshaw:** I would have thought that myself. The number one predictor is child mortality.

[01:10:11] **Nate Hagens:** So the higher the child mortality, the higher the number of

[01:10:15] **Corey Bradshaw:** kids. Fertility rate increases precipitously. It's not even linear. It's actually a threshold effect. So getting it around 10.03 child mortality.

[01:10:27] There's a huge spike in female fertility and that's the insurance policy effect. So that may not even

[01:10:33] **Nate Hagens:** be a social conscious thing, that's just a biological reaction.

[01:10:38] **Corey Bradshaw:** Exactly. So as ironically, as our child, children die faster, and I'm doing a lot of work on child mortality and child health, as it relates to both demography and climate change, and all those things are peaking.

[01:10:51] Yes, we've hit a plateau, but now they're starting to go up again. The ironic thing is that as you kill children, people's fertilities increase, and you see a regression back to that demographic change, that people change through the development cycle. And this demographic transition will go backwards.

[01:11:14] So we, if anything, we're going to see increasing rates of human population growth closer to these extreme events. And that will eventually equilibrate because, you know, your carrying capacity is lower and your overall mortality rates will be higher, but people will compensate, overcompensate for that just by fertility alone.

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[01:11:36] **Nate Hagens:** So we're gonna, we're gonna go to 10 billion much poorer humans than the average today, I expect.

[01:11:45] **Corey Bradshaw:** You think too that, you know, from a demographic perspective, and I do a lot of work on you know, reducing invasive species, and we try to kill populations like cats on islands, and we just did a project on pigs on Kangaroo Island here in South Australia, and we try to maximize the way we can kill these populations to remove them from very ecologically sensitive areas.

[01:12:06] And if you get a demography like humans, The quickest way to do that is to target young reproductive females. In other words, those are the individuals that count from a demographic perspective, males are irrelevant. And so are people beyond their reproductive years. So you don't have to kill every, I basically if you have a massive mortality event, but you're still keeping the core of that young fertile female intact.

[01:12:36] That's what drives populations. All the other stuff is kind of demographically peripheral. That's a very empirical way of saying that, you know we have this system where females are driving the demography, and that's always been the case, just based on our biology. So if that component is maintained, even over a short period of time, Like if you manage to survive from say the ages of 14 to 25 or even 30, you, most of your reproductive lifespan is that is encompassed by that period.

[01:13:06] So if you die thereafter, not a problem from a demographic perspective, your population will still grow. Your age structure will change. Yes, but your overall trajectory won't.

[01:13:20] **Nate Hagens:** So had we just started the interview now, I would have two hours of questions.

[01:13:24] **Corey Bradshaw:** Yeah, this opens up a huge area.

[01:13:27] **Nate Hagens:** Let's start here and then backtrack.

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[01:13:29] If we had a reality round table right now with you and Elon Musk, he's saying kind of the exact opposite that the human system needs more babies. Otherwise we're going to implode. What is your response to that?

[01:13:44] **Corey Bradshaw:** That's exactly what a CEO would say in our economic system. The number of consumers increases his profit margins, and that's the only thing.

[01:13:53] There is, if you look at all the evidence for how population affects average well being of the individual, in every single case, more people equals a lower profit margin. Lower wellbeing. We have housing crisis, we have transport crisis, we have political crisis, we have refugees moving in that increases people's perception of their jobs being stolen, that their resources are being taken, so we have an uptake in extremist politics, we have we have school issues, you know, the number of schools being built, we have infrastructure problems, We have expansion of agriculture and then precipitating more extinctions, every single element you look at in terms of human high up human population densities, in terms of disease and children, in terms of, the availability of food and the distribution of wealth, every single one of them.

[01:14:46] Reduces average wellbeing. The only thing it increases is profit margins in a completely capitalist society.

[01:14:53] **Nate Hagens:** That's it. Well, it, it increases the market. The market needs babies to buy diapers, then toys, then teachers than cars.

[01:15:01] **Corey Bradshaw:** When a CEO o of a corporation tells you they need more people because it's good for society, it's good for them, and that's it.

[01:15:08] **Nate Hagens:** Until we are at a three degrees world with half of the species, including pollinators, gone, there are no profits.

[01:15:14] **Corey Bradshaw:** No, that's exactly right. So it's a short term response, but the best thing we can do to increase the well being of people on the planet today is to reduce our densities. If you look at all the highest well being indices in almost every country in the world.

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[01:15:32] The places with the highest well being indices are those with the lowest population densities.

[01:15:37] **Nate Hagens:** So you said reduce our densities. Is that meaningfully different than reduce our populations?

[01:15:44] **Corey Bradshaw:** All that means is that we should basically impart large scale, culturally appropriate, non coercive family planning globally.

[01:15:52] And that we should open up our immigration policies to include people that can work to provide, for example, the labor shortages. It's an easy problem. That's an immigration problem. It's not a fertility problem. It's a choice countries make. You know, places like Japan, places like Italy that have declining populations Japan's case in particular, that's mainly because of their immigration policies.

[01:16:17] They don't allow people to come in to take up those labor shortages. We do it in Australia as well.

[01:16:22] **Nate Hagens:** And in Japan, Jeremy Grantham was on the show and he said, people aren't interested in having sex anymore as one.

[01:16:29] **Corey Bradshaw:** Well, look, in Australia, if you took out the immigration component, we would be just at replacement right now.

[01:16:36] So replacement is

[01:16:37] **Nate Hagens:** like 2. 1 babies. Yeah.

[01:16:39] **Corey Bradshaw:** 2. 1 ish. Yeah.

[01:16:40] **Nate Hagens:** Yeah.

[01:16:41] **Corey Bradshaw:** But we're growing at 1 percent per annum. That's net immigration.

[01:16:45] **Nate Hagens:** 1 percent people per annum? Yes.

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[01:16:48] **Corey Bradshaw:** Yep. That's our population right now is growing at that rate. And that's almost entirely immigration.

[01:16:53] **Nate Hagens:** I think the number I looked 10 years ago, if you take the the deaths and if you take the births and subtract the deaths 10 years ago, it was like 85 million net new human babies per year.

[01:17:06] I think it's down to 81 million per year or something like that.

[01:17:10] **Corey Bradshaw:** That's correct. Yeah. So we've entered a new phase. In fact, we entered that phase in the early 60s where and this is work we have ongoing at the moment that shows that we went from a, what we call a, these are technical terms and I'll try to explain them well, from a depensation phase to a compensation phase.

[01:17:29] Now let me explain what that means. Depensation in population dynamics means that when you add individuals to a population, The average fertility or the average rate of increase also increases. So this is the idea of a minimum number of people that society needs to function well. Beyond a certain point, the per capita competition, it starts to kick in and therefore every subsequent increment in population size actually decreases population growth.

[01:18:01] That's because there facilitation component. to adding more people. More people is a net detriment because actually fertility ends up declining. We've passed that phase in 1962. And ever since then, the entire globe has been on this downward track trajectory that more people added, lower population growth rate.

[01:18:24] Such that even if you extend that out to the, to zero growth, i. e. stability, that still puts us in the range of about 10 billion people. Bye. 2080 end of the century.

[01:18:36] **Nate Hagens:** Does this rhyme or track with other species as well? I assume

[01:18:42] **Corey Bradshaw:** this is pretty much the standard amongst all species. The only difference is that in humans we've artificially inflated our carrying capacity through technological innovation over the course of our development.

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[01:18:54] Because of fossil

[01:18:55] **Nate Hagens:** fuels, I would say. Mainly because of fossil fuels. Yeah.

[01:18:58] **Corey Bradshaw:** If you also look at that transition from depensation to compensation, that pretty much was contemporaneous with this transition from using more than one earth per year in terms of the global ecological footprint. So we transitioned to net users of resources as opposed to net replacers.

[01:19:19] So now we're operating at the sort of I think what's the average about two earths per year. We're taking about double what we could possibly replace, and it's up to, you know, six times in the U. S. And that's just the,

[01:19:33] **Nate Hagens:** the daily and annual flows that assumes away the ancient sunlight and minerals that we're adding.

[01:19:39] Yeah. Yeah. So, so let me here, here's a very salient question in discussions today for those people who are very aware and concerned about global heating and understand the global economic juggernaut, what is the proportion impact of, of population growth on climate change in comparison to just the consumption of existing populations?

[01:20:07] How would you break out the impact on climate and emissions between those two? But,

[01:20:13] **Corey Bradshaw:** About 80 percent of our total. emissions contribution to heating is from increasing population, 20 percent from increasing consumption. So you add the, because that's the other thing people don't tend to realize is that the average per capita consumption rate globally has doubled since 1970, pretty much.

[01:20:38] So not only have we increased by fourfold, Almost, well, threefold since then. But the average per capita rate of consumption has doubled. So not only are there many more people, but on average we're using twice as many resources per person. So it's not the opposite. And so when you look at the contribution to warming, and we've done this relationship about 80 percent is due simply to the number of people.

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[01:21:04] Because it's growing at a much faster rate compared to actual per capita consumption rates. It's quite striking. That, that I can provide that paper to you at some point if you're listening. Yeah, we'll put it,

[01:21:15] **Nate Hagens:** we'll put it in the show notes. Yeah. So I assume that, if we are headed and you were pretty confident that barring a nuclear war you know, including pandemics and wars and famines and stock market collapses or whatever else that we are headed to 10 billion because of the momentum that you described.

[01:21:36] So what would be the environmental impact if we continue to have the same levels of resource consumption per capita with, you know, the you know, energy, water, agricultural impacts at 10 billion that we have at 8 billion. Obviously I've answered my own question. I

[01:21:52] **Corey Bradshaw:** think you have. Yeah, it's not a rosy picture.

[01:21:55] Put it that way. I, we're getting into the realms of, you know, trying to predict proportions and percentages and things like that are quite difficult. The, I guess to encapsulate or summarize this, there isn't a single metric that we can see today that's in the right direction. In other words, all of these things are conspiring to go exactly the opposite that we want them to, or that they should be going, and that means that all of these complex interactions will multiply and cause these unforeseen outcomes that we can't possibly predict, even with a very, you know, complex, Because these are emergent, these are basically, this is, you know the butterfly effect in complex adaptive systems.

[01:22:40] We have these interacting elements that will interact in such complex ways that it's difficult to see how that will be anything but magnifying the predicted extent of the damage that we will see by the end of the century or beyond. So I don't. Like I said, it's hard for me to see any way out, no matter what we do.

[01:23:03] There's, it's almost to the point now that what you accept again, I come back to my sort of mantra. You accept that the future will be terrible, but you can perhaps make it a little bit less terrible for some people. And. That doesn't mean you should hoard resources and exclude everyone, sort of like the extremist right wing politic approach to things.

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[01:23:26] But it does mean that solutions need to be of sufficient magnitude that they address certain things. Like, for example, food wastage. You know, that seems like a very small thing, but you know, if we managed to eradicate food wastage, or at least reduce it substantially, we wouldn't need, we wouldn't need the agricultural expansion that our growing populations will demand quite to the same extent.

[01:23:50] So we'll have fewer extinctions as a result. So that's a good thing. It doesn't mean people won't suffer. It just means that we'll have a slightly less catastrophic. outcome.

[01:24:03] **Nate Hagens:** So what are the policies that could make a difference in this? And by the way here's my view on population. I think there, well, you just told me the facts.

[01:24:14] It's 80 percent due to population numbers and 20 percent due to consumption. Obviously, I think the wealthier nations should use less. And we probably shouldn't have as many people having babies worldwide, but I. Of the three timelines that I talk about, pre crisis, bend versus break, and a more stable state in 20, 30, 50 years from now, I think population, the discussion of population isn't going to happen in the near term.

[01:24:45] And if it did, if we stopped having babies worldwide for whatever reason. That would precipitate the financial overhang and wars over resources, et cetera, because it, we it's been a musical chair Ponzi scheme the financial representations of biophysical reality. So I, I think climate change is hard enough to convey to people.

[01:25:08] The population story you've told is another order of magnitude harder.

[01:25:13] **Corey Bradshaw:** True. But if you take that perspective of. And I'll quote you, stopping having babies. That's not actually what one should advocate at all. I think a family planning so that you manage your family size to a point that is acceptable to you as a human, as an individual, but also takes into consideration the legacy effects.

[01:25:37] So if you, Recycle, if you don't do overseas trips, if you buy an electric car, if you hang your clothes out to dry instead of using the dryer, you eat

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vegetarian, blah, blah, blah, all the things one individual can do. The effect on your emissions are an order of magnitude lower than having to, deciding to have one fewer children in your family.

[01:26:01] **Nate Hagens:** So zero instead of one, one instead of two, two instead of three, etc. Exactly.

[01:26:05] **Corey Bradshaw:** If we had a policy, for example, say two is great. More than two? Maybe we want to think about that. It doesn't preclude people from fulfilling that goal. evolutionary need to reproduce, which we all have. I mean, that dictates all of human behavior, basically.

[01:26:22] We're not saying people don't have babies. We're just saying, think about how you, how the kind of life you can give to your children. And part of this is reducing child mortality. You know, there's an ulterior motive there because it does reduce fertility. It's the strongest effect in reducing female fertility and having the ability to make those decisions at the family level for both men and women.

[01:26:45] That's essential. So, and it has to be done culturally appropriately. It has to be done in a non coercive way. It has to be ethically acceptable. It's not, there's no one size fits all. It kind of has to be

[01:26:56] **Nate Hagens:** done globally, doesn't it?

[01:26:58] **Corey Bradshaw:** It has to be done globally, but it's a sort of a tailor made approach.

[01:27:01] That's what family planning is about per region. And it considers all of the other components that religion in the society, the economic development level the cultural components belief systems, various other things. And there are plenty of examples where it's worked very well without being an imposition.

[01:27:19] And, you know, middle aged white blokes like myself living in rich countries aren't saying you should stop reading because that's not what we're saying at all. We're saying that we need family planning.

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[01:27:27] **Nate Hagens:** So 2.1, maybe you could briefly explain why 2.1 children per female is the replacement rate globally.

[01:27:36] If you get married and you have 2.1 children and everyone did that, the population would stay the same. Is that correct?

[01:27:43] **Corey Bradshaw:** Yes, well, that accounts for both the fact that you're going to have female and male children. Males don't reproduce per se. They don't produce babies. They produce sperm. So you can only have as many babies as there are a number of women, right?

[01:28:00] And until men start getting pregnant, that's not going to change. And then the small 0.1 there accounts for the global mortality rates in children.

[01:28:09] **Nate Hagens:** Okay. And what is 2.1 would be even what what is the number now, the fertility rate globally?

[01:28:15] **Corey Bradshaw:** Globally, it is, if I recall about 2.8, 2.9, somewhere in that vicinity.

[01:28:25] Yeah. So it has been declining globally, but it's still high enough that we won't make that transition in most countries until quite, you know, later down, down the track.

[01:28:36] **Nate Hagens:** So how important is education, especially for women and can education or overcome the financial market economic imperative that drives our society?

[01:28:59] **Corey Bradshaw:** Yes. Well, this is a little bit problematic for several reasons because it's Emancipation of women's rights and giving people, the economic freedom to make decisions in their life and not be coerced and be in control of their own bodies and, and improving their own well being, both economically and otherwise, through education.

[01:29:24] These are all grand things. You know, you make better informed decisions. Generally speaking, your family members have better lives, there's less suffering and you have more freedom and you experience more of life. And so

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these are all great things. The flip side, of course, is that when you increase your economic standing, you increase your consumption rate.

[01:29:46] So, that's partially imposed by the economic systems that we have. So that there's it's almost imposed that you increase your consumption as your education and therefore, and your per capita wealth increases. You, there's a great example of that in, in, In terms of refugees, when refugees come from low consumption countries, on average, and they move to high consumption countries, they adopt the same consumption rates of the high consumption country, their host country, within a few months.

[01:30:19] And this happens globally. So it's imposed by the system. You can't even choose not to be a consumer when you move to these countries because that's the system that's there. And if you have more means, you have, you end up spending more. It's designed to make you spend money. and therefore consume.

[01:30:37] So it's a multi level problem. And it is a very, again, a complex set of systems, but it's, it come fundamentally comes down to giving people the choice to make their own decisions. And that education is essential component of that. And that's incorporated into the best practice family planning programs that are available.

[01:30:55] **Nate Hagens:** And access to birth control widely and freely, I assume is a big part of it too. It's

[01:31:01] **Corey Bradshaw:** more than just access because access alone will not shift fertility per se. It has to be accompanied by actual education and family planning programs. And that's a huge cultural component to that as well.

[01:31:14] **Nate Hagens:** Okay.

[01:31:15] So here is a, an oft stated assertion. I'd like your opinion on it. If people understand our ecological brink and understand the scientific thesis you've outlined here and they realize that globally we should continue our evolutionary imperative of having children and doing the acts that cause having children, but to point one, global average is the more sustainable outcome number.

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[01:31:52] Those people around the world that are equal it and have a value system that care about future generations in the biosphere will actually choose to do that, whereas the people who don't have a value system about dolphins, oceans, and a livable earth might have six kids. So how's that? I hear that a lot.

[01:32:13] What are your responses to that framing?

[01:32:16] **Corey Bradshaw:** Yeah, well, I guess part of the educational component is just showing the net benefits of smaller families for those people and that the average wellbeing per individual in the family, it actually comes right down to that, that if people realize that, you know, a very crowded house has fewer diseases for children, for example, there's fewer hospital trips, there's less competition among siblings.

[01:32:37] There's usually a better part of resources available for the extracurricular activities of the children in the family. And the list goes on and on. They have a better quality food. So. Except,

[01:32:48] **Nate Hagens:** except let me ask you this. So you said earlier there was a biological imperative that if there's low fertility rates, that results in more babies.

[01:32:59] What if we go from 50 to a hundred years of economic growth to the backside of the carbon pulse, there will be an economic equivalent of low mortality. The it's low economic vitality that doesn't that, could that imply the impulse to have more children to support you as you get older and such?

[01:33:20] **Corey Bradshaw:** Well, if we also have simultaneously focused on reducing child mortality.

[01:33:26] in those situations. So while you might not have a lot, but if you focused on preventing, and most child mortality occurs in the first year of life, right? If we really put the emphasis on child health and the raising of children to that age, you would have less of an impetus to invoke that subconscious insurance policy in terms of fertility.

[01:33:48] So I, you can't, you'd have to do both.

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[01:33:52] **Nate Hagens:** So we're in a mess. But what you're telling me is of all the things that we could do to improve the odds of avoiding a ghastly future that reducing infant mortality is one of them.

[01:34:08] **Corey Bradshaw:** That's a big one. I'd say probably the next biggest thing is a complete restructure of the economic system in which we work.

[01:34:15] And, and that's, that's a big ask because it's, it's, it's tendrils have penetrated every orifice of every component of society. So it's not something that it's a quick fix. I personally think the worst invention that humans ever came up with, it wasn't nuclear bombs and it wasn't, you know, chemical warfare.

[01:34:36] **Corey Bradshaw:** It was actually in corporatization. So the creation of companies and public companies going public so that you outsource the ownership to people that aren't making the decisions. You divorce ethical decision making from profit maximization. And so I think the worst thing that ever occurred is the creation of a stock market.

[01:35:00] That one brilliant idea provided the template for the destruction of the planet. And that, to me, was when it really started because there's no way that you can incorporate good human decision making that's morally eco environmentally ethical when your decision makers have nothing to do with those decisions.

[01:35:24] All they want is the bottom line.

[01:35:26] **Nate Hagens:** I don't know how much you know of my work, Corey, but one of the lines in my movie, and I say it often, is we've outsourced our wisdom and decision making to the market.

[01:35:35] **Corey Bradshaw:** Exactly. So I think we're on the same page there. Another thing we could do is we could make all political donations illegal because there isn't a single democracy on this planet.

[01:35:46] It's all shades of a plutocracy. And as soon as you can buy decision making for profit maximization, then again, you have the same effect. You do, you have decisions that are for the few and not for the many, and that includes a societal wellbeing. And so, Those three things alone, reducing child mortality,

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getting rid of public companies, and making political donations illegal, would make a huge dent in reducing how shitty our shitty future is going to be.

[01:36:17] **Nate Hagens:** What kind of changes have you made in your own life, in your personal life, being aware of these things to be more aligned with the future you'd like to see? Or do you think individual choices are not relevant in the scale and scope of what you're describing?

[01:36:31] **Corey Bradshaw:** Individual choices are relevant, I think.

[01:36:33] But they have to be gauged relative to these, you know, the scale effects, obviously. So I think if I was you know, traveling overseas every second day. And I were, I had 16 children and I was, you know, embraced in all sorts of consumerism that I could possibly think of. If I managed to say, for example, make political donations illegal, it would sort of dwarf all of those negative effects, right?

[01:37:02] So you want to

[01:37:03] **Nate Hagens:** be a net positive for the planet.

[01:37:05] **Corey Bradshaw:** Exactly. But at the same time, those personal choices are really important, not just for, you know, I'm a hypocrite, like all humans. I'm alive. So I'm a hypocrite. You know, it's the, I like that old meme. It's very old now is, you know, the woman holding a sign at a rally and it said, save the planet, kill yourself.

[01:37:23] That's a bit of an extreme, but fundamentally, she's right. So, you know, just being alive, you consume, right? So there are choices to, yes, I. As an academic, I fly overseas and that's bad. I have a car. That's bad. Public transport isn't available. I live on a farm. One of the reasons I bought the farm is to produce more food so I would rely less on, you know, importing food from elsewhere.

[01:37:46] I like my wine, so I make it myself. You know, I made choices. I have one child.

[01:37:50] **Nate Hagens:** You had two choices of buying the farm. You bought the real farm instead of buying the farm.

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[01:37:55] **Corey Bradshaw:** Yes, exactly. But you know, I have one child. I try to limit my consumption. I eat locally. I, you know, there's small things I can do, but, you know, from the As an individual, you know, I support the parties with policies.

[01:38:10] I think that's one of my biggest influences is my vote. And in Australia, you are obliged to vote. We don't have a choice. So, that's a good thing.

[01:38:20] **Nate Hagens:** Is there, like climate change, probably even more than climate change, natalism and overpopulation is a very heated and uh, contentious topic that doesn't make it into the national stage because it's very threatening.

[01:38:39] Talk about cognitive dissonance. Have you seen any change in that in your lifetime of studying these things?

[01:38:46] **Corey Bradshaw:** Well, I mean, the first population paper I ever wrote, I received death threats quite regularly from that. Biggest hate mail campaign I've ever received. As soon as you start talking about human reproductive rights, it gets very heated very quickly.

[01:39:00] And that's wrapped up into culture and religion and all sorts of things, politics. So that comes with it. What, you know, some of the bigger changes I've seen in my life the, for development agencies in the United Nations. which were very active in family planning right up until the 90s. And then a massive shift happened where the Catholic church actually got involved and it became basically anathema to even mention the word family planning thereafter.

[01:39:30] And that still has an effect. And even today, when we deal with development agencies in the United Nations, one of my colleagues was just at one of the United Nations meetings and they're actually, the United Nations precludes their employees from even mentioning it. So it's a policy that is starting to break down because there's a lot of people in so called lower income countries that are, you know, well educated and are seeing the benefits, or at least seeing the detriments of high populations in their countries are starting to say, look, this isn't just white people in rich countries from the West telling, you know, Doc people in low income countries in the South, how to do business because we actually can benefit from this.

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[01:40:10] So we're working with a lot of local people now that's starting to come out in the conversation, but it's a very, it's still very heated, even in the development circles. I mean, these are the very educated and ethically and morally upstanding people that, that really want to better the world, but even their politics are so tight around this subject that it's almost impossible to get them to speak about it publicly, let alone privately.

[01:40:36] So we still have a lot of work there. Definitely.

[01:40:38] **Nate Hagens:** What's the what's your best speculation at a sustainable human population over the longterm?

[01:40:46] **Corey Bradshaw:** That's a very interesting question. There's been a lot of work done on that over the years. From today, from an ecological footprint perspective, from a demographic momentum, from an, from a wellbeing perspective and from an overconsumption perspective, all things are kind of pointing into that two to 3 billion range, perhaps slightly more, perhaps slightly less, which was approximately what we were back in the fifties just before the, as the baby boom was taking off.

[01:41:16] So if we managed to get us globally, and again, that's highly geographically variable. Because some places have higher productivity than others, but on average, globally, if we've sort of stuck to that kind of number, that would be a good target. It would certainly provide adequate consumers for markets to be more or less free, with some limitations, of course it would give people a very good lifestyle and benefit and well being.

[01:41:44] Our health would be better our long term. Food production would be more sustainable. We would be able to reel in a lot of that climate change momentum, and perhaps even fix it. We'd even be able to restore a lot of ecosystems. But, will we come to that by design or by disaster? I tend to think the latter.

[01:42:03] Rather than a planned sort of target.

[01:42:07] **Nate Hagens:** That's my base case too, that we continue to grow population for another 30 years or so, and then there's gigafamine in the back half

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of the century. But Rex Weiler has been on the program. He was one of the co founders of Greenpeace and he did the math with me.

[01:42:24] And like we said, we're growing 80 million net new humans per year. So that's 800 million per decade. But if we did What you said earlier, a campaign on education especially of women family planning, education, access to free contraceptives, that you could reverse that and go to a negative 1.1 percent per year which is a lot.

[01:42:51] actually works out to around 800 million per year with no draconian early deaths or famine or wars or anything. So in, you know, 30, 40, 50 years, if that were true, we could be at 2 billion in theory.

[01:43:10] **Corey Bradshaw:** Yeah, I think actually if I looked at some of the reduction, it would put us probably more like the middle of next century.

[01:43:16] That would be viable to, to reach some of those numbers. But yeah, we're talking about the same timeframe. I mean, the century timeframe

[01:43:21] **Nate Hagens:** is like a fantasy sci-fi novel. I mean, I don't even know what 20, 20 30 is gonna be.

[01:43:27] **Corey Bradshaw:** Exactly.

[01:43:27] **Nate Hagens:** Yeah.

[01:43:28] **Corey Bradshaw:** No. But yes, that it's the timeframes are sort of in the hundred year range that we could possibly do that.

[01:43:34] **Nate Hagens:** Yeah. Okay.

[01:43:34] **Corey Bradshaw:** If it were designed, I feel more like you though that a lot of that will be imposed. Yeah. And not in a nice way.

[01:43:44] **Nate Hagens:** Well, you're not the first to suggest that on this show. So

[01:43:48] **Corey Bradshaw:** no, definitely not.

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[01:43:49] **Nate Hagens:** This has been eyeopening and enjoyable. Uh we've never spoken before and you're a good bloke.

[01:43:58] Let me ask you a few closing questions and thank you for your time. This Adelaide morning. Do you have any personal advice to listeners? Either those who are very familiar with what you've said or those that you just dropped a bomb on their life with the last hour and a half. What are you advise people who are becoming aware of our reality?

[01:44:20] **Corey Bradshaw:** I think I could say to most people that indifference is probably the worst path to choose. So you can avoid uncomfortable conversations and topics. But ultimately, even though it's uncomfortable, ultimately you can improve your own well being and that of your family's if you put a little bit of emphasis on what these biggest scale decisions mean for you.

[01:44:47] And, you know, in most people that I don't care if you were brought up in the inner city or you you know, hard right winger or you know, left, lefty greeny, you put someone out in the bush somewhere and a nice day and. They feel good, you know, and you just, you don't even have to see a lot of animals, you know, a butterfly might flip by it.

[01:45:10] It's a good feeling. We evolved in these kinds of systems and we feel comfortable there, just the fact that you have some green space and get away from people and you want to maintain some element of that into the future and your children can benefit from that. It's worth making it.

[01:45:27] A bit of noise about how we can change these systems for the better. So I think ultimately it sounds selfish, but I think we, the humans, we think in a selfish or at least a very nuclear way, the people around us and our own lives. And if, once we realize that we can make our lives better by consuming less and being more involved with the decision making that affects our societies, then I think we have a chance of a future that's not awful or ghastly as we like to say.

[01:46:00] **Nate Hagens:** Well, you wrote some papers with the title ghastly and then we'll put them in the show notes. What about young people? How would you change that advice for someone in their early twenties? Well,

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[01:46:10] **Corey Bradshaw:** 17 year old daughter who is in fact, Right at that age and being my daughter, of course, she's been aware of this since she was five years old.

[01:46:20] I remember making her cry when she was about six, just telling her about climate change alone and feeling very bad about it afterwards. But she, you know, she's made many decisions already and, you know, 17. You make a lot of decisions that don't necessarily manifest later on. Most of her generation, they shun mass consumerism, that I've seen anyway.

[01:46:43] They do not want families. They don't want to drive. Even in Australia, they don't want to drink or take drugs, which is, Blows my mind. It's quite a difference. Why would

[01:46:53] **Nate Hagens:** that be? You would think that would be an escape, just on a cultural demographic observation. Yeah,

[01:46:58] **Corey Bradshaw:** it's a very interesting topic.

[01:46:59] I'm not sure that I have any of the answers, but they seem to be in a little bit of a shell shock about the future, and they're really focused on being Good people I think and I think I do have a lot of hope with the younger generation seeing that is that they're not chomping at the bit to make the most money or to see the most places or have the biggest family, just that ownership, that consumerism.

[01:47:26] I don't see the same that when I grew up, I could be wrong. There's the seed

[01:47:29] **Nate Hagens:** of a cultural change there. I see it too.

[01:47:32] **Corey Bradshaw:** Yeah. And that's encouraging. And I think while there, they're generally, they're very sensitive, you know, at the university, the students coming in now that you have to walk on eggshells because the slightest thing will put them off, you know, COVID really knocked them for six.

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[01:47:45] As we say in Australia they're very susceptible and their resilience is very low and you can understand why. And they've generally very freaked out about the future. But they're also thinking about it, not in a form of desperation. They're actually changing how they live. So do you, are you teaching right now?

[01:48:03] I am. Yes.

[01:48:04] **Nate Hagens:** What is the name of the class you teach or more than one?

[01:48:07] **Corey Bradshaw:** Well, I teach into quite a few, but I do everything from biodiversity conservation to restoration ecology to teaching statistics and mathematics and modeling to talking about, know, global food systems and things like that. So touches on all elements of environment.

[01:48:23] **Nate Hagens:** So the topics that we discussed on this podcast, you tell your students?

[01:48:27] **Corey Bradshaw:** Yeah I'm actually a little bit infamous for freaking out people in the second and third years. So they say, Oh, we would wait till Corey's classes. Cause he'll give you a, so do people choose

[01:48:39] **Nate Hagens:** to take your class or do they have to?

[01:48:42] **Corey Bradshaw:** Well, depending on which stream they're in, yes, they often have to take it, but it is, it is quite interesting to see that most of them are quite up to speed with the fact that things are bad. They don't quite get the gravity or the magnitude of how bad it is. And I think that's what really kind of shocks them.

[01:49:01] Almost always there's someone at the end of one of these classes that says, what are you doing to tell more people about this? That's the question that comes out the most. And I'm thinking, well, I'm doing a lot, but clearly I could do more. You know, if it takes Second year university students to get this message.

[01:49:19] I'm clearly not getting the message out as much as I should.

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[01:49:22] **Nate Hagens:** I agree with you. So let me ask you this, and I know we're running a little over here. It was my experience when I taught Reality 101 for nine years at the University of Minnesota. They signed up for it cause it was kind of cool.

[01:49:37] Cause we were talking about climate change and energy and the environment. And then during the class, they were totally shell shocked cause I told them things that they had never thought about like plastics and peak oil and, and the, the. money's relationship to net energy. But at the end of the semester, they're like, I learned more depressing things about our reality than I had imagined, but I actually feel better about it because I have a context for understanding how things fit together.

[01:50:05] And it sucks, but I feel better for understanding it. Do your students feel something similar? Do you think?

[01:50:12] **Corey Bradshaw:** I get some feedback occasionally that the kind of information that we give them is often very useful for their immediate families and friends and connections. And that when people go, Oh, you know, don't worry about that stuff.

[01:50:23] It's not a big deal. And they can, well, actually, X, Y, Zed, and ABC, and this is happening. They feel empowered that they can actually start elicit change within their own peer groups and their own families. And I think that's where it has to start because we are social beings.

[01:50:39] We operate in small nuclear networks. We don't have influence at the political level, most of us. And so, if we can affect some small change within even the perspective of our immediate neighbors and our families that's an empowering feeling. And so I think that's what I hear from students often is that they can do that now.

[01:51:00] **Nate Hagens:** A few more questions. What do you care most about in the world, Corey Bradshaw, other than velvet worms?

[01:51:09] **Corey Bradshaw:** What I care about most in the world, I think just the Look outside and see the beauty of natural systems. That's makes me the happiest,

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you know, when I see destruction, when I see, you know, I, it just, it affects my soul. I can't describe it any other way. And so just maintaining some sort of naturalness, naturalness look

[01:51:30] **Nate Hagens:** outside and see the beauty.

[01:51:32] of the forest and the ocean and the kookaburras and the platypus or whatever you see, do you simultaneously see a future echo of it? And the emotions of discounting that back because of your research and awareness of the future of global ecosystems.

[01:51:54] **Corey Bradshaw:** When I went to South Africa for the first time and I went to the Kruger National Park, I took a photo of a white rhino running away in the dusk.

[01:52:03] And the way it worked out is that it was kind of fuzzy and a little, because it was low light, it almost looked like the rhino was a ghost or becoming one. And I use that as an analogy often in my talks about the ghost rhino that's disappearing. I got to see that rhino that day. Will I be able to see it in 20, 30 years?

[01:52:22] Maybe not. And so, but I took great pleasure in the fact that I could see that animal and it might be gone, but I took pleasure in the moment and I can do stuff to hopefully push. You know, maximize its resilience and potential for persistence in the future. But I saw it then, and so I took pleasure in that.

[01:52:42] Then I take a lot of photos. That's, you know, it's not very fulfilling from that perspective. I like seeing things in the flesh, but at least I can look at the photo and say, you know, that's a beautiful thing. I saw that. I took that photo. I was there. I took some pleasure from that, and that keeps me kind of going, you know.

[01:53:00] **Nate Hagens:** If you could wave a magic wand and there was no personal recourse to you, what is one thing you would do to improve human and planetary futures?

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[01:53:10] **Corey Bradshaw:** If I could do one thing, I would make all political donations illegal. That to me would be the biggest impact I could possibly make on the planet.

[01:53:20] If I could snap my fingers, we had democracies, actual democracies, be more than I could ever hope to achieve in my lifetime as a scientist.

[01:53:31] **Nate Hagens:** Well, here. So this has been great. I would like to have you back because I think we just scratched the surface. If you do come back, what is one topic that is relevant to human futures that we didn't discuss today that you are a passionate about or a nerd about that you would be willing to take a deep dive on?

[01:53:51] **Corey Bradshaw:** Well, I think that there's a lot of more deep diving to do. just on the population child health, climate change interactions. And we're just starting to explore those in more detail. And I think that we could get into a lot of arguments about certainly net benefits and detriments in terms of population density and the evidence underlying those.

[01:54:16] We could go into a lot more detail there, I think. If that's, if there's an appetite for that, perhaps, yeah.

[01:54:22] **Nate Hagens:** It's part of our future and it's quite relevant. So we'll try to do a population roundtable and I will invite you back.

[01:54:29] **Corey Bradshaw:** Well, I would certainly, if that occurs, definitely getting some better representation to both in terms of gender, origin, race.

[01:54:38] It's a, I think that's a really good idea and you get different perspectives, but you also see that it's a bigger problem and it's, yeah, I, you know, I can't help the way I look or who I am, but it's, I'm very cognizant of the fact that I'm a middle aged white man from a rich country. And regardless of the evidence, you need to open that conversation up to a broader group.

[01:55:00] **Nate Hagens:** I'll set it up, Corey.

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[01:55:01] **Corey Bradshaw:** Okay, that'd be brilliant. And I can even potentially suggest names too, Nate if you're interested.

[01:55:08] **Nate Hagens:** Thank you so much. I hope you enjoy your Adelaide weekend and to be continued, my friend. very much.

[01:55:14] **Corey Bradshaw:** Thank you, Nate. Lovely to meet you and I appreciate the chance to talk.

[01:55:18] **Nate Hagens:** If you enjoyed or learn From this episode of The Great Simplification, please follow us on your favorite podcast platform.

[01:55:26] You can also visit thegreatsimplification.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.