The Great Simplification

Nate Hagens (00:00:00):

There's a saying that two heads are better than one, and I couldn't agree more. On this episode of The Great Simplification, I welcome geologist David Montgomery and biologist Anne Biklé to discuss soil life interactions, the microbiomes of our gut, nutrient deficiencies in our diets, and the key pillars of regenerative agriculture. David Montgomery is a professor of Earth Sciences at the University of Washington in Seattle, where he researches the evolution of topography and the influence of geomorphological processes on ecosystems and on human societies. Anne Biklé is a biologist and landscape architect who has worked in field biology, watershed restoration, and environmental planning and public health. In addition to David's popular and award-winning book, *Dirt: the Erosion of Civilizations*, David and Anne have co-authored *The Hidden Half of Nature, The Microbial Roots of Life and Health*, as well as a recent book published last year, *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. Please welcome husband and wife, soil biome experts, David Montgomery and Anne Biklé. Welcome David and Anne.

David Montgomery (00:01:37):

Well thank you.

Anne Biklé (00:01:38):

Yup, thank you Nate.

Nate Hagens (00:01:40):

A biologist and a geologist combining forces in life and in literature to write about a very important topic, which is soil, regenerative agricultural, and our food system. I really look forward to unpacking this with you both today.

David Montgomery (00:01:59):

Well thank you. We're glad to be here talking with you.

Anne Biklé (00:02:02):

Yeah.

Nate Hagens (00:02:03):

Did you guys know that this was your ultimate path when you met, these topics, or did you fall in love and get married and then decide to study soil and food and such?

David Montgomery (00:02:17):

Well ironically, the one class that we had together in graduate school was a soil science class. Now whether that was a premonition of things to come or not, I don't know, but it certainly wasn't planned. There's a long story behind how Anne and I got into thinking and writing about soils and their connection to the longevity of civilizations and our individual health and so on. But I think I can say with some confidence, it was not planned.

Anne Biklé (00:02:41):

No, definitely not.

Nate Hagens (00:02:45):

I taught a class for eight years, haven't taught in the last two years, called Reality 101, a survey of the human predicament, and it was intense. Climate change, oil depletion, all the things that are ahead, and the students that took it were speaking the same language. They went through emotionally and intellectually this experience. And so I do think it sets you apart from your peers. So the fact that you two met in a soil science class ultimately makes sense looking back.

David Montgomery (00:03:22):

Well it wasn't actually how we met, but it was the one class we did have together.

Anne Biklé (00:03:27):

And oddly enough, I'm not sure, I can't recall exactly why we thought that class at that time for both of us when we were in graduate school, but we did. And it was a good class. I liked it.

David Montgomery (00:03:48):

Yeah, I know why I took it. It was at the end of my PhD experience and I decided I needed to know more about soils as a geomorphologist who is studying the evolution of the surface of the earth. So it was my last shot at getting a little bit of solid grounding in that area.

Nate Hagens (00:04:04):

I had no intention of sharing this story, but there were a couple classes in college where I looked up who was taking this class, and if there was a woman that I wanted to get to know better was on the registrar list, I signed up for that class. Not saying that was the case in yours. So getting to your soil question. So my work is about energy and how our society is energy blind. We don't understand the importance of energy to our lives, the fact that we're all alive during the carbon pulse, but really you could make the same arguments about soil and food. We are soil and ecology blind. So maybe we could start out, David, the first book, I think your first book, it's certainly the first of your books that I've read, *Dirt: the Erosion of Civilization*. Maybe you could unpack that a little bit as a foundation for the rest of our conversation. Can you explain briefly the connection between agricultural productivity, soil degradation, and as you just mentioned, the decline of civilizations?

David Montgomery (00:05:17):

Sure, one of the things I should point out at the start of this is foundational to all discussions about the past and future of soil is it's basically where our food comes from. Something like 97% of our food directly or indirectly comes from the soil, filtered through plants and then livestock and into us depending on what we choose to eat. So the way the soil works to help us grow crops is really fundamental and foundational to supporting agricultural societies, which most societies post ice age have been. So when we look at soils, it's sort of a foundational deal, and I started writing about the erosion problem after I'd been working around the world as a geomorphologist, the kind of geologist who studies what shapes the surface forms of earth's topography. So studying erosion was kind of my bread and butter, but natural systems.

(00:06:10):

And what I realized working all over the globe is I was starting to see patterns where societies, where the land had been degraded, where the soil was degraded, where it

had been eroded off or it lost a lot of its organic matter, lost its fertility, that the populations were relatively impoverished, and that that could actually have been the soil degradation that led to that could have happened a long time ago, and places that we know today is Syria and Libya, for example. And so I started putting together the idea it would be fun to research and think about what the role that soil erosion had played in human history. And the farther I got into it, the more I realized I was actually writing a history of farming, because that was the mechanism through which land degradation had played out. And the one sentence summary of the dirt book is that societies that don't take care of their land, that don't take care of their soil, don't last.

(00:06:58):

It's a recurring pattern and theme in human societies and civilizations. And we have a pretty bad track record, frankly, at a planetary scale, in preventing soil loss and degradation as a result of agriculture. And the dirt book was really an attempt to pull that history together and to look at possible lessons for the future because we don't really have anywhere else to go to farm new fresh unharmed soils these days. We have to figure out how to make agriculture sustainable and not just sustainable in an economic sense, but in an environmental sense relative to the ability of the land to actually keep producing food for the future.

(00:07:37):

And that's what really got Anne and I onto this path of thinking and writing about both the backstory of problems of soils in past societies, but also what we can do about it today. And that led to some much more optimistic books that have come out a little more recently than the dirt book where we've learned of the stories of farmers who have been really turning around the problem of land degradation and rebuilding healthy fertile soils at a geologically astounding pace. But that's getting further ahead of the narrative. So the dirt book was really a look back at what's gone wrong in the past.

Nate Hagens (00:08:10):

So let me ask a couple questions about that. First of all, for new listeners that haven't learned much about this topic, what is your definition of the difference between soil and dirt?

David Montgomery (00:08:24):

Oh, that's a great question. And I did take a little bit of heat from some soil scientist colleagues for calling a book about the history of soil erosion dirt, because the one thing you're never supposed to call soil in soil science is dirt. It's not a respectful term. So you can think of dirt as soil where you don't want it. It's on your shoes, it's tracked into your house, it's on the car mat in your car when you get into it after stomping them about in the mud. That's one way to think about dirt is soil where you don't want it. Another different way to think about it is that soil is much more than just the mineral components, than just the geological part of it. It's really the merging the marriage of geology and biology. And so you can think of soils as having both a living component, the organisms that are living within it and helping to cycle nutrients and keep things moving and getting those minerals out of the geological realm and into the biological world.

(00:09:17):

But it's also a place where once living things, what we know of is organic matter, is actually quite important as well, because it helps to provide the fuel that drives that underground economy that differentiates soil from dirt. So that living half is what I think is so fascinating about soil to me these days. And it's partly why Anne, who's a biologist, and I got sort of thinking about working on this together, is that when you think about soil as an ecosystem as opposed to an object, you really start to think about it differently. And the way that it gets influenced by our agricultural practices, by our cultural practices really start to come into a different framing and a different light when we think about it as another ecosystem we need to worry about our impact on.

Nate Hagens (00:10:03):

So dirt is the inert component, and it could have 0% organic matter or it could have 3% or 5% or 10%, but once we add the mycelium and the small insects and the microorganisms, then dirt can be labeled soil, yes?

David Montgomery (00:10:26):

Yeah, I would say that the real difference is life, the impact of life on the soil and the life in the soil that really comes together to make it something very different than just a pile of minerals.

Nate Hagens (00:10:39):

And are there lots of places in the world that don't have life in the soils now?

David Montgomery (00:10:45):

Yeah, one of the prominent places that has less life in the soil or a different mix of life or different communities of life in the soil, which matters as much as whether there's any life at all, are agricultural fields. The places that we rely on to feed ourselves. Globally, we've lost roughly about 50% of the organic matter in most agricultural soils on average. Results on your farm will vary. It's highly variable depending on context, of course, as most things are in geology and geomorphology. But we've done a real number on degrading the soils that we really depend on to feed ourselves and that has been of concern in the past. And we're not the first people by any stretch to write it and think about this, but it is one of the fundamental problems facing humanity today. It's kind of on par with the climate problem, the freshwater problem, and the population issue. They're all intertwined and they're interrelated, but of those, I actually think the soil one might be the most solvable because we already know how to do it. But that's, again, getting a bit ahead of ourselves in this saga.

Nate Hagens (00:11:50):

So one more question about your first book and then I will switch to your co-author and wife to ask about your recent book. You said it was unexpectedly a history of farming, the erosion and the impact of loss of soil in prior civilizations. But what would happen in Pakistan or in Australia a couple of years ago, they got two feet of rain in one day. Is that enough to erode the topsoil and change things from a non-anthrocentric sort of way?

David Montgomery (00:12:28):

Yeah, erosion is a natural process. If erosion wasn't happening to reshape the surface of the earth, we'd eventually not just… We wouldn't run out of soil, but we'd run out of nutrients in the soil because we need to basically keep cycling nutrients out of fresh rocks into weathered rocks, into soil to replace things like zinc or iron that plants need for their health, we need for our bodies. So that some erosion is happening is a very natural thing. With that example of that Noah's flood kind of rainfall that you're talking about from those examples, there's going to be erosion even in natural systems. The real issue is how much erosion and how often. And so when you get a large rainstorm event like that, let's say on a freshly plowed field where there's no roots holding the surface together, you're going to get an enormous amount of erosion, but you can also get it in a very average rainfall when you have a freshly plowed field.

(00:13:24):

Nature is pretty good about clothing herself in plants, and that's a very effective way to shut down erosion to very low rates, not to turn it off because life itself depends on erosion for refreshing the elements that make us all up, but vegetation helps to limit that process to a background rate that is sustainable. And when we have bare freshly plowed fields and we get even modest rain on them, you can erode off a centuries worth of soil formation in an afternoon. But when you get two feet of rain in a day or something like you were talking about that, that's just off the charts. And so one worry is that those events become more common. We might want to rethink the way that we lay the land out in advance of those kind of events.

Nate Hagens (00:14:14):

Last question for you. I recall reading your book like 10 years ago, and in the early chapters you talked about Charles Darwin's fascination with earthworms, and I don't remember the math, but you speculated how long it would take with no humans around for the soil to be regenerated naturally with worms and bio geochemical cycles. How long does it take to grow an inch of topsoil without interventions?

David Montgomery (00:14:48):

I actually did a review of that in the Proceedings of National Academy of Sciences that summarized the data that I was looking at when I was writing *Dirt* on that very

issue. And if you look globally, the average pace of natural soil building is about 2% of a millimeter a year, two one hundredths of a millimeter per year. Your fingernails grow faster than that. That's a slow rate in terms of nature building soils. The other thing I looked at in that same study was the average road of topsoil erosion today off of conventionally managed agricultural fields. And the average rate there was about a millimeter and a half a year globally. And there was a recent study that just came out from Evan Thaler and Isaac Larson at UMass Amherst that basically found a similar rate, 1.8 millimeters a year, as an average erosion rate across the American Midwest for the last century and a half.

(00:15:37):

So the numbers are pretty robust. That pays, it takes only about two decades, 20 years to lose an inch of topsoil, and at 2% of a millimeter a year as a natural soil building rate, it takes 500 to 1,000 years to replace that inch of topsoil. That's the problem. That's one of the problems right there. The other problem, of course, is the loss of soil organic matter, and thereby soil fertility. But if you lose the soil itself, which can happen in just a few centuries of farming at that kind of pace, that's a very effective way to impoverish societies well into the future. But you can come into problems with soil fertility much faster than that by degrading soil organic matter as well, which modern farming practices do.

Nate Hagens (00:16:19):

So I'm very worried about oil depletion the next 10 or 20 years because we've built our lifestyles around it. But the next couple centuries, soil depletion could arguably be much more impactful to the generations that follow us.

David Montgomery (00:16:37):

Oh yeah. Oh yeah. And it could have impacts this century as well. I mean, it's one of these things that we're not actually going to run out of soil, but we may run out of enough fertile land with healthy enough soil to feed everybody if our population keeps going up and we keep degrading the land that we are growing our food on. And an open question, and a very fair question I think, is whether we want to place blind faith in technology to solve the problem, or do we want to take advantage of ecological knowledge we already have in hand about better ways to farm that could actually

solve that problem for not only humanity over the long run, but for those of us who are alive in the 21st century? We've got a few decades to really fix this problem and we could do it, but we're not yet on track to do so.

Nate Hagens (00:17:23):

I have lots of questions there, but I want to give your co-author, Anne, a chance to say hello and give us a summary of your latest book the two of you wrote together, I believe it's your latest, called *What Your Food Ate: How to Heal Our Land and Reclaim Our Health*. It focuses on nutrients in our food and how industrial inputs have been undercutting the nutrient density in our food. So Anne, for the average person watching this program, can you outline for us what their food likely ate?

Anne Biklé (00:18:06):

Yeah, well nice to be here, Nate. Thanks for having us. And as far as that question goes for listeners and viewers, it all depends what is in your food maybe that you had for breakfast or lunch or dinner. That all depends on the practices that the farmers used to grow those crops and raise animals. And what David and I uncovered in the latest book is that all of this gets kicked off by this series of relationships that are nested in the soil. And so as a biologist, I'm really interested in all of this soil life and in their interactions with one another as a community. So there's a ton of research out there that goes back decades, and some of it is also very recent.

(00:19:09):

And the bottom line on all that research, Nate, is that the organisms that are indigenous to the soil, that live in the soil play a huge role in how crops take up mineral elements is one example. And so David had been talking about the importance of erosion and we need to get zinc out of rocks and iron out of rocks and so on, and it's the microorganisms in the soil that help shuttle those mineral nutrients out of these broken up rocks into the roots of a plant and then from there, the plant can take over and send that zinc or iron or whatever the mineral is to wherever it needs to go.

Nate Hagens (00:19:58):

How do they shuttle the minerals from the rocks to the plants?

Anne Biklé (00:20:03):

Well there's some very helpful fungi that participate in this process. The large group, there's different groups of fungi. Those that are the transporters, David and I call them the truckers and the miners of this mineral world in the soil. They are our microrisal fungi. So these are not the kind of fungi that are breaking down organic matter. They have these long thread like structures that are a part of... They're fungal bodies that run all throughout the soil, in a healthy soil, I should say. And it is through those fungal hyphy that iron, zinc, phosphorus, even other kinds of compounds for which we don't have a full and complete list, they're running from some distant location in the soil through these hyphy all the way to the roots of the plant. So you can think once these mycorrhizal fungi enter the root zone of a plant, it's sort of like the doorstep.

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They've kind of knocked on the door and let the plant know, "Hey, I got that stuff." And there's symbiotic relationships. So these are relationships that benefit plant and microbe alike, because fungi aren't doing this for free. They are getting nutrition that their bodies need from the plant when they drop the goods off at the doorstep. So zinc, iron, phosphorus, other compounds get dropped off. The plant has been manufacturing an array of sugars, proteins, fats, and that picnic basket of goods is left at the doorstep for the mycorrhizal fungi to take up. So this exchange is going on just ceaselessly and endlessly in the soil. And so that's how at least the microbial world is interacting with our crops to suffuse them with nutrients.

Nate Hagens (00:22:17):

How long have we known this, what you just described?

Anne Biklé (00:22:21):

Well, in the book, we write a bit about some of the early organic agriculture pioneers in the UK. So this is Sir Albert Howard and Eve Belfort. Now back at that time, of course, they didn't have all this DNA analysis and super-duper microscopes, but they were some very observant farmers, and they could see that when they increased organic matter on the fields, that their crops would do better. When they paid closer

attention to how they were grazing their animals and what those plant communities, what kind of condition the plant communities were in that the animals were eating, that animal health was better. And so they surmised that organic matter played a role in this and Belfort and Howard in particular thought that the key lay with fungi, they didn't know about microrisal fungi, they knew fungi decomposed things.

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So I want to say for the last 50 or 100 years, people have been thinking about these kinds of relationships. And it probably goes back a lot further because you start to look into people like Louis Pasture and Robert Koch, the French and German microbiologists respectively. So these were the folks that were on pathogens in human disease. And so they knew the microbial world was capable of a lot from fermentation to disease. So it's not like you can pinpoint one one time to say, "Aha," we didn't know…

Anne Biklé (00:24:03):

One time to say, "Aha. We didn't know anything, but then overnight, we knew." So it's been a process, like all of science. Things accrete and accumulate, and the picture becomes clearer about what is happening. And this is certainly the story with respect to soil health and its role in agriculture.

Nate Hagens (00:24:21):

So I want to let you finish giving an overview of your book, but as usual, when I am really interested in a topic, I come up with 10 intervening questions. So what you're describing is, I've read a lot about the human gut microbiome, which we can talk about, and how important that is. But it sounds like the soil in my backyard also has a microbiome which is changing, depending on what I do or don't do, et cetera. Is that an apt analogy?

Anne Biklé (00:25:00):

Yes. That's a totally apt analogy. What we know about microbiomes in the human gut, in the soil, in the whale, in the cow, wherever these microbiomes are, they have co-evolved with their host organisms. So normally, we think of co-evolution, or maybe a better way to say that is pollinators and flowers are one of the most common ways that we think, "Oh, look at that. The hummingbird beak, slipping down into that

tubular shaped throat of a flower to get food, that's coevolution." What we know about microbiomes and their host organisms is that they are just as co-evolved, and that these co-evolutionary relationships go back a very long time.

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I mean, for example, with the human microbiome, if we didn't have the microbes in our gut and on our skin and everywhere else that they are on and in us, we wouldn't be able to digest our food. We would not have a robust enough immune system to survive for very long. So it's been going on a long time, Nate. Evolution works in a way that if something's not working out, that relationship dies off. And the relationship that organisms have with their microbiomes are constantly changing depending on the diet that say I eat or you eat.

(00:26:48):

In the book, we refer to the soil as having a diet. And so that diet for the soil, that can either be things like a lot of synthetic inputs, nitrogen, phosphorus, potassium, or the three big fertilizers, or it can be a diet of organic matter. And when the diet is organic matter, there's not only that nitrogen, phosphorus, and potassium coming through to the plant, there is a vast array of other compounds and molecules that are also made available to the plant. So the plant in its microbiome are communicating about, the plant needs more of compound X. The microbiome hears that so to speak. There's a lot of chemical signaling going on, can fetch that. These fungi, we call them the fetching fungi. Certain bacteria, I call them nitrogen nabbers. So these microbes are acquiring things, delivering them. And then as I had described before, they're getting these compounds from the plant.

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These compounds have a great name, Nate, they're called exudates. Just think exuding, flowing out of the plant into the microbe. So that's an overview of how some of these basic mechanisms work. And when you begin to study this and go more deeply into it, it becomes quite apparent why ag practices affect these relationships. You have tillage and plows and various farm implements and even gardening tools for that matter. And they're slicing and dicing up the soil physically, or a lot of chemical inputs are scrambling the words, and the language, and the conversation. And it

becomes very difficult for a host to communicate robustly, accurately, and to the benefit of both itself and its microbiome if communication is messed up.

Nate Hagens (00:28:59):

I have so many questions. So let's just use rough ballpark. The majority of our food in the grocery stores in the United States, we can focus on the US or North America for now, was produced somewhere for industrial agricultural system. Yes, there are farmer's markets, and there's some niche systems where we're doing things more no-till, more locally grown, et cetera. So you could make a case that what our food ate mostly is nitrogen, phosphorus, potassium, without all of these other actors in the mix, right?

Anne Biklé (00:29:44):

Yes. I'm afraid to say yes. Yeah.

Nate Hagens (00:29:49):

What does that mean for their role in exuding nutrients to us and passing, leaving nutrients at our doorstep in the food? What are we lacking?

Anne Biklé (00:30:03):

Yeah.

Nate Hagens (00:30:04):

On account of this.

Anne Biklé (00:30:04):

Great question, yeah. So plants are not just these brainless sitting ducks out there in the soil. When they are given piles and piles of synthetic inputs, they respond by, well, let's see. I've got this particular, and nitrogen, phosphorus and potassium, you can think of them as the macronutrients that are needed for plant growth. Somewhat of the equivalent of proteins, fats, and carbohydrates in the human diet. Those are the three things we need, the macronutrients. Plants get the N, P, and K, and they're like, "Wow. Let's see. I could put more energy into growth or big leaves, big fruit, big vegetables. But in order to do that, I'm going to cut back on my exudates because I've

gotten all this nitrogen from this other source. I don't really need to make exudates, I can put the energy I would've put into making exudates into bigger plant, bigger growth."

(00:31:12):

So when a plant starts making these exchanges, they're really trade-offs, making fewer exudates to be able to take advantage of the big pile of nutrients right in front of them, it shorts the soil microbiome of nutrients of the things that it needs. So what these fetching fungi do and the nitrogen nabbers do, and these whole communities of microorganisms, they get starved. They're malnourished when crops are primarily fed a diet of N, P, and K because the plant's not providing as much in the way of exudates. And what this means then is with these microorganisms being malnourished and lower in numbers and community structure is perturbed, the plant's not getting all of these other compounds that are also important for its health.

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In the case of the botanical world, there's a certain thing to think about here. And that is that plants we know themselves make a huge variety of what are called phytochemicals. So all that means is plant made chemical. It's everything from say, beta-keratin in our squashes, anthocyanins in our berries, there are thousands if not tens of thousands of phytochemicals. This is how plants survive their sitting duck lifestyle. Insect herbivores, mammalian herbivores come at these plants, they consume a little bit of it. In a robust, healthy plant that is having a great conversation with its microbiome, the microbiome can help the plant interpret signals for making more phytochemicals that push back on pathogens, that push back on herbivores. And these phytochemicals that are important for plant health, they're in our diet, but these crops need to have a certain level of challenge, if you will. We don't want couch potato crops. Okay, that's really bad. It's bad because they then don't have a good defensive system. And that defensive system in part consists of a lot of phytochemicals and they benefit our health as well.

Nate Hagens (00:33:38):

Speaking about coevolution, this is almost human-based selection that we are having plant biologists and plant breeders working for big corporations that are optimizing

for plant growth and yield, which indirectly is causing a shrinkage of these micronutrients, these phytochemicals you're referring to. But it's still, they're succeeding because if there's enough N, P, K, we get the plant growth, but the micronutrients are maybe missing. And can you give us some data on the micronutrients missing in the average diet and why that's important? What I just described, is that what's happening?

Anne Biklé (00:34:25):

Yeah, that pretty much is what is happening, although there's a couple other things to consider here. So when we breed for yield and when we breed crops in which their genomic expression is really matched up with acquisition of N, P, and K, it's a really different kind of a crop than one that has a genome that is more geared toward communication with soil life and the microbiome. And when you have that, you can grow a lot of that particular plant, but it comes at a cost. First of all, you've got to buy all these inputs, the actual nutrients. What it also means is that the plant, if it's putting more of its energy into growth and not so much into phytochemicals, somehow you have to compensate for the defensive function of all of those phytochemicals in a plant, if you've skewed it toward yield. And the compensation for all those defensive phytochemicals is pesticides.

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So you have two really big groups of inputs in ag. You have the stuff that makes plants grow, crops grow, and then you have the inputs that are necessary to compensate for plant defense against pathogens and herbivores. So there's something called a dilution effect. You grow all of this biomass on a plant, a bigger potato, a bigger corn cob, a bigger bean, whatever it is. And because the plant has put so much energy into growing its macronutrients, it tends to have less in the way of phytochemical diversity and phytochemical abundance. So that's the basic problem with a practice of growing our crops heavy on inputs, the growth ones and the pesticides that compensate for defense.

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The other thing about that is plants are not having as robust a conversation with their microbiome, say these fetching fungi. The fungi are, you can maybe picture them a

little bit, they're a little bit lost themselves in the soil if they're not communicating with their plant. And if there's not a call for zinc or iron, which are two really important micronutrients, then the levels of those micronutrients and others: manganese, selenium, boron. These micronutrients are really a good example of something that you need a little bit in the human diet. But that little bit has an outsized effect on the health of the person, the plant, or the animal. And so that's why it's thought that you're skewing crop growth toward yield, that is having an effect on micronutrient, phytochemical. And as we write about in the book, there's a few other important compounds that are either making their way into the plant body or not as a result of agricultural practices.

Nate Hagens (00:37:51):

So the soil story that you two are unpacking here is in many ways a microcosm of our economic system, is that our macroeconomic system is focused on GDP and profits, but we're really not looking at the micro wellbeing of our citizenry and our health and our security. And it's all focused on the bling and the high level shopping centers and GDP and things like that just came to mind. Question, do we have evidence that the average person has less zinc, manganese, selenium versus 50, 70 years ago? Have we studied that?

Anne Biklé (00:38:42):

Yeah. We go over some research in the book that dates from some research that was done in the UK that was looking at average declines across a series of crops and also looking at animals. And that research was looking at, I can't recall exactly. Looking at an array of micronutrients from... Iron was one of them because I remember the declines in iron in beef were quite high. There was also, calcium was in there. Dave, I don't know if that's on the top of your head perhaps.

David Montgomery (00:39:26):

Yeah, this is a couple studies out of the UK looking at historic declines in the mineral density in particular fruits and vegetables in the UK. And they were 25 to 50% range losses, there were some that were even higher. There's been other studies in wheat in particular in terms of iron and zinc contents. Wheat and zinc deficiency is actually a

huge problem in the Global South in the areas where people have been dependent on green revolution varieties of wheat for example. So there are studies that have looked at that.

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There have been fewer studies that have tried to actually connect that to direct human health outcomes. There's a lot of things in between the health of the soil and the health of an individual person, let alone the aggregate public health of a whole society. But so what we tried to do in *What Your Food Ate* is break it down into the little links, between how farming practices affect how micronutrients get into crops, how then they get from the crops into our bodies, and then the medical literature, what do those things, the antioxidants and anti-inflammatory compounds that phytochemicals become in our bodies or the roles they serve in our bodies.

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The medical literature is full of evidence that that's affecting human health. So when you put all those little connections together from different disciplines, you can trace the path from soil health to impacts on human health. But the number of studies that have tried to demonstrate it directly are fairly small. So we tried to bring all that info together.

Nate Hagens (00:41:00):

So I'll ask you to just speculate on this, but if someone is hungry and they eat a pizza or some nachos or something, and then they're still hungry and they keep eating, is that possibly because they got the macronutrients, they got the carbohydrates, the protein, and the fat, but in their diet, somehow in the soil is missing these micronutrients that our bodies are craving somehow manganese or selenium, or something that we're missing? What do you think about that, either of you?

Anne Biklé (00:41:36):

It's not really speculation, Nate.

Nate Hagens (00:41:37):

Oh, okay.

Anne Biklé (00:41:39):

There's a ton of research and evidence.

David Montgomery (00:41:45):

Yeah, it's a good point.

Anne Biklé (00:41:46):

Yeah, there's a good deal of research and evidence out there that there are, just as I talked about, all of this chemical signaling that goes on between a plant and its microbiome in the soil, that very thing is happening within our bodies. So you take in that pizza, and okay, you've met your sodium intake within about two bites, so body is not hankering for any more sodium. You probably got a pretty decent amount of fat, so don't really need any more fat. All the sausage and pepperoni, yeah, met the protein, so the body's not really hankering for that. But the body might be hankering for, let's say this was a type of pizza that didn't have tomato sauce. So the body's like, "Well, I could really use some lycopene." That's one of the main phytochemicals in tomatoes.

(00:42:36):

So this is all happening, I need to say, on an unconscious level. I mean, we joked about having voices in our head at the beginning of the show, but think about this, there are voices in our bodies that are at an unconscious level so to speak. Our cells are communicating with our nervous system, with our brain to influence our behavior to keep reaching for pizza. Because we think that, wow, if I keep eating more pizza, somehow, maybe down the road I'll be getting enough lycopene, enough manganese, enough of anthocyanins. And of course you're never going to, all that's going to happen is you're going to keep taking in more calories, but the calories are not going to have the full complement of nutrients that the body is hankering and calling for.

Nate Hagens (00:43:32):

So using that logic, if I ate a pizza in this example and took a daily multivitamin, might I crave that third slice a little bit less? Or do the multivitamins not really solve the problem you're talking about?

Anne Biklé (00:43:50):

No, the multivitamins don't solve that problem in part because they're not coming… Those vitamins, were they embedded in the pizza somehow in the actual foods that the pizza is made of, then the body's hankering for say vitamin C or the suite of B vitamins or whatever, it might have been met. But these things in isolation, it's just not how biology works. It's not really how an omnivorous diet works. So we're omnivorous, and part of the beauty of this flavor feedback system, I mean, that's what this is all called, Nate.

(00:44:29):

It's these feedbacks between flavor. Our body takes that in and goes, "Oh, you know what? You're still missing X, Y, and Z. Head out to the buffet and try again because you need where the cells need more of this or that." So the multivitamin thing, unless there's vitamins are great, if there's an acute deficiency, this is what scurvy was all about. This was a one-to-one correspondence between vitamin C cures scurvy. So then we thought, oh, well maybe we can apply vitamins, other vitamins in that way. But it doesn't. Not all vitamins work that way, nor do they work with human biology that way. But if you have an acute deficiency and you know exactly what it is, yeah, a vitamin could probably take care of that.

Nate Hagens (00:45:19):

So in your book, one of you wrote, "Once we realize our bodies themselves are ecosystems, it changes how we consider health and wellness." Can you explain what you mean by that?

Anne Biklé (00:45:35):

So ecosystems are complicated places, whether in the ocean or the soil or forest or a meadow. And if you study biology, ecology, anything, you can go out there and you can try and study these bits of the ecosystem, but sooner or later, you come away with the realization that it's not any one part of this ecosystem that is really the takeaway. The upshot on ecosystems is it's all of the processes and the organisms and the players that are in relationship together that are really determining whether or not that ecosystem is functioning normally. And we don't need super function out of an

ecosystem. We just need normal function, like the way say a wetland can capture pollutants and help control erosion.

(00:46:34):

And so the body ecosystem, we just need a normal omnivorous diet free of say, residues left over from conventional agriculture. We need our plant animal foods to be suffused with the nutrients and compounds that crops need for robust growth, but also defensed. We need our animals to be on diets that suffuse them with a balance of fats and an array of other nutrients. So this is all normal, all of this flavor feedback between plant and soil, between animal and plant communities that they're eating, you roll that up into the human diet. And our flavor feedback system is working normally on an omnivorous diet, so that's eating a lot of different foods.

Nate Hagens (00:47:29):

So this is going to be a six-hour podcast, I hope you guys don't have dinner plans. Let me ask you this, since you wrote these last two books, have you changed your own diets based on what you learned and researched and wrote about? Do you grow any of your own food or do you shop at farmer's markets, or can you speak to that briefly?

Anne Biklé (00:47:57):

Take it away, Dave.

David Montgomery (00:48:00):

Yeah, we changed our diet really as a result of the.

David Montgomery (00:48:03):

Yeah, we changed our diet really as a result of this series of books in two steps. When we wrote *The Hidden Half of Nature*, which was the book that was looking at the relationship between microbiomes and their host organisms and laid out the parallel between the what goes on around the roots of a plant, what goes on in the human gut, and cast the root system of a plant as an external digestive system that related to... Well, that reframed our thinking around seeing our bodies as an ecosystem, and that led us to think about, oh, how do we feed our microbiome? We had thought that we had a really good diet, but we were probably eating not enough plant matter,

eating too much bread and cheese, which I love and still love, but don't eat quite as much of as anymore.

(00:48:45):

We essentially started trying to eat more with the idea that filling half of a plate with greens or vegetables as a routine matter during dinner. Anne and I are omnivores, as she mentioned. We'll eat almost anything, but we changed the proportions and the sourcing of what we were doing as a result of writing that book in terms of realizing that we're not just eating to feed ourselves, but we're eating to support a microbiome that really wants all that fiber that my doctor was always telling me to eat, and that I was wondering, "Well, why?" Once you understand that's what actually makes your microbiome healthy so it can help make you healthy, I started going, "Oh, it's kind of like when we have a dog. You need to feed the dog food that's appropriate for the dog."

(00:49:32):

Well, your microbiome needs appropriate food for it as well. The care and feeding of that internal menagerie turned out to be something that structured how we thought about eating. We also, in terms of thinking about knowing how farmers actually raised the food that gets into us, led us, and particularly Ann, to do more of our shopping at farmer's markets where you could ask, "Well, what are you doing? What is the soil like on your farm?" She has her favorite farmers that she likes to get stuff from the farmer's market. Then as a result of writing *What Your Food Ate*, we took another sort of leap in changing because we started looking at what the diet of livestock matters, not only to the energy costs of animal agriculture, but actually what gets into our food.

(00:50:25):

The balance of fats in our meat and dairy products are very much dependent, it turns out, on whether those animals were eating grain derived feeds, things like corn derived feeds, seed oil derived things, the kind of things they get in the feed lot. That tends to enrich meat and dairy with omega-6 fats, which roughly speaking are pro-inflammatory and a livestock that was eating dominantly or 100% grass-fed sources, pastured and not living in a feed lot, they tend to have meat and dairy products that are rich in omega-3 fats, which tend to be anti-inflammatory.

(00:51:03):

Now, to be fair, you need both omega-6s and 3s in your diets, but you don't want an overload of omega-6s, which is what we get with a diet full of seed oils and conventionally raised feedlot fed livestock, whether you're eating meat or dairy. We went to buying 100% grass-fed meat and dairy where we can get it as well. We did notice health benefits that flowed from all these dietary changes over a number of years. Of course, it doesn't help that we're getting older either, but that's fighting an uphill battle here.

Nate Hagens (00:51:34):

You both look great. I've had many guests on, I had Robert Lustig gone recently about the ills of processed food, and so it sounds like what I'm hearing from you is there's at least a two-step process. One that I'm getting more comfortable with is to have more vegetables, more plants, broccoli. Dick Gephardt is a friend of mine, he has intermittent fasting and he breaks his fast at 11:00 in the morning with vegetables in cold water that he has in his fridge, like cauliflower, broccoli, radishes. He's done it for years and now he really looks forward to it. That's hard for me, but I understand the logic of having a lot of roughage fiber plants.

(00:52:22):

You're suggesting there's a second step in addition to changing the proportion of... You've mentioned bread and cheese to more vegetables. The second step is finding out where those vegetables came from, because at a normal grocery store, the broccoli and the cabbage and other things that I'm buying were made with or were grown with conventional agricultural processes. The soil and the micronutrients might be different than what you said that Anne goes to the farmer's market and asks, "What were the processes of the soil?" Am I right? There's two different steps.

David Montgomery (00:52:59):

Yes, that's a very clean way to think about it. There's basically the choice of what you eat and then there's the choice of what your food ate, which is the whole point of the title of the new book is to encourage people to think about that second step.

Anne Biklé (00:53:15):

Right, because say Dick Gephardt's radishes, cauliflower, and other things that he's eating to break that fast. He could eat all of those quantities and those particular vegetables that he wants, but what if the farm that produced those has soil with inadequate levels of mycorrhizal fungi so that all the things that he thinks are in those vegetables are really not at the levels that are really good for his body?

Nate Hagens (00:53:49):

Okay, so this opens up a ton of questions. Let's just say that everyone knew, and everyone read your book and everyone understood this. We don't have the amount of vegetables and fruits grown with the right mycorrhizal relationships in the soil microbiome to serve that demand yet, correct? There would be a scale problem.

David Montgomery (00:54:15):

It's actually worse than that. We don't have enough fruits and vegetables grown in any way to actually provide the minimum daily required recommendations for the human diet in the US. We don't grow enough in this country to actually feed that, and that's before you get to the question of how they were grown, but your point is right. We do want to think about how they were grown and get more fruits and vegetables into our diets. But it's a real challenge for agriculture to meet with our focus on commodity crop production focused predominantly on grains. We need to diversify what we're encouraging people to grow and farmers need to be able to sell what they raise.

(00:54:59):

If we're thinking about that, we all ought to be thinking about taking steps to maybe diversify our diets a bit. Your point about processed foods is a big one that we go into in *What Your Food Ate* in some detail. But in terms of what would be the healthiest prescription for a modern diet in the way that Anne and I see it would be a diet that's rich in fruits and vegetables, grown in soils from healthy fertile soils. It's fresh, whole foods grown in healthy fertile soils and livestock that have been actually grazing rather than eating corn derived feedlot rations would be a very solid recommendation for healthy eating.

Nate Hagens (00:55:42):

This is going very well. I'm learning a lot. It's very interesting. I'm very confident my listeners are also learning a lot, and now is the point where I'm to ask you about agricultural regeneration practices, but before I do that, I'm going to go down a rabbit hole because I'm curious. You've heard about fecal transplants where someone is missing something and they share the poop of someone in their family or something and it injects some... It's something that affects the microbiome. It's why my coach from India says that we're supposed to commune with a lot of other people in chanting and cooking together, because we indirectly share our microbiome. People living by themselves, most of the time, their immune system starts to not function well because they're not sharing the microbiome of others.

(00:56:40):

Question number one is how true is all that can we interact with others in our own microbiome? But my ultimate question is can we do the same with soil? Can I take a cubic yard of amazing, fertile, rich, live soil with mycorrhizal fungi and all the things you were talking about and dump it in a field that isn't poisoned or anything, but there's very little... There's organic matter, but not a lot of life in it. Does that act like the soil equivalent of a fecal transplant or what can you say about all that?

Anne Biklé (00:57:20):

Yeah, okay. I love it. You're picking up on the root gut epiphany. That's a good example. We have this wonderful soil chock-full of life, microbial communities are functioning, and we've got some soil in a nearby field that's struggling. We need to get it back up on its proverbial feet. Yeah, you can inoculate. You can get a sample of this fantastic soil, inoculate the other soil with it. It's a little bit like probiotics. It's a culturing process, so it's like the way you might make sauerkraut. You leave it exposed to the air, microorganisms get in and they begin to culture things. You're moving it from one field to another.

(00:58:17):

What's key here is you can't just do that and walk away. Those organisms that are in the good soil that you've just transferred, they're used to a certain kind of lifestyle. That lifestyle is one in which farming practices supply an abundance of organic matter, hopefully minimal chemical and physical disruption, and hopefully also that

great soil came about in part because cash crops as well as cover crops were grown year round, so exudates are flowing. That microbial community that you've just transplanted, you've got to feed it and you've got to care for it.

(00:59:01):

That's how you can inoculate soil, but it's like planting a tree. You don't just plant the tree and walk away. There's care and there's feeding, and it goes the same with fecal microbiota transplants in humans. Initially, research has shown that you can get rid of really nasty pathogens with a fecal microbiota transplant, but if you want the microbial community that you transplanted to stick around and continue providing those benefits, you've got to nurture and care for it. In other words, all life, no matter what, needs to be nourished. That nourishment is related to a specific diet given that organism, whether plant, animal or person.

Nate Hagens (00:59:55):

Excellent, thank you. Okay, so this has been a great intro. Now, moving on to the what to do about it part. Can you explain the three pillars of agricultural regeneration, which you cover in your book?

David Montgomery (01:00:19):

Yeah, basically after I wrote *Dirt*, we were left wondering, can you actually rebuild fertile soils on active farms? We wrote a lot about our experience at our home garden where Anne did that to our soils in *The Hidden Half of Nature*, where we started thinking about microbiomes and all these connections between microbiomes and host organisms and the parallels between the human body and plant roots and all that. At the end of writing that book, we were left at the question of, well, how can we do this on real farms, on profitable farms around the world? That led to writing *Growing a Revolution*, which set the foundation for *What Your Food Ate*, by looking at what are the practices that farmers who had done to their farms what Anne did to our yard, who had taken degraded, thoroughly worn out soils, and brought them back to a high state of fertility, by mostly by reintroducing biology along the lines of either inoculation but predominantly practice change.

(01:01:21):

I visited farmers in Ghana and Central America and across North America who had already done that and basically asked the question, "Well, what did they do? What were the commonalities?" It turns out that the common elements in across all those farms were that they were minimizing disturbance of the soil. They were either going no-till or very minimal tillage and minimizing chemical disturbance, so minimizing the physical and chemical disturbance that don't disturb the life, in other words. They were planting cover crops, keeping living roots in the soil at all times to help promote that exudate production, but also to shut down erosion because a shield of plants is the best defense against erosion. They were also growing a diversity of crops. They weren't just growing one or two crops. They weren't doing monocultures. Some of them had very diverse fields. Some of them had sort of diverse fields, but none of them had monocultures and were just growing one or two crops.

Nate Hagens (01:02:14):

What does the diverse crop contribute to the biology that Anne was talking about earlier, as opposed to a mono crop?

David Montgomery (01:02:23):

What happens when you have a diversity of plants in the field is that soil is receiving a diversity of exudates, a diversity of those compounds that plants are leaking into the soil to help recruit their microbial partners. The trick is that each plant will be releasing a different exudate cocktail. You get a very diverse set of exudates, which recruits a diverse set of microbes, which if you think about a baseball team, if everybody on the baseball team was a catcher, you'd have a horror. You'd never make the World Series. There's an advantage to having specializations when you work in teams. Microbiomicology is pretty much a team sport. Pathogens tend to be single organisms that do single things. The beneficial organisms tend to work in communities, and so you can think of them as a team and a team needs different players to play different positions to provide different functionality.

(01:03:18):

That's what the diversity gets you. The minimal disturbance is like you're not disturbing their house. The cover crops is you're helping to build organic matter to feed them, so you got food and housing. The third piece is partners and collaborators, and that's

how you can get a very effective and diverse community of soil life through those three principles of minimal disturbance, cover crops and diversity. Those three principles happen to be pretty much the opposite of what we've taught in modern agronomy for almost 100 years, where we've encouraged aggressive mechanized tillage as a routine operation. We've encouraged the over-application of synthetic agrochemicals for both plant nutrition and plant defense, as opposed to relying on their natural defense systems or helping to support their natural defense systems. We've been growing things in monocultures or functional monocultures of things like a corn soybean rotation, a two crop rotation, which is an invitation for pests to come into the fields as well.

(01:04:18):

These three pillars are a very different way of thinking about how to treat the land in the act of farming. Many people involved in regenerative farming would offer up a fourth pillar as well, in terms of reintegrating animal husbandry into cropping operations. You can think of animals in that sense as something that can help to process the crop stubble by consuming it and turning it into manure and returning that manure to the land. It's not just the nutrients that are returned, but a cow is also actually an inoculator. Their manure is full of microbes from the rumen that can then make it into the soil. There's a number of connections, all rooted in how you would cultivate, if you will, the beneficial life in the soil is by feeding them, housing them, giving them a community to work with, maybe giving them the accelerant of a faster organic matter breakdown through livestock on the land.

(01:05:15):

Regenerative farming systems employ all three of those components. The three major pillars that you identified are really the foundation for what the UN calls conservation agriculture. It's a system of farming that depends on doing all three, no- till, cover crops and diversity. There's very few studies that have looked at how the all three combinations, all three of those principles, work in combination, but those studies that have looked at that find big effects from the combination, much bigger effects than if you just went to no-till or if you just rotated your crops or if you just planted cover crops. There's a lot of synergy that comes through this new system, and it's all through

cultivating the life and the soil as an ecological system. It's a radically different way of thinking about the soil as the foundation for farming.

Nate Hagens (01:06:07):

I seriously have a lot more questions. I don't know how you guys are doing for time, but let's just keep going and just flag me if you have to stop, but this is clearly going to probably be a two-part thing. I'll have you back later. Let me ask you about no-till. A couple years ago, I stopped with the land we have back here with the corn, soybean, and now we're putting barley grass with bees and stuff. It's no-till. People that are vegetarian and they just choose to eat wheat and grains and things, the industrial practice is every year you get those big combines and those machines and they till up the soil. Clearly, that's killing worms when it's all dug up, but is that disrupting the soil? Is that also killing the homes of all these tiny little mycelium and micro critters that are helping the plant? And then they have to start all over until next March, it's tilled up again, and this cycle is just not ever giving them a chance to build a stable home?

Anne Biklé (01:07:17):

Pretty much, yeah. That's what's going on. The effects and the impacts of that vary, and it varies with crops. With an annual crop, like, say, a cereal grain, it's probably not as bad as if you're doing those kinds of practices running through a vineyard. Grapes are a perennial crop, or an apple orchard. You've got these trees with root systems all over the place and you can't just go slicing up those root systems. That's going to be pretty bad for the plant. If you're going to do that kind of a practice, it's better to do it with annual crops than perennial, but, that said, what it also means is that you're starting out every growing season with this huge disruptive event. That sets the microbiome communities off in a different trajectory.

(01:08:20):

I would say organic farmers, the very best ones, that are really on top of their organic matter management and how much they're applying and in what form, they've been able to thread their way through this tillage problem, because organic farmers till a lot, because it's for weed control purposes. Like I said, it's our very best organic farmers. It's not all of them. They manage to do okay on soil health, but it's only because they are paying a lot of attention to how they're preserving to the extent they

can and constantly adding organic matter so that the microbial communities that are left after the tillage have the best possible chance of reproducing, getting those numbers back up, and getting that conversation going right away with their crop partners. You fall down on the organic matter, and organic can become an industrial level process.

Nate Hagens (01:09:31):

Where does this organic matter that these farmers that you just said the best organic farmers are adding, where does that come from?

Anne Biklé (01:09:41):

Yeah, that comes from organic farmers that are using animals as a part of their cropping system. Dave had mentioned before you get a ruminant animal, so that's... Cows, goats and sheep are ruminants. They are basically walking compost heaps. Now, as a gardener, that is what I want. You can have these big windrows. This is a big long pile of compost and you're turning it with your tractor and you're providing all that material. That's a job in and of itself for anybody who's done that. What's vastly better than that, in terms of energy inputs and convenience and your time and your labor, is to have walking compost heaps that are dropping compost out of their back ends onto your fields, which is right where you want to get all of this stuff.

(01:10:37):

That's one source of organic matter. Another is cover crops. These are exudates. Exudates are carbon and other compounds, and that's a form of organic matter that's different than, obviously, animal manure. That is another source, and then also just leaving mulches and residues of dead plant parts on top of the soil as a mulch. That's another way that organic farmers and conventional farmers, some of them, will return organic matter to the soil.

Nate Hagens (01:11:18):

On the scale question, something I worry about is our current industrialized system is a 10 to 14 to one, depending on the boundaries, energy sink that we use 10 to 14 fossil calories to deliver one food calorie to our plate. A lot of that, like you said, is the pesticides, it's the nitrogen fertilizers, the ammonia, et cetera. What is not often

spoken about, and I looked this up and I got the reference from a guy named David Montgomery, is that there's a decline of around 20 to 60% loss in the organic content in global

Nate Hagens (01:12:03):

soils, something like that. And so, there's a double-edged sword here, right? There's the risks in the future of having less fossil fuel inputs as oil declines, but then it's like the heroin addict needs another fix. Our soils are having less living systems in them, and the organic matter is been cut in half or a third from where it used to be, and we're going to have less inputs. So, isn't that a huge risk? And how do we get ahead of that for those people working in agriculture?

David Montgomery (01:12:45):

That is a huge risk as we're basically, if you imagine a post oil agricultural future, we're going to have to figure out how to get along with far less use of things like synthetic nitrogen fertilizers that are very energy intensive to produce, but we're going to have to do it and maintain agriculture in a system that doesn't have all those things. So, we need to basically figure out how to generate a very intensive agriculture capable of high yields in a way that doesn't degrade the ability of the soil to actually maintain those yields without fossil fuel inputs, and that's the real challenge in a nutshell. And the same kind of things you would do to rebuild soil organic matter, the farming practices that would do that sort of help to fix all those problems, because they will use fewer, there will be less reliance on fossil fuels, but will also encourage and enhance our ability to grow large amounts of crops without that reliance.

(01:13:49):

And so, the longer we maintain conventional agriculture and degrading soil organic matter, we're just digging the hole deeper that we're going to have to figure out how to get out of. Now, the good news is, I think that we do have methods in terms of regenerative agriculture that could supplant conventional methods today. And we've got a few decades to manage that transition, but we don't have a few centuries to do it. We need to do it this century. And so, our interests in helping to combat and mitigate the climate issue really line up with our interests in being able to maintain the fertility of our soils, because they both argue that we need to transition towards

this more regenerative style of agriculture that is less fossil fuel dependent and can rebuild the organic matter content of our soils.

Nate Hagens (01:14:38):

So, like many areas in society, this discourse seems to be polarized. There's two interest groups in agriculture with diametrically opposed views on what the right thing to do working on food systems. On the one hand you have folks doubling down on very modern, very tech intensive, more mechanized systems with the Gates Foundation is promoting in Africa for yields, efficiency, et cetera. On the other hand, you have permaculture, agroecology, people, many other names working on this, pushing for more diverse cropping systems, replacing external inputs, and embracing, but also updating traditional systems. Do I have this right? And what is your take on which approach to be pursued and how do we steer that conversation?

David Montgomery (01:15:33):

I think you're right in terms of casting, the conversation is usually pitched around those two end member views, but I think it's the wrong way to look at it. I think the right way to look at it would be towards reorienting agriculture towards soil health building practices, and those are technology-agnostic. There's technological solutions that can help with that process. But, there's also an awful lot of what I like to call ancient wisdom in terms of the ideas of cover crops, crop rotations. Those are not new ideas. These are simple practices that many traditional societies around the world embraced, because it helped them sustain the fertility of their land, even in the cases of societies that were plowing the hell out of it, like I wrote about in *Dirt*. The Romans were all about manure and returning organic matter to the land, but they plowed eight or nine times a year. They really went overboard on the tillage.

(01:16:26):

So, where I think the future of agriculture ought to lie would be on merging modern technology with ancient wisdom. But, what I mean by modern technology are things like no-till planters. John Deere has this amazing technology to help farmers plant no-till, but it needs to be coupled with the wisdom of doing cover crops and crop rotations, and adopting a fairly different system of agriculture. So, I tend to view it that the over reliance of thinking on one or the other ends of that currently polarized

spectrum is missing the bigger point that we ought to unite them around, where the technology that we do embrace in agriculture going forward needs to be oriented towards building soil health. And if it's not, then it's probably inappropriate technology for sustainable agriculture. That's essentially the way I look at it.

Anne Biklé (01:17:22):

And, what's ironic to me, Nate, about some of the things that are going on and what you had mentioned as being tech intensive visions for the future of agriculture, it is ironic and just completely befuddles me as to why some of these ideas don't really even consider the soil. Because, sure, there's some things you can grow hydroponically, but that's not going to be the majority of how we produce our food in the future. It is going to be soil-based agriculture.

(01:18:02):

And so, technologies that don't support, or do research in, or trial and do demonstration farms on things like we've been talking about, whether that is this idea of inoculating soil with beneficial microbes, and then nourishing that in a soil that's maybe depauperate or lacking those things, if we're not doing research on this vast world of plant communication with the soil microbiome as well as flavor feedback processes that are happening between animals and the kinds of plants that are available to them in a pasture, technology and science and research that doesn't merge these two things and be asking questions about what technology is relevant to the biology that is inherent and innate in soil, plants, animals, and people, is a technology that we need to push off to the sidelines. That kind of technology is not helping us. On the other hand, the more we dovetail with how our bodies work, plant bodies, animal bodies, the soil body, then we're going to get to a vision and a future in agriculture that will be, I would call a wisdom based vision instead of intelligence, increasingly artificial intelligence based kind of a system.

Nate Hagens (01:19:37):

So, on that note, I have one more content question. And then, if you have a few more minutes, I know David has a PhD defense coming up. I have some personal questions to wrap up, but yes, this is yet another example of intelligence being bound by wisdom. But, how can we shift the system if our entire economic system is based on a

single goal, which is monetary profits, when from a sustainability standpoint, from a propelling human futures for centuries and millennia to come, soil and soil health, as David has pointed out many times, is going to be one of our most important variables. How do we as a culture start to bump that up the priority list when all we care about is dollars? Is there a way?

David Montgomery (01:20:37):

Yeah, because it's like the economy as a whole suffers similar problems. We live on a finite planet, so infinite growth is an impossibility, and the basic problem behind economics. So, what do you do? You basically put sideboards on things. So, when you look at things in terms of, if you're dealing with the market economy, you think about people's monetary incentives that they will be attuned to as they go through life. And so, in dealing with farming you're talking about, how are our agricultural subsidies arrayed? Are we rewarding farmers for doing the right things by their soil, or are we subsidizing them for doing the wrong things by their soil, which in fact we are doing today. So, we could think about, it's our regulations, incentives. We could think about opportunities for essentially trying to reward farmers for putting carbon back into the ground.

(01:21:29):

I think there's actually real opportunities for political alliances between urban dwellers who are very concerned about the climate issues and rural residents who are struggling, trying to make a living on farms where it's hard today, because farmers are caught between high input prices and low commodity prices that they get for their crops. They're kind of in an economic squeeze play. There's a lot of policy initiatives that could help to try and reframe the incentives that both consumers have, and also in terms of what farmers face.

(01:22:02):

And one of the biggest things that we're missing is, well, again, one of the big points that Anne and I made in *What Your Food Ate* is that, when we think about agricultural policy, if we track that all the way through to how we raise our food influences our health on individual levels, and then integrate that to a societal level, we look at our healthcare costs in the U.S. today where seven out of 10 of us suffer

from some type of chronic illness. One of the biggest levers we have for undoing those costs and the human suffering that's entailed for them is changing our diets and the way that we raise our food, that our agricultural policy really is health policy when we think of it in a broader framework. So, that's one way to start thinking about how to reframe that.

(01:22:46):

And one of the things I was very encouraged by in the research for the last two books is, it looks like some of the economic incentives for farmers are starting to line up with the ecological incentives for our society in terms of these regenerative practices actually being more profitable for farmers today, even without restructuring many of our incentives and subsidies. That's a positive sign forward, but it could use a little more support in the policy arena.

Nate Hagens (01:23:15):

Excellent. I'm just super passionate about this topic and I want to learn more, and you two are fonts of wisdom and intelligence, so I'm going to have to have you back. But, as is my habit, I end these interviews with some personal questions. Maybe you could each give brief answers, because I know you have to run. More broadly beyond your four books and your career choice, do you have any personal recommendations just as a human being alive at these times to the listeners of this program who are aware of our food climate, economic, geopolitical predicament?

Anne Biklé (01:24:04):

These topics can be really... If we drench ourselves in the hopelessness that too often I think comes along with conversations and discussions like this, it's not good for us. It makes us feel, well, hopeless. So, I'm always for at least once a day getting outside and finding some moment of wonder or awe out there, because I find that all of a sudden my thinking can turn and I, instead of dwelling on so much of the negative stuff, I can start to see a little bit of blue sky and where we might go with solutions, and some of the policy stuff that Dave was talking about. I think it's really important to get back to, I don't really know, it's a bit of a reset. It's a bit of like, we got to clear the doom and gloom out if we actually are going to pursue some of these other things that really need to happen in terms of setting up framework, policy, lifestyle, lives,

societies, built environments and all of that. You've got to get to the right head space to begin thinking about that.

(01:25:32):

And we were recently on, I can't remember the event, but it was too much about the negativity and the crises that we're in, because these are solvable. We have intelligence and wisdom to solve the climate thing, the food thing, the oil thing. It's just that we are locked in political and economic systems that are sort of this ball and chain on us. So, I'm all in favor of at least once a day get outside and find some awe and wonder. You can reset in as little as a five-minute walk depending on where you are. Springtime is a great time of the year to do that too, because spring is about renewal. And at least in our neighborhood right now, and being a person enthralled with botanical world, I can't wait to get out and, what's changed out there today? Oh my gosh, this thing is now out and it's singing its song and I love that, and it makes me feel fresh and ready to approach, how are we going to solve these other problems then?

Nate Hagens (01:26:51):

I love that too. I incorporate that in my life, what you were just saying. The challenge is that, most people are ecologically and energetically unaware of these things, so we still have to do the education, but a lot of people like yourselves are already aware of that, and you're rolling your sleeves up working on, how are we going to respond to this? David, how would you answer that question?

David Montgomery (01:27:17):

Well, in a kind of similar fashion. I would say that, I run into a lot of what I would call climate despair or climate anxiety among undergraduates on campus these days and I advise people, don't give into it. Instead, channel your energy towards actually fighting to change the system and to produce positive change in directions. There's a lot of really interesting and innovative things going on that are just starting to get off the ground that could help with many of these things, and dedicating one's time to furthering those is a very worthwhile proposition. Giving into climate despairs is a recipe for inaction and not changing the status quo. So, basically, keep fighting is one way to think about it.

Nate Hagens (01:28:06):

What do you care most about in the world? Briefly, you can each answer.

Anne Biklé (01:28:10):

That's a hard question. I think, for me, it just stems from my background in biology and in the world of gardening and everything. And one thing that's super important to me is that we hang on to the intact ecosystems, the intact and functioning ecosystems that we still have. And the reason I think that's so important is that, that is how nature is supposed to work. And when we chip away and start to unravel those things we lose, talk about losing wisdom, and losing knowledge, and losing intelligence. That is what I don't want to lose any more of, because so far, Nate, every time in all of this research and writing, the more you get into how plants are communicating with soil, animals, with their diet, it's as complicated as it is clear to me that when things are normal, things are right in an ecosystem. That is how the world and nature works. And we need to hitch ourselves to that if we want to continue persisting on this planet. So, I'm all about understanding that stuff, and then taking care of it.

Nate Hagens (01:29:48):

David?

David Montgomery (01:29:50):

Well, this may sound corny, but I'll endorse what my wife just said. I think that in the very big picture of things, what I care the most about is that we don't degrade this amazing gift that we have of this planet that we live on, and the natural abundance that we've essentially inherited from geologic time. We've risen to dominance globally in terms of the globally dominant species. And I don't want to see us lose what actually makes Earth incredibly unique and precious in the grand scheme of things for all we know. It's the one place that we know of with life. We inherited it with an amazing diversity of life, and we're living through what may be a very real bottleneck on that diversity and abundance of life. And I would like to see us do everything that we can to come through with as much nature intact on the far side as possible. And agriculture is at the center of those arguments.

Nate Hagens (01:30:49):

You both are my people in your sentiments. Last question. If you could wave a magical wand and there was no recourse personally to you or your status, what is one single thing that you would do to improve human and planetary futures?

David Montgomery (01:31:10):

Well, I'll go first on this one. I would wave my magic wand and make regenerative agriculture the new conventional agriculture in the sense that everybody was doing it.

Anne Biklé (01:31:20):

And I second that, and I think I have a few things, Nate.

David Montgomery (01:31:28):

Can she wave the wand a few times?

Anne Biklé (01:31:31):

First wave is, let's tackle poverty through educating girls and women everywhere. Because, when everybody does better, the entire global population can do better. And I would stop all wars, and those are my two big wand waves. Education of girls and women, and stop the violence and war where it's occurring.

Nate Hagens (01:32:06):

Those are big wishes. I agree with you on that. Are you guys working on another book by any chance?

David Montgomery (01:32:15):

We are just about through the, oh my God, I'll never write another book phase of book writing. So, we're thinking about it.

Nate Hagens (01:32:27):

So, if you were to come back, and I did a poor job of covering all the questions that I planned on asking you, just because I'm a kid in a candy store with two people like you. But, what is one topic that you would like to take a really deep dive on that is

very relevant to human futures? Could be super esoteric academic topic. Do you have brief ideas on that?

Anne Biklé (01:32:54):

Well, I always like talking about microbiomes in the soil and the human body. And in part, I say this a lot in public talks, but long before agrochemicals and pharmaceuticals, we had what we ate, where we lived and our microbiome. And that's taken us far as a species. That's been 99, if not more percent of life as a human. So, I like to think about the implications of that, where we are now and why we may want to be thinking about diets, for the soil and diets for people.

Nate Hagens (01:33:35):

Excellent. David?

David Montgomery (01:33:38):

I would be happy to have longer conversation about the feasibility of some of these regenerative agricultural practices, and how it is they can be scaled up, some of the other ancillary benefits that flow from them, and the experiences of farmers in different parts of the world. Because, there's no magic bullet in terms of regenerative farming. So, there's a lot of arguments to say about what it is, what it means, how to define it. And I tend to subscribe to the view that it's farming practices that build soil health through intensive farming, and the experience of farmers around the world are really different in terms of how you might achieve that. So, it'd actually be fun to talk about the many flavors of regenerative agriculture. What is the future, and what's the prognosis for the future of agriculture? Can we get through some of the roadblocks that people like the people who sell nitrogen fertilizers are undoubtedly going to start throwing in the way?

Nate Hagens (01:34:32):

Excellent. Thank you both so much for your time and for your work. And I expect you're both going to be very busy in the coming decade as more people take off their soil blinders and look at how everything is connected on the ecosystems in our fields and in our bodies. So, thank you both.

David Montgomery (01:34:53):

Well, thank you, Nate. It's a pleasure talking to you.

Anne Biklé (01:34:53):

Thank you, Nate.

Nate Hagens (01:34:56):

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