

The Fate of Food

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Recorded on July 19, 2019



Greg Dalton: This is Climate One, changing the conversation about energy, the economy, and the environment.

Greg Dalton: How will climate disruption impact the food we eat in a hot and crowded world?

Amanda Little: We see disruption in the auto industry, we see disruption in tobacco, you know, disruption is coming in the meat industry.

Greg Dalton: But lab-grown meat and other innovations may not address the social impacts of the food industry.

Twilight Greenaway: Will there be technology that really can feed into a more democratic food system that allows for different types of ownership less concentrated ownership.

Greg Dalton: Can cutting-edge technologies and traditional agriculture (together) create a climate-smart food system?

Amanda Little: We need the scale, we need the sort of good guys and bad guys to collaborate, right. Maybe this is a way of bringing more intelligent practices to industrial ag.

Greg Dalton: The Fate of Food. Up next on Climate One.

Greg Dalton: How will we feed a planet that's hotter, drier, and more crowded than ever? Climate One conversations feature oil companies and environmentalists, Republicans and Democrats, the exciting and the scary aspects of the climate challenge. I'm Greg Dalton

Greg Dalton: Technology is changing how we produce food - and what we eat. Innovators are trying to re-invent the global food system to be more productive and nutritious.

Twilight Greenaway: There are very clear benefits. I'm really interested in who's producing the

food and how.

Greg Dalton: Twilight Greenaway is a contributing editor with *Civil Eats*, an online source of news about food, health and environment. With a world population pushing 9.5 billion by mid-century, U.N. climate experts predict a 2% to 6% decline in global crop yields every decade going forward because of climate pressures.

Amanda Little: That paradox of increasing demand and declining supply presents a real problem.

Greg Dalton: Amanda Little is a journalism professor at Vanderbilt University who also writes for the New Yorker and Bloomberg about energy, food, and climate. Her new book is called *The Fate of Food: What We'll Eat in a Bigger, Hotter, Smarter World*. I began our conversation on the future of food by asking Amanda about Memphis Meats, a company in Berkeley, California, that she writes about in her book.

Amanda Little: Memphis Meats is producing what are called cell-based meats which are meats that are grown from cells taken from animals but grown outside the animal. And the cells are given sort of a very comfortable environment in which to grow in a bioreactor which in lay terms is this very sophisticated crockpot essentially and then grow and grow and grow until they form muscle mass and are blended with connective tissues and fats. And essentially a meat product that is meat just grown as separate from the animal. And I tested a cell-based duck breast about nine months ago or so in the Memphis Meats laboratory. But that interested me as part of this growing industry in alternative meats.

Greg Dalton: Because much of the climate conversation really gets down to meat and protein. Lot of it is animal protein and this lab meat, you know, is one way to kind of in theory reduce the environmental greenhouse gas impacts of factory farms the intensive impacts of industrial production of animal protein, right. So there's a lot of big companies, Tyson, invested in Memphis, Cargill, even Hormel, maker of spam is looking at this kind of thing. Is this where meat is going away from the pasture to the lab?

Amanda Little: Yeah, actually I got interested in the story in part because I was writing about Tyson for Bloomberg and I found that they were investing in Memphis Meats. Cargill Meats had come in I think first and then brought, you know, Tyson came in thereafter. A number of, you know, sort of more predictable investors had also come in, Bill Gates, and Richard Branson so on. But I thought this was fascinating that the conventional meat industry was investing in sort of disruptive technologies and asked Tom Hayes who was then the CEO of Tyson, why are you going into cultured meats or, you know, a.k.a. cell-based meats or lab meats. And they said, well, or he said, if you can grow the meat without the animal why wouldn't we do that. There's a huge, you know, resource advantage for us and obviously ethical advantages to growing the meat without the animal. And he said we see disruption in the auto industry we see disruption in tobacco, you know, disruption is coming in the meat industry. That fascinated me that this was something that conventional meats were investing. Now granted, it's a small fraction of what they're investing in conventional production methods, but the conversation is starting.

Greg Dalton: A lot of that is driven by the ability to lock up intellectual property which businesses like investors like to kind of put a moat around their investments so new competitors can't come in. Twilight Greenaway, does this idea of lab meat or industrial does that fascinate or horrify you?

Twilight Greenaway: A little bit of both I think like a lot of Americans. I recently was thinking about this issue actually when the announcement was made, Tyson decided to do an end run it looked like they were gonna be in, you know, really for the most part putting their money into

existing companies and then they kind of decided to put their own products out. At the time I was thinking about a conversation that had happened years ago about this idea of an organic Twinkie and I don't know if you remember that --

Greg Dalton: Wait. Organic Twinkie.

Twilight Greenaway: Yeah. So there was a discussion of now that organic is having this groundswell what will it mean when there's organic junk food basically. There will be the benefit on the one end there'll be the, you know, there's a lot to say about changing practices on the land and what organic means in terms of pesticides and other environmental benefits. But on the other hand, you'll still end up with the Twinkie and I think that that discussion felt very apt when I started to think about cell based meat because -- well, cell based meat, plant based meat and the investment in the huge kind of groundswell around, seeing it as the solution. And I think there are obvious benefits there are also some downsides. So for me it feels very similar. One of the main questions I have is about the ingredients that go into that, particularly the plant-based meat. How will it be raised will it be regenerative on a large scale. I think was it impossible they just came out declaring their pride at using American genetically modified soy. So I do think that it's very complicated and I'm curious to see how it plays out.

Greg Dalton: So Amanda, your response, I mean, you know, GMOs, people on the left are rabidly against them. Other people say, well, you know, there's cell editing or there's all sorts of techniques here. But really what we're talking about is the kind of the role of innovation and technology in food whether food ought to kind of be like our grandparents or a product that's engineered and designed to address the hunger and climate challenges we're facing.

Amanda Little: Yeah. I'm interested to get to the GMO topic. With the lab based, the cell-based meats it's interesting because some of the claims I mean the potential is so exciting that there are actually could be health benefits. Memphis, there are many of these cell-based companies that are merging and so Memphis is only one of them. But the founder who is a cardiologist by training was interested in potentially, you know, the human health benefits of, you know, bringing in healthy fats also addressing some of the contamination problems in meats that this would actually do more than sort of what an organic Twinkie would do. It could create a lot more safety for the years of the meats and certainly offset of course the impacts on the animals themselves. So in theory it's really exciting certainly, what is the, you know, medium in which the cells are grown what is the cost of this from an energy standpoint, how great are the, you know, potential climate benefits a lot of that, you know, we don't yet know but in concept it's exciting. And this is what's so interesting about a lot of these areas of food tech or what they call climate smart agriculture that are emerging. You know, the risks the benefits seem to outweigh the risks by a longshot, but it's still so early in the phases of a lot of these technologies that it's really hard to say for sure, you know, this is a slamdunk.

Twilight Greenaway: And I think it depends a lot on who we're talking about as benefitting grade. I mean I think there are very clear benefits. I'm really interested in who's producing the food and how. And I think a lot about rural communities, I think a lot about small-scale small and medium scale producers. And I feel like that I would like to see that piece of the conversation integrated into the discussion around cellular meat more than it has been.

Amanda Little: One of the people that got me interested in this was not just Tom Hayes, the Tyson CEO, but a farmer who produces meats on a small farm. He uses, you know, managed grazing, rotational grazing and he basically said the challenge is that what I produce on a small scale is not affordable for my neighbors. So who am I to begrudge some of these sustainable approaches that can produce cheap meat sustainably, you know, with better human health and environmental impacts. If we can't all necessarily go to craft meats, what is the solution for middle and low income

meat eater? And he's interested in this as a potential solution for sort of the mass-produced meats not necessarily as an alternative to craft meats but, you know --

Twilight Greenaway: Yeah, I think that's my prediction is that ultimately this is gonna be what's in our fast food. It's not necessarily gonna be the -- I think there will always be a grass fed steak available to the elites.

Amanda Little: And that's what I think the folks who are in this area are saying too. I mean they don't see this completely offsetting. I think actually Pat Brown of Impossible Foods has said there will be no animal derived meat by 2035 or something he's made some pretty dramatic claims that I don't --

Greg Dalton: That's his wish.

Amanda Little: That's right. I don't know that that is shared by everyone in the alternative meat industry but it is pretty extraordinary how far things have come. I mean to see the Impossible Foods product now adopted in Burger Kings and White Castles and Shake Shacks and so on when three, four years ago people are saying, will mainstream consumers go for the veggie burger that bleeds with synthetic animal blood this seems so far-fetched. The fact that we're seeing these ideas that had seemed far-fetched, you know, get embraced and adopted pretty rapidly is surprising to me. Again, exactly what the benefits are and how these industries are managed is another question.

Greg Dalton: Amanda Little, you mentioned kind of the small iconic American rancher. If meat is produced in a laboratory owned by a large corporation that is serving institutional shareholders, doesn't that just wipe out the, you know, small-scale cattle rancher. Consolidate power, economic power in the industry.

Amanda Little: I don't think so. I think as Twilight was saying they're different products. And so what is --

Greg Dalton: But if this is aimed towards the mass-market fast food and yes the people on the coast can have their grass fed burgers, grass fed beef, if they just continue to eat meat which is questionable in a hot world. But isn't that just gonna consolidate power when cargo can have its own factories they don't need ranchers when they own the factories producing this meat.

Amanda Little: Yeah, and I think it's creating a lot of concern for stakeholders in those conventional meat industries. I will say that a month after I reported in Bloomberg on Tyson's decision to get into alternative meats, Tom Hayes, the CEO resigned. And I'm not saying that it was because of that piece but, you know, it's a tough time the meat industry has been going through all kinds of price instability related to tariffs and other things. But it's a tough time to be talking about self-disruption in an industry that's been sort of bit volatile. So, yeah and I think that there's a lot of concern about how it's managed and what it means to control the, you know, have ownership over cells that are grown and all the stuff. I mean it's if there are many, many unanswered questions and risks and, you know, the way that the oversight and the way in which you know, environmental activists and policymakers, you know, shepherd the growth of these industries and make sure that we do this in the right way is essential. But, yeah, there are big questions.

Greg Dalton: And Twilight Greenaway, do we even know the lifecycle analysis of lab meat? Is it really less greenhouse gases to produce, you know, fake meat than real meat?

Twilight Greenaway: Great question. I haven't seen that yet and I don't think it's out. I mean we do have some lifecycle analysis for plant-based meat. There's been a lot of discussion around that

lately. There's also been some new lifecycle analysis around pasture that's come out in the last few weeks. They're both from the same third-party organization, Kwantas [ph], I think it's called, neither are peer-reviewed. So there's a lot of fast talk at this moment but I'm glad you brought up ownership because I feel like, you know, there are a lot of great things about your book and one of the questions that kept coming up for me was about the role of technology and what that technology ultimately does. Is it gonna feed the system that we have which is very top-down, you know, a few companies own the bulk of it, you know, whether we're talking seeds whether we're talking pesticides, whether we're talking meat. And so many of these startups their goal is to sell to these big companies as you mentioned with Blue River for instance. But I think it's fairly common that that's the business model. So are they feeding into the system that is extremely top-down or will there be technology that comes along. And I do think there probably is some now, but will there be some that really can feed into a more democratic food system that allows for different types of ownership less concentrated ownership that's my big question.

Greg Dalton: You're listening to a Climate One conversation about the future of food in a hotter, drier, more crowded world. Coming up, we'll hear about expanding the meaning of agriculture and farming.

Amanda Little: A lot of the people working in the ag space are not hands in the dirt people, you know, there are IT folks, there are mechanical engineers, electrical engineers. There's a much broader definition and that's both exciting and concerning.

Greg Dalton: That's up next, when Climate One continues.

Greg Dalton: You're listening to Climate One. I'm Greg Dalton, and we're talking about feeding a hot, dry, and crowded planet with Amanda Little, professor of journalism at Vanderbilt University and author of the new book, *The Fate of Food*. And Twilight Greenaway, contributing editor with *Civil Eats*. I asked Amanda to follow up on what Twilight had mentioned about Blue River Technology.

Amanda Little: Okay. Blue River Technology is a company based in Sunnyvale, California and it's, you know, a block from Yahoo. It's an AI robotic company that has developed a way of deploying herbicide with sniper-like precision so that this sort of system of cameras attached to the back of a tractor can identify and distinguish between crops and weeds. When the weeds are very young can deploy a concentrated fertilizer or herbicide kill the weed, protect the crop keep the chemicals off the crop as an alternative to broadcast spraying which we've seen with roundup ready and so on. There's huge amounts of herbicides that are saturating crops and creating all kinds of concern about the public health impacts of those chemicals. It's a really exciting technology in part because, you know, this maiden voyage of the early tests of these robots they've seen 90% reduction in herbicide applications on the fields in which they are used. They also hope to apply this to fungicide, insecticides and eventually fertilizers. And what it means is plant by plant farming rather than field by field farming. So, potentially bringing in, you know, intercropping and more diversity into fields when the intelligent machines can manage the, you know, the plants individually, you can potentially move beyond monocropping. So all this is great, it's elevating the principles of sustainable farming and bringing them into, you know, a large-scale food production it would all be great. I think it was last September, Blue River I think three or four years into its existence and was sold to John Deere for 305 million. And the CEO, I remember was in the midst of reporting the story and I talked to Jorge Heraud who's the CEO and I said, what you're selling to John Deere, you know, one of the

oldest brands in ag, this is, you know, part of this trend that's so concerning to so many of us. And he basically said we need to scale we need to get these machines into the field we need to produce them and not really, you know, sound and reliable way. This can get, you know, our robots into 10,000 distributors globally like this needs to happen. And the result is disruption of ag chemicals and the ag chemical industries. And so we need the scale we need the sort of good guys and bad guys to collaborate, right. It doesn't mean that that is disrupting the, you know, the rise of local food webs and farmers markets and CSAs and locally sourced foods. It means maybe this is a way of bringing more intelligent practices to industrial ag. So I don't know that they're necessarily at odds with each other that improving practices in industrial agriculture inherently threatens the growth, you know, the diversity the diversification that's happening in local food webs. But it's again really concerning because if you have very expensive intelligent robots on farms that farmers don't know how to fix that, you know, can breakdown that can be hacked --

Twilight Greenaway: Or aren't allowed to fix.

Amanda Little: And maybe aren't allowed to fix, right. So yeah, it's again this interesting challenge of sort of risk benefit risk benefit but certainly, you know, the potential benefit of bringing inter-cropping to in a large scale agriculture is I think important enough that for me was exciting to get inside there, see how it worked what, you know, what it could become. Again, it has to be tightly, you know, regulated and observed and that's, you know, a discussion that needs to happen.

Greg Dalton: And you write about See & Spray and other robotic weedkiller, potato which is thinning lettuce to allow certain, the stronger lettuce thrive and survive and killing the weaker lettuce. In your chapter called Robo-crop, Twilight, let's have your take on robots on the farm whether that's going, you know, kind of robots are gonna kill monoculture or they're gonna do something else?

Twilight Greenaway: Well, I mean we're moving towards automation in so many ways culturally. And I do think that it's happening in food, absolutely. I mean, I'm seeing it, we're seeing it and it's really right there on the horizon. But I mean it's already the \$250,000 John Deere that I wrote in a combine a year and a half ago I got to sit there in an air-conditioned space and the farmer let me drive it just around the corner and into the this giant parking space he built in a barn and, you know, he could watch a sitcom while he runs through the field and it's a very different experience I think than what most people will think of as farming. So I do think there's already been a fair amount of technology, you know, in play.

Greg Dalton: Is that sad, is that a loss for you?

Twilight Greenaway: I think it's complicated. I mean I don't think that I'm as diametrically opposed to Amanda's take as it may seem. I think that I mean you brought up diversity and I think. So rural communities are already emptying out they've already been emptying out. And that technology has played a serious role in that and will continue to and that has been a big focus of mine recently is trying to figure out like what would it take to bring more people back to these places. And when I went to Iowa and spent time with a really wonderful innovator named Sarah Carlson who's working with farmers conventional and organic all across the Iowa landscape to bring about diversity as she put it, just to give people permission to plant other things. Because in this part of the country as I'm sure you know corn and soy is it. And there are a lot of farms that are corn and corn and corn they've even cut out the idea of a two crop rotation. And so spending time with her was very enlightening for me as a Bay Area, you know, food world person. And she at one point when we met the first time she really leaned over and was like this is really about bringing people back like this is my community. She talked to me about how her high school had consolidated with another high school when she was younger and how the hospitals in her area had

consolidated or shut down. How there is this whole world there that's changed for the worse for the most part. And diversity as she sees that and I was pretty convinced by the end of my time with her bringing back diversity to crops and bringing animals onto farms and bringing cover crops and small grains and essentially shifting the marketplace so that we don't just get corn from one place, oats from -- now oats are in Canada, if we can bring oats back to Iowa for instance, it would be huge because you could get a three crop rotation going. It would actually require a little more labor which might bring back a second generation of farmers. So I'm interested in solutions like that as much as I am interested in technology.

Greg Dalton: And Amanda Little, you write in there with 2% of people in America are involved in producing food from land there needs to be more, you know, is the industrialization and introduction of robots gonna bring more people back to producing food or is that gonna reduce the number of people producing food?

Amanda Little: Well, great question. I mean the definition of farmer is definitely expanding. A lot of the people working in the ag space are not hands in the dirt people, you know, there are IT folks there are mechanical engineers, electrical engineers. There's a much broader definition and that's both exciting and concerning it certainly exciting to a lot of young people that I interviewed who are coming into the ag space because they're interested in, you know, engineering and whatever it is, drone, sensors, smart farms all these things that are, you know, post organic or have great potential benefits to human health and the environment, but it's not hands in the dirt. I don't think though, I think that there's going to be so much demand from all of us who continue to want to support local farms who continue to want to, you know, see diversity in farm scape that were not going to all go to this sci-fi future of robots farming food. I think that there is a double whammy challenge. One is to address and redress all the problems of existing industrial agriculture and there are so many. The second challenge is to begin to prepare for and maybe even preempt, a lot of the population and environmental pressures that are coming down the line. So, you know, the IPCC, the International Panel on Climate Change has predicted that we'll see a 2% to 6% decline in global crop yields every decade going forward because of climate pressures. We also hear from, you know, the U.N. that we're going to 9.5 billion people by midcentury, right. So that paradox of increasing demand and declining supply presents a real problem. Some of these solutions can potentially do both can help, you know, redress the existing problems of industrial agriculture make it smarter and better and more nimble and while also sort of beginning to sort of prepare for some of these increasing climate pressures. But I don't think that it's sort of one or the other it's like, are we gonna do sustainable local organic small-scale agriculture or are we gonna do is it all gonna be robots and, you know, industrial food production. It's got to be both and to present it as sort of one of the other I think is misleading and I think we totally agree on that.

Greg Dalton: If you're just joining us we're talking about the future of food with two authors Amanda Little and Twilight Greenaway from Civil Eats. I'm Greg Dalton. About a decade ago, fruit breeders in Florida noticed that the state's peach crops were not on schedule. They looked into historical data since the 1970s and founded some peach varieties were blooming earlier and earlier others later and later. The culprit, climate change, Jose Chaparro is a professor of Horticultural Sciences at the University of Florida in Gainesville he's in charge of their fruit tree breeding program. We spoke to him about the approach they took to hedge their bets against future climate fluctuations.

Jose Chaparro: What we have noticed is that our highest chill peaches the varieties that require in excess of 350 chill hours were blooming later and that we were having problems having a consistent yields. And that the lower chill varieties, varieties that only required 150 chill hours what would be considered to be a subtropical peach were actually blooming earlier and earlier. In terms of breeding what we have decided to do is that we've decided to straddle the chilling requirement of

North Central Florida. And we've established two satellite programs one in Attapulugus, Georgia three hours northwest in Gainesville. And then we've established a satellite program in Fort Pierce where we barely get 75 chill hours with the idea that regardless of where the trends had long term we're selecting germplasm that's divergent and capable of adaptation to different zones. Maybe the optimal location will no longer be in Florida it'll be in Georgia or maybe the coastal plain of North Carolina. But there would be other crops like citrus that will expand north maybe avocado production in Florida. So there will be opportunities other people in other regions of the world are gonna need improved high-yielding varieties in order to have viable agriculture. We have to focus we have to select for adaptation we have to take advantage of the genetic diversity that exists in nature and just forge ahead.

Greg Dalton: That's Jose Chaparro professor of Horticultural Sciences at the University of Florida in Gainesville. Twilight Greenaway, there's a couple of things in there. One is hedging bets, you know, may be Florida may be Georgia maybe North Carolina, which again gets the kind of the scale you have to have some scale and money to do that. And the other part of that is just the adaptation well, if we can't grow this, we can't grow oranges we'll grow avocados. So talk to me about the resilience and adaptation part that that professor is getting to.

Twilight Greenaway: Well, I think I mentioned to you when we spoke earlier that I grew up on a farm and my mother who still farms in Hawaii is seeing a lot of what he's talking about there.

Greg Dalton: It's a coffee farm.

Twilight Greenaway: It's a coffee farm but she's also seen all kinds of fruit trees that she planted when she first moved to the property 25 years ago, making fruit that like mangoes and coconuts that were coastal much lower elevation fruit suddenly it's showing up. She sort of planted them on the wind and now they're fruiting. So that's happened within my lifetime and I feel like it's a pretty clear message that things are moving fast.

Amanda Little: Yeah some of what Chaparro and other agronomists are looking at is how you think about reading plants with resilience so they can continue to grow in the regions where they have grown for so long, right. So, some of his researches adapting peach and citrus plants to survive the new normal as he said, right. So can we continue having the same peaches we know and love but with, you know, new properties like drought tolerance, you know, insect resistance for migrating insect populations. Heat tolerance, frost tolerance and you know, and this is one of the areas of focus on breeding. I interviewed a farmer in a very different region, Wisconsin actually, cherry farmers and apple farmers in the Midwest have been dealing with seasonal shifts that have been causing all kinds of premature blooming and then what they called total kill events where a frost will come in April or May at a normal time the tree will have fully fruited. And then in this case of this one farmer who has about 300 acres of apple trees he had total kill. So he lost more than a million dollars in harvest in two hours of freeze over one night in early May. And he had then began to install frost fans which are these fans that bring warm layers of air down into, you know, from above into the sort of lower areas where the trees are growing which was, you know, many tens of thousands of dollars of investment. There were some farmers who are bringing in helicopters to push down this layer of warm air to try to protect these trees from freeze.

Greg Dalton: What's the carbon impact of all that.

Amanda Little: Exactly, right I know. It's like we're trying to mix up this atmosphere in order to deal with these major atmospheric shifts. And it was, you know, totally chilling, pun intended, to see what is happening on the ground, you know, these adaptation efforts. You can't pick up and move a tree that's been in the ground for 10, 20 years you know it's very hard to say let's just shift north or,

you know, shift the region. I mean it's hanging on to this multigenerational farm and don't want to start growing avocados or whatever. So part of it is how do you sort of address the breeding challenges of building resilience into the plants and part of it is do we see the regions where plants are grown shifting. And this is particularly true, I mean I researched this in areas of Western Africa where they're you know, having really serious difficulty growing some indigenous crops because of climate environmental pressures and again some of the scientists there are basically saying we want to continue growing heirloom and indigenous crops, but we have to use modern technologies to find ways to build resilience into these crops. So again, it was sort of confounding some of these questions about what's local and traditional and indigenous and what's survivable in that climate era.

Greg Dalton: You're listening to a Climate One conversation about food and agriculture technology in a warmer world. Coming up, we'll hear more about the people working in the fields.

Twilight Greenaway: It's a deep irony that the folks who are growing our food face some of the biggest risks related to climate change, you know, heat stress and other illnesses caused by long-term exposure to heat.

Greg Dalton: That's up next, when Climate One continues.

Greg Dalton: This is Climate One. I'm Greg Dalton. We're talking about the future of food with Amanda Little, professor of journalism at Vanderbilt University and author of the new book, *The Fate of Food*. And Twilight Greenaway, contributing editor with *Civil Eats*. Amidst the stories about the technology and business of food, Twilight writes about the people who produce it - including Victor Gutierrez, a 30-year-old farmworker in the Central Valley of California.

Twilight Greenaway: I worked on an unfortunate story recently about soil borne illness called Valley fever that's been around in California and in the Southwest for over hundred years. But the increase in dust storms climate field dust storms it's gone up something like 240% in the Southwest. And what that means is everyone in the Southwest is at increased risk for this soil borne, it's a fungus that once it gets into your lungs if you have a really healthy immune system, most people can fight it off or it might turn into a cold or a flu. But anyone who's all immune compromised is at risk really. And in fact sometimes people who aren't even particularly immune compromised seem to get it. So I wrote about Victor Gutierrez and a few other farmworkers and farmworker advocates who are really facing the problem head-on because they face all different kinds of other challenges that can impact the immune system from living. And food deserts, ironically, the Central Valley is really significant food desert to lack of clean water, but also very tight agriculture due to nitrogen use and stress and other factors essentially as I came to see it over the course of researching this piece. Put farmworkers at greater risk as do the fact that they have less access to healthcare the fact that they're often living in poverty. So it's a deep irony that the folks who are growing our food face some of the biggest risks related to climate change, not just Valley fever but also heat stress and other illnesses caused by like long-term exposure to heat.

Greg Dalton: It's a big deal. Back in 2011, you wrote that the estimated health costs in California have more than \$2 billion to treat Valley fever. So this is big money and something that is climate related and often not recognizes the climate impact but that's a lot of money. Want to talk also

about carbon farming. We'd be remiss, we haven't talked a lot about soil yet so far carbon farming the idea that they're gonna put carbon back in the soil we basically last couple hundred years we've taken carbon out of the ground, burned it, smoked it, put it up in the air. Now the idea is to put it back in the form of plants and roots, stored it in the soil. So either one of you can tell me about carbon farming as one of the real bright spots potentially if it can scale in the climate equation. Amanda Little.

Amanda Little: One of the many areas of carbon farming that I looked at or I'm particularly interested in is no telling how --

Greg Dalton: No-till agriculture.

Amanda Little: No-till agriculture. So the idea is that instead of plowing up the soil every season you're leaving the crops in the ground you're actually letting the agricultural remnants of that crop decompose back into the soil creates sort of a carpet on top of the soil. Planting right into that carpet of old, you know, crop matter and keeping the soil intact. And all of the wonderful the microbiome in that soil and the insects and so forth in that soil intact. The challenge has been that it's very herbicide intensive because you get a lot weeds that like to grow up in the no-till zone. And actually this is one of the interests for the AI robotics folks that if we can be very targeted in the way that herbicides are used to address the weed problems and no-till farming it could really dramatically expand the use of no-till across the board. It's pretty amazing how little expansion there has been of no-till given how much of an advantage it is from a carbon sequestration sampling but also irrigation. Because the tilling brings so much moisture out of the soil it's really more and more costly for farmers to replenish that moisture so it saves quite a bit of money from a water standpoint, irrigation standpoint and again from a soil health standpoint and, you know, fertilizer input standpoint. But it's not growing very quickly because it doesn't, you know, the look is nice it's just a departure from for a lot of farmers from the way they've been doing things. But to find ways of incentivizing no-till of helping to grow that particular practice among other carbon sequestration practices is a hugely important area of focus. And if we can do it in ways that are much less herbicide intensive then it's a no-brainer.

Greg Dalton: Twilight Greenaway, North Face has sold like Cali wool beanie that they said was climate beneficial. So the idea that this can actually help the climate. So tell us about some of the, you know, climate beneficial or carbon farming as well as efforts in California on healthy soils.

Twilight Greenaway: Sure. I mean I also spent some time with some no-till guys. I went to a conference where there were hundreds of no-till guys. And when they do it concert with other practices, I do think they are often able to bring down the pesticide use as well when they do it in this kind of regenerative way that brings animals and that brings cover crops. But California has definitely been a leader and it's exciting because there are 39 other states, California has a healthy soil initiative. They've recently just stop the funding for fairly dramatically and there are 39 other states where there are healthy soil initiatives coming up. So that is for me a really significant positive step. In terms of the beanie the wool, I worked on a story about an effort to recognize certain practices on farms in California. And there's an effort to bring particularly people who are doing fiber related farming and in livestock that way, but also meat and dairy. And to really reward them and fund certain efforts like for instance, I know you've had the Marin Carbon Project as well but bring compost a thin layer across some of this agricultural land whether it's for grazing or otherwise has been shown to be able to really make a significant difference in terms of carbon drawdown into the soil. So that's encouraging but there really hasn't been enough money put into it yet and that is what I found when I wrote about it. They keep bumping it up, Gavin Newsom, I think the most recent number I saw might have been 24 million, don't quote me on that, but it's --

Greg Dalton: Lot of money but still small potatoes.

Twilight Greenaway: It's a drop in the bucket because, you know, that's a few farms a few loads of compost like it goes really fast. So what really in theory what needs to happen is a much larger scale.

Greg Dalton: Amanda Little, I wanna ask about some foods that we don't hear a lot about that we may be learning more about in the future as we go into a world of, you know, hot world of 9 billion people. So Kernza, you've written about is it moringa which can, you know, sometimes called famine food. There's cassava perennials that have all sorts of attributes that can be good sources of carbohydrates. I think most people haven't heard about cassava, moringa or Kernza. So tell us about some of these foods that might be coming, a bigger role in the future.

Amanda Little: Yeah. So the book is a sort of five-year adventure into the lands and mines and machines working on the future of food. Some of that is very high-tech and some of it is, you know, some of those efforts are really focused on restoring ancient practices and traditional practices of farming. And I looked at edible insects which are consumed in many cultures today and have been for thousands of years. And ancient plants and what we can learn from them and the research that's going into bringing some very nutrient dense ancient plants back online. That chapter starts out in Mexico with a farmer who is researching moringa you probably have heard about moringa because it has a lot of traction in health-food circles and has incredible nutrient properties and it's very drought resilient. The tree is almost sort of Dr. Seussian in its many, you know, benefits and sort of capabilities both nutritionally and environmentally. But it hasn't really been picked up in sort of modern food circles beyond in a very kind of specific niche area. So this scientist is working on making it easier to grow this food making it easier to harvest it and sort of expanding the access to moringa particularly in dry tropical regions where the plant, you know, was native to equatorial nations. And so it's an interesting area of focus. Kernza is another area where a plant that has very, very deep roots that's able to has inherent drought resilience because it's able to tap water supply very deep in the soil. Again, it's not as productive as modern wheat by a longshot so a lot of the breeding research is going into how can we bring sort of the drought resilience properties of this plant, you know, online in a bigger way by making it easier to produce. I think it's a quarter or a third of the actual sort of productivity of modern wheat. But again has so many useful and important sort of attributes that it's very relevant to the discussion of climate resilient food sources. Quinoa is another ancient plant that's there's a lot of interesting research around how to make that adaptable to new environments for farming. But, you know, even the algae and duckweeds they're all these kinds of interesting areas of focus right now. How much of it will really become accessible to, you know, broader populations. Will we be able to feed more people with less food because it's more nutrient dense? Really interesting and important questions. Again, it's really sort of research stage right now but helps sort of inform the bigger conversation.

Greg Dalton: Want to go to our lightning round and ask you some quick questions. I'm gonna mention a food and ask you, say the first thing that comes to your mind with -- unfiltered, the first thing that comes to your mind. So Twilight Greenaway. Tofu.

Twilight Greenaway: I mean tofu has had this kind of interesting history. I think people have really strong feelings about it either way.

Greg Dalton: One word or phrase. Okay. Amanda Little. GMO corn.

Amanda Little: Yes. It is necessary on some level if it has the right genes.

Greg Dalton: Twilight Greenaway. Almond milk.

Twilight Greenaway: Water intensive but not as much as dairy.

Greg Dalton: Amanda Little. Your favorite food cooked by your mother or father.

Amanda Little: Four-cheese lasagna.

Greg Dalton: Twilight Greenaway. Your least favorite food cooked by your mother or father.

Twilight Greenaway: Steamed vegetables and brown rice.

Greg Dalton: Also Twilight Greenaway. Your guilty food pleasure.

Twilight Greenaway: Lamb. I love it. I eat it about once a month because I know the carbon impact.

Greg Dalton: Amanda Little. Your least favorite cuisine.

Amanda Little: I love it all. I really don't -- there's no food I don't love.

Greg Dalton: The answer of a food writer. Twilight Greenaway. Your favorite cuisine.

Twilight Greenaway: California.

Greg Dalton: Amanda Little. Your food habit you'd most like to change.

Amanda Little: Meat consumption. I have a very fraught love affair with meat. I have tried to be a vegan and a vegetarian in every version of that and I keep going back to the barbecue.

Greg Dalton: Confessions of a barbecue lover. Okay. Twilight Greenaway. Your food habit you'd most like to change.

Twilight Greenaway: Going to Costco.

Greg Dalton: Alright let's give them a round of applause for getting through the big --

[Applause]

Amanda Little, before we wrap up I wanna mention 3D printing of food, perhaps for military rations. I mean just explain to us is this where we're going, you know, 3D printing of food?

Amanda Little: The short version is at the Natick Research Laboratory in Massachusetts there are researchers developing or adapting 3D printers to deposit pastes of food, food paste it could be chickpea paste or an avocado paste or sort of nut butter or something else into a nugget or a bar that is also mixed with specialized nutrients that can be, you know, specific to the needs of a particular soldier. And this they know from sensors that are testing the sweat and blood of the soldiers sending this information wirelessly to the 3D printer which then makes the bar or nugget of food with that certain cocktail concoction of nutrients that the soldier needs. That is printed out, it's given to, you know, a drone and then it's delivered into the field of combat and there is the personalized food nugget. And so that seem to me to be in sort of the category of like post food future that was very hard for me to imagine in happening again I'm a nostalgic eater, you know, like I have done tried out soylent and tried my hand at adult baby formulas that are available on the market. But I much prefer my mom's rib sticking four-cheese lasagna. Food is a proxy for love, for a lot of us. This is how, you know, I relate to this topic I'm not a great cook, I'm not a farmer but I care about this issue as we all do. And we don't want to see our traditions and our sort of the rituals

around food destroyed and something like 3D printing, you know, sort of like, etc., feels like a threat to that. The argument from many of the soldiers and scientists at the research laboratory was hey, this is a lot better than an MRE, you know, this is actually much, it's fresher it's more nutrient dense, and it's gonna be preferable to most of the soldiers in the field. And it was interesting watching this 3D printer named Foodini try to print out a hummus flatbread with an avocado army star squirted on top of it. And the thing kept sort of malfunctioning and getting like clogs and trying to sort of purge the clogs and I mean it was like watching a toddler learn how to, you know, how to make sense of anything really there's like learning along the way. And you know, again it feels very strange, and impossible to imagine that this is all a reality. It is, you know, at least in the laboratories in the case of the 3D printed food. But what I would like to say with that question about, you know, history and sort of the context is it technology or not technology when we think about the future of food. You know, historically over millennia since essentially the first, you know, farms, you know came to be what was it 10,000 BC something around there. And the first plow was developed in, you know, roughly 6000 or 7000 BC. This has been a story of, you know, tools and techniques and new, you know, implemented technologies along the way. This is not a new story it's an old story. We have been, you know, the narrative of running out of food, we can't feed humanity, is thousands of years old. And in part the way we've moved through that story, and moved through that process is by applying new tools and techniques and good judgment. So as we move through this phase I think, you know, this notion that it's either we reinvent food or we de-invent food that we, you know, restore the past or we hurdle into the future is sort of a story of false opposite. It's gonna be both, you know, we have to move forward seeing how we've misapply technology in the past. And you know, that may or may not involve 3D printed avocado flatbread, I hope not, but I know that a lot of what I end up eating out of a plastic clamshell is not very high nutrient or good for me or the environment. So there's a lot to fix, but for the most part I'm very hopeful.

Greg Dalton: We've been talking about the future of food in a hot and crowded world with Twilight Greenaway, contributing editor with *Civil Eats*, an online source of news about food, health and environment. And Amanda Little, professor of journalism at Vanderbilt University and author of *The Fate of Food: What We'll Eat in a Bigger, Hotter, Smarter World*.

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Greg Dalton: Kelli Pennington directs our audience engagement. Tyler Reed is our producer. Sara-Katherine Coxon is the strategy and content manager. The audio engineers are Mark Kirchner, Justin Norton, and Arnav Gupta. Devon Strolovitch edited the program. Dr. Gloria Duffy is CEO of The Commonwealth Club of California, where our program originates. [pause] I'm Greg Dalton.