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1. Desertification is turning the Earth barren – but a solution is still within reach

David R Montgomery, Professor of geomorphology at the University of Washington, and author of Dirt: The Erosion of Civilizations and Growing a Revolution: Bringing Our Soil Back to Life. Source: Guardian International Edition, 2 Sep 2021

This summer's record-setting heatwaves and dramatic fires in southern Europe and the American west were stark reminders that the climate crisis has arrived. But as the world warms, there is also a quieter, lesser-known crisis unfolding underfoot. Desertification, long seen primarily as a threat to developing nations, is coming for Europe and North America too, as worsening droughts bake soils already degraded by conventional farming and grazing practices.

In Spain, for example, about a fifth of all land is now at high risk of desertification, as is much of the agricultural land across Italy, Greece, and western North America.

Desertification is a process that turns fertile farms into barren land through the interacting effects of human activity and climate extremes. Soil degradation is the diminishment of a soil's capacity to support crops and livestock, either because of the erosion of fertile topsoil or the loss of water-holding, nutrient-rich soil organic matter and the life it supports. Semi-arid grasslands like the Sahel and western plains of North America are most vulnerable because loss of drought tolerant native vegetation can trigger rapid soil degradation and loss of agricultural productivity.

A changing climate, however, is not the only cause behind desertification. How we treat the land – how we farm and ranch – matters too. Healthy, life-filled soils better retain the moisture that falls on farmers' fields.

Desertification is a growing problem. A 2018 report by EU auditors found that an area twice the size of Portugal had fallen into high risk of desertification in the preceding decade, in Europe alone. In recent decades 13 EU states declared themselves affected as the

Mediterranean region experienced a significant expansion of drylands – regions with low rainfall. Soil degradation is estimated to cost the EU tens of billions of euros a year, and yet, how farmers treat their soil remains essentially unregulated in regard to soil health on both sides of the Atlantic.

The threat of desertification and land degradation will increase as the climate crisis progresses. A 2018 report found that land degradation already affects the wellbeing of at least 3.2 billion people – more than a third of humanity. Between 1982 and 2015 unsustainable land-use practices already desertified 6% of the world's drylands. Globally, the area of drylands is projected to increase by up to 23% this century.

Rising temperatures are already predicted to reduce yields of staple crops such as wheat, rice, maize and soya beans, by 3-7 % for each 1°C increase. In Washington state, for example, wheat yields are down this year by about half due to a devastating drought. Madagascar is now facing a climate change-induced famine.

But it's not just droughts driving the problem. Farming practices that degrade the soil reduce the resilience of crops as worsening conditions affect harvests. Drylands in particular are sensitive to degradation from both tillage and overgrazing. If it continues, soil degradation will further increase the threat to agricultural production in regions that humanity depends on for food.

Looking back through history, it's clear that desertification and soil degradation are not new problems. Since the arrival of agriculture humanity has degraded as much as a third of the world's potential farmland. This pattern reflects both a long history of tillage-induced erosion and more recent adoption of modern farming practices that deplete soil organic matter and disrupt soil ecosystems. Unfortunately, we are repeating the problem on a global scale.

Now-conventional farming and ranching practices that degrade the soil leave farmers around the world increasingly reliant on huge amounts of chemical fertilisers and pesticides. Declining soil health due to depletion of soil organic matter and soil life is increasingly recognised as a critical problem.

According to a 2015 UN report we are on track to degrade another third of global farmland over the course of the present century. We're leaving the land more fragile and our harvests more vulnerable at the same time climate change is creating unprecedented environmental pressures.

To combat and reverse the growing threat of desertification and land degradation we need to both reduce carbon emissions and change the way we farm. We don't have to relearn the lessons of past societies that degraded their land. But to avoid their fate we need to reorient agriculture around farming and grazing practices that regenerate soil health.

Several years ago, I visited and wrote about farms and ranches around the world that had restored fertility to once-degraded lands. I saw how regenerative farming and grazing based on soil-building practices can reverse soil degradation, rebuild soil health and make farms

resilient to extreme weather – while maintaining good harvests. But it requires replacing conventional farming practices dependent on intensive tillage and massive chemical fertiliser use with practices that put soil health first.

In addition to intensive efforts to reduce fossil fuel-derived carbon emissions, we need a sustained global drive to rebuild the health of the world's agricultural soils. Fortunately, the latter can help with the former. Farming practices that build healthy soil convert carbon dioxide captured from the atmosphere into soil organic matter. While the potential of storing carbon in the soil remains hotly debated, even low-end estimates would help slow climate change.

The soil is the foundation for life on Earth. As we face a century of increasingly volatile weather and a growing population, we need it in its best shape to sustain us. Humanity must get serious about our collective intergenerational responsibility to preserve the health and fertility of our land – wherever we live.

2. One in three trees face extinction in wild, says new report

Extracts from report by Helen Briggs, BBC Science and environment correspondent, August 2021

At least 30% of the world's tree species face extinction in the wild, according to a new assessment. They range from well-known oaks and magnolias to tropical timber trees. Experts say 17,500 tree species are at risk - twice the number of threatened mammals, birds, amphibians and reptiles combined.

Conservation groups are calling for urgent protection efforts amid threats such as deforestation, logging and climate change. "We have nearly 60,000 tree species on the planet, and for the first time we now know which of these species are in need of conservation action, what are the greatest threats to them and where they are," said Dr Malin Rivers of the charity Botanic Gardens Conservation International in Kew, London.

- Half of Amazon trees 'face extinction'
- Madagascar palms 'are dying out'
- Ash tree set for extinction in Europe

For a healthy world, we need tree species diversity, added Sara Oldfield, co-chair of the Global Tree Specialist Group of the International Union for the Conservation of Nature. "Each tree species has a unique ecological role to play," she said. "With 30% of the world's tree species threatened with extinction, we need to urgently scale-up conservation action." The report, State of the World's Trees, found that at least 30% of the 60,000 known tree species face extinction.

Some 142 species have already vanished from the wild, while 442 are on the very edge of extinction, with fewer than 50 individual trees remaining. The biggest threats to trees

globally are forest clearance for crops (impacting 29% of species), logging (27%), clearance for livestock grazing or farming (14%), clearance for development (13%) and fire (13%). Climate change, extreme weather and sea level rise are growing threats to trees. But the authors say with conservation action, there is hope for the future.

The experts are calling for a number of actions, including:

- Preserving existing forests and expanding protected areas (currently at least 64% of all tree species can be found in at least one protected area)
- Keeping threatened species in botanic gardens or seed banks in the hope they can one day be returned to the wild (currently about 30% of all trees are backed up in this way)
- Providing education to ensure reforestation and tree planting schemes are carried out scientifically, with the right tree in the right place, including rare and threatened species
- Increasing funding for tree conservation.

Scientists estimate that one million animals and plant species are threatened with extinction. Over the past 300 years, global forest area has decreased by about 40% and 29 countries have lost more than 90% of their forest cover. Research shows that seven main commodities drive more than half of deforestation worldwide.

Trees at particular risk of extinction include:

- Large tropical trees known as dipterocarps that are being lost due to the expansion of palm oil plantations
- Oak trees lost to farming and development in parts of Mexico, Chile and Argentina
- Ebony and rosewood trees being felled for timber in Madagascar
- Magnolia trees at threat from unsustainable plant collecting
- Trees such as ash that are dying from pests and diseases in the UK and North America

3. Agrivoltaics – Three Dual Land Use Examples





Dubbo farmer Tom Warren says sheep and solar panels can co-exist to the great benefit the landowner.

4. Making Milk by Fermentation (New Scientist, August 2021)

BACK IN 2014, bioengineer Ryan Pandya had a demoralising encounter with a bagel. It wasn't so much the bagel itself as its filling, a "bland and runny" substance made from soya which was supposed to resemble cream cheese. Pandya was a recent convert to veganism and was struggling to give up dairy products. But when life dealt him bad cream cheese, he made ice cream.

Today, Pandya's company Perfect Day is at the vanguard of a food revolution. It makes and sells milk, but has no cows. Its farm is a bioreactor in which it cultivates microorganisms genetically engineered to secrete milk proteins. The proteins don't resemble milk – they are milk, identical to the real thing. Perfect Day hasn't quite cracked cream cheese yet, but has arguably gone one better: ice cream. It is the only such milk company to get a product on the market so far, but won't be the last.

The past couple of years have been an absolute beanfeast for people like Pandya who want to give up animal products but also don't want to give them up. Plant-based burgers from companies such as Impossible Foods and Beyond Meat have proved that vegan "meat" can get pretty close to the real thing. Cultured meat – actual muscle tissue grown from stem cells – is being served in high-end restaurants and is inching closer to the mass market.

But between these two extremes, a third revolution has quietly been brewing. Quite literally. It is called "precision fermentation", which means using genetically engineered microorganisms to produce animal products. Milk is where most of the action is right now, but is by no means all there is on the menu: think of an animal product that isn't meat, and somebody somewhere is working on brewing it up.

Of course, microbial fermentation is hardly a new food technology. Bread, cheese, yogurt, beer and wine were all invented millennia ago, and derive much of their taste and texture from the waste products of yeasts and bacteria eating their raw materials. Ditto sauerkraut, kimchi, miso, kombucha, tempeh and more.

In 1990, these traditional ferments were joined by a new technology, when the US Food and Drug Administration (FDA) approved genetically engineered chymosin, aka rennet, for making cheese. This enzyme curdles the milk protein casein, and was once exclusively harvested from the stomachs of unweaned veal calves. By the 1970s, there was a shortage, so biotech companies raced to use genetic engineering to produce chymosin in bacteria or yeasts. Pfizer won. Today, about 90 per cent of rennet is made by genetically modified microorganisms.

This 1970s technology – clone the gene and stick it into a bacterium or yeast – is still the basis of precision fermentation, but is now coming into its own. "What can we actually make with fermentation?" says Nate Crosser at the alternative proteins investment incubator Blue Horizon in Zurich, Switzerland. "The

answer is, essentially whatever we want. If an animal can make it, it's likely that we can produce at least a relatively faithful facsimile with fermentation." Many companies are busy making good on that promise, developing all manner of animal products such as egg proteins, pet snacks and various additives for cultured or plant-based meat, including fats, collagen and the blood protein heme.

But the real action is happening with milk. According to a report Crosser wrote last year for his former employer, the Good Food Institute (GFI) in San Francisco, about three quarters of precision fermentation companies are working on the white stuff. "There is a real revolution going on here," says biotech investor Jim Mellon, a leading backer of precision fermentation and author of *Moo's Law: An investor's guide to the new agrarian revolution*. Many of the milk companies will follow Perfect Day and get products on the market this year, he predicts.

Precision fermentation is part of a broader industry called cellular agriculture, which is best known for cultured meat and seafood. Firms like Perfect Day are often spoken about in the same breath, but their technologies are actually very different. "Milk is simpler," says Josh Milburn at the University of Sheffield, UK, a philosopher who researches human-animal relations. For meat, the starting point is stem cells extracted from the animal, which are cultured in a growth medium to generate muscle plus sometimes fat and connective tissue. Milk, on the other hand, is just a mixture of biomolecules suspended in water, and hence a lot easier to recreate.

To a first approximation, milk is just six proteins – four caseins and two wheys – plus fats, sugars and minerals, all suspended in water. Right now, most of the fermented

"If an animal can make it, it's likely that we can make it too"

dairy companies are focusing on protein components of milk rather than whole milk. Perfect Day, for example, produces whey proteins in a fungus (*Trichoderma reesei*) for use as a food ingredient. This "non-animal whey protein isolate" is the "dairy" component of three brands of vegan ice cream currently on sale via mail order in the US.

Maile O'Donnell at the GFI has tasted one of them, made by a company called Brave Robot. "I liked it," she says. "Friends who tried also said it really tasted like dairy ice cream in a way plant-based ice creams haven't yet." It is competitively priced at \$5.99 a pint (about half a litre). That is in stark contrast to cultured meat, where a few pieces of chicken can cost as much as a fancy steak dinner.

That is because fermentation is already a mature technology familiar to the food industry, so nobody has to invent new production processes and scale them up. Even better, nobody has to convince regulators that the foods are fit for human consumption, because they are made using microorganisms and processes that are already "generally recognised as safe". When Perfect Day asked the FDA to approve its whey protein in 2020, the agency said yes right away.

Ice cream and beyond

In fact, says Milburn, cultured milk could theoretically be healthier than the real thing. It is produced without antibiotics or hormones and is less likely to be a carrier of food-borne infections. It can be made without lactose, which many people are intolerant to, can feature healthy fats and could be fortified with nutrients. "But this is all quite speculative at the moment," he says.

Ice cream is the only product on the market, but probably won't be for long. Many other leading companies are focused on cheese. Formo in Germany and New Culture in San Francisco are concentrating on pizza toppings.

Formo ferments caseins and whey and then uses standard cheese-making to turn them into mozzarella and ricotta. Like many in the industry, its founders are driven by a desire to replace ethically and environmentally troubling animal products with guilt-free replicas. "In the Western world, the demand for dairy products is kinda limitless," says CEO Raffael Wohlgensinger. Demand is rising in Asia too. All this is putting unsustainable pressure on the environment, but many consumers are loath to give up cheese. "The biggest consumer pain point for flexitarians who want to get rid of animal products is

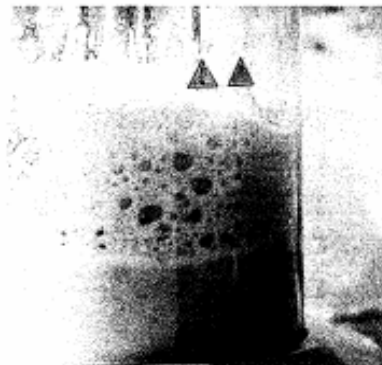
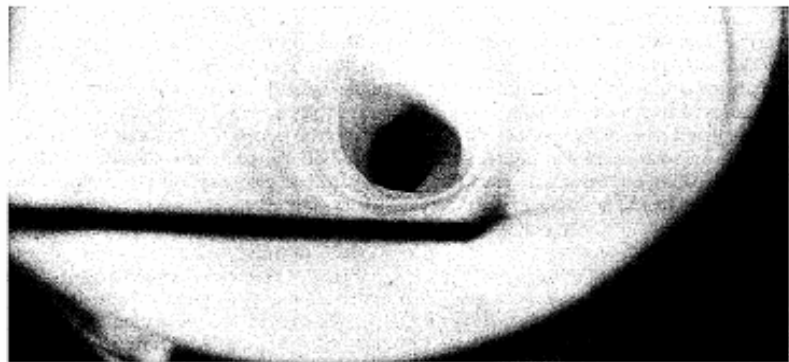
cheese because plant-based products are not performing well," says Wohlgensinger.

Pizza toppings may not be everyone's idea of the full-fat cheese experience, but Formo also has its eyes on a more sophisticated market. "We really develop products for the cheese lovers, this is the market we're going for," says Wohlgensinger. Formo is planning to unveil its prototypes at a tasting event in Berlin later this year, with the food prepared by Ricky Seward, head chef at Michelin-starred vegan restaurant Seven Swans. "We focus on taste and texture. I'm very confident when I look at what we've been able to achieve," says Wohlgensinger.

That, however, is a challenge because these cheeses derive much of their character from the whole milk, not just the protein. That would mean precision fermenting milk fat, which is the product of a complex metabolic pathway rather than a single gene.

Animal-free milk proteins created through precision fermentation are being used to make cheeses

"No one has to convince regulators – these processes are already recognised as safe"



But it is work in progress. "That's a definite technology development that is going on at the moment," says Wohlgensinger.

Gourmet cheeses also trade on a mysterious quality called terroir, which is a distillation of the geography, vegetation and climate where the milk was produced and fermented, plus the skill of the cheese-maker. That will be tough to replicate with bioreactor-created milk.

But such cheeses are a tiny sliver of the market, says Wohlgensinger, and if precision-fermented cheeses only eat into the mass-produced varieties it will be mission accomplished. Some food snobs will never be won over, but they should examine their consciences, says Milburn.

Animal welfare is a major issue in the dairy industry. Despite its carefully cultivated image of rural idyll, dairy farming routinely involves milking cows to exhaustion, repeatedly inseminating them, separating them from their offspring and disposing of male calves that are surplus to requirements. The dairy industry also has cow-sized environmental problems. Producing milk in a live animal is fantastically inefficient and the dairy industry alone is responsible for 4 per cent of our greenhouse gas emissions, according to the UN's Food and Agriculture Organization, which, as Wohlgensinger points out, is more than shipping and aviation combined.

But take the cows out of the equation and these problems vanish. Zero animals – aside from small biopsies to supply stem cells or DNA – means zero animal welfare issues. And a recent estimate by scientists at Duke University in Durham, North Carolina, estimated that the carbon footprint of milk made through fermentation could be as little as 1.2 per cent that of traditional milk production.

"I am very much an advocate of this technology," says Milburn, "primarily because of my concerns about animal rights, but because of environmental impacts as well."

With ice cream on the market and cheese in development, the obvious next place to go is whole milk for drinking or putting in tea and coffee. That is a whole other challenge, however – not because of technological limitations, but because of what have been dubbed the "milk wars". In the EU, for example, the dairy industry has successfully lobbied law-makers to stop plant-based dairy substitutes made from oats and nuts from using the words "milk" and "yogurt". Last year, the European Parliament voted to extend the ban to cover any "evocation" of the concept of dairy, but in May it dropped the plan after lobbying by a coalition of environmental,

consumer and animal welfare groups.

Similar barriers exist in the US, where the FDA defines milk as "the lacteal secretion, practically free from colostrum, obtained by the complete milking of one or more healthy cows". US legislators are currently considering an extension to this definition to include the lacteal secretions of other dairy animals, and also to prohibit the application of the words "milk," "yogurt" and "cheese" to plant-based alternatives. The FDA already designates these alternatives as "nutritionally inferior" and prohibits them from being stocked alongside traditional dairy products.

In the EU and UK, meanwhile, milk is defined as "the normal mammary secretion obtained from one or more milkings without either addition thereto or extraction therefrom". "This definition does exclude the products made via precision fermentation," says Sophie Clarke at trade body Dairy UK.

The dairy industry is right to be running scared, says Mellon. In the past two years, two of the US's biggest dairy companies, Borden Dairy and Dean Foods, have gone bust, in part

Alternative materials

Food isn't the only category of animal product that could be made without animals. Materials such as silk, fur, wool and horn are also brewing. But the first animal-free animal material to reach the market will probably be leather. A company called VitroLabs in San Jose, California, has developed a technique to grow tannable cowhides from stem cells. The process is similar to the one used to make cultured meat, but according to biotech investor Jim Mellon – who has a stake in the company – leather will be easier to bring to market because people aren't expected to eat it. The company has already signed a deal with a luxury goods company and will be going into production soon, although details are hard to obtain due to commercial secrecy. The potential benefits are huge because leather production is a major contributor to cattle farming's huge and unsustainable environmental impact.

because of competition from alternative milks.

The industry has yet to start lobbying against precision fermentation, yet its aggressive pushback against plant-based alternatives is a taste of what companies like Formo can expect, says Lisa Jordan Powell at Sweet Briar College in Virginia.

Keeping abreast

But there is a market where something resembling whole milk might gain a foothold, and it has nothing to do with cows. According to the GFI, two precision fermentation firms in the US – Harmony in Boston and Helaina in New York – are working on human breast milk. Two other companies, Biomilk in North Carolina and Singapore's TurtleTree, are eyeing the same market, but going down a different road, culturing human mammary gland cells and collecting the milk they make. This is closer to cultured meat technology than precision fermentation.

None has yet demonstrated a prototype and it isn't clear which alternative breast is better. But the potential is huge, says Mellon. "I don't know how long it will take them to get on the market, but it's not too many years off. And it's a big market – we think over \$50 billion."

Beyond that, name your animal product. Fats, collagen and blood are in development, mostly to add to cultured and plant-based meats to make their taste and texture more authentic (vegan black pudding, anyone?). Eggs too, despite whole ones being tricky because making a separate white and yolk is complex. A company called Clara Foods has already cracked the technology for fermenting egg white as a commercial bakery ingredient, although it isn't yet on the market. Another company, MagicCaviar, has said it is working on a version of another type of egg – from fish. And there is a whole realm of non-food products out there waiting to be fermented (see "Alternative materials", left).

Ultimately, says Zak Weston at the GFI, success or failure will be determined by what always determines the fate of new foods: taste, price, accessibility and convenience. If precision fermentation can deliver on those, companies like Perfect Day will be creaming it in. As Milburn says, "the proof of this pudding will be in the eating". ■



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5. It's not the cow, it's the how': why a long-time vegetarian became beef's biggest champion

Extracted from a report by Patrick Barkham, *Guardian International Edition*, 30 August 2021

After refusing to eat meat for 33 years, Nicolette Hahn Niman bit tentatively into a beefburger two years ago. She had become a vegetarian because she was concerned about animal welfare and the environmental cost of meat. Unlike most vegetarians, she had experience of the dire conditions on factory farms during her career as an environmental

lawyer campaigning against pollution caused by industrial meat production in the US. Then she married Bill Niman, a farmer.

Hahn Niman's journey from vegetarian activist to cattle rancher to writing a book called *Defending Beef* may be driven by love, but it is also informed by a lawyerly desire to stick up for small farmers besieged by the growing ethical and environmental clamour against meat.

Hahn Niman was raised in semi-rural Michigan and was working in New York as an environmental lawyer for Robert F Kennedy Jr when she fell in love with a farmer. Kennedy Jr's charity, Waterkeeper Alliance, was seeking to stop livestock farmers from polluting water bodies with slurry, and Hahn Niman began working with farmers who were doing the right thing, including her future husband. When she moved from New York to the Pacific coast to be with Niman on the rough, arid terrain of his 1,000-acre ranch, she planned to continue as a lawyer.

For seven years, she worked full-time on the farm, where they refuse to use chemicals on the land or animals, before raising their two sons. She says she and Bill are constantly learning. "The most important thing I learned was that in the two years I'd been working on agricultural issues as an environmental lawyer, I just scratched the surface in terms of understanding the real daily issues of agriculture."

Many environmentally aware people believe that if they are still eating beef they probably shouldn't be. Fuelled by the popular Netflix film, *Cowspiracy: The Sustainability Secret*, there has been a backlash against the meat. Rainforests are razed for cattle grazing, and the industrial farming of cows causes soil erosion and water and air pollution. Meanwhile, people who gorge on burgers, butter and ice-cream seem beset by chronic diet-related diseases and ballooning obesity rates. Worst of all, livestock farming is driving the climate crisis, causing around 14% of annual greenhouse gas emissions.

Hahn Niman's argument is summarised by a slogan T-shirt she likes to wear: "It's not the cow, it's the how." A cow is not an innate eco-devil, but how they are farmed is often fiendishly damaging. She does not defend grazing on obliterated rainforests, but joins other influential farmer-writers such as Gabe Brown, Charles Massy, Simon Fairlie, and the controversial, iconoclastic ecologist-grazier Allan Savory, in proposing a better kind of cattle farming. If cows are freed from barns and feedlots – the cramped dirt pens in the US where they are fed grain – and allowed to roam and eat diverse natural grasses and shrubs as their wild ancestors did, they can restore soils, enhance natural diversity and help capture carbon. Cows, she believes, can engineer healthier ecosystems, and healthy grass-fed animals provide meat with measurable health benefits over factory-farmed stuff.

This sounds reasonable, but the carbon cost of cattle is what troubles most environmentalists today. In her book *Defending Beef*, Hahn Niman explains how naturalistic cattle grazing adds manure and organic matter to the soil and encourages plants that help draw down carbon. Unlike crops, which are traditionally cultivated by ploughing the soil and releasing carbon, there is a wealth of evidence showing that carefully grazed grasslands sequester carbon.

But evidence also shows that grasslands' rates of carbon sequestration tail off after 20 years. A scientific study in 2017 concluded that, at best, careful cattle grazing could offset 20-60% of its annual emissions. The same study calculated that, globally, 1g of protein per person per day comes from grass-fed animals, whereas 32g of protein per person per day comes from all animal sources including fish, with 49g from plant sources. Ruminants already collectively take up about a quarter of the planet's useable surface; it would not be possible to move to grass-fed meat and keep eating it at current levels without devastating environmental consequences, turning forests into vast prairies.

These kinds of big global studies frustrate Hahn Niman because, she argues, they fail to account for the complexity and diversity of land. "In that report, they say, 'This is crazy, you have this huge amount of land used for grazing and it's only producing this tiny percentage of nutrition.' But if you ignore what those lands could actually be used for in agriculture, then that statistic means nothing." For instance, her own ranch has rough, dry ground and Mediterranean-style weather; they cannot grow crops there. So the Nimans are converting arid grassland into sustenance where no other human food could be produced.

Many environmentalists argue in response that if diets were to become much less meaty, all such grazing land could be rewilded, sequestering even more carbon, while cropland is farmed more intensively to feed the world. This, responds Hahn Niman, fails to acknowledge the soil erosion and carbon emissions caused by intensive, plough-based farming. As the innovative Australian farmer Charles Massy puts it, says Hahn Niman, "Natural landscapes have a way of functioning. And in modern agriculture and modern human life we tend to ignore what that functionality looks like – where there should be watercourses, grasslands, forests".

The true cost of cheap food includes all "these downstream effects": water and air pollution, soil erosion, animal cruelty – and the poor human health they cause. Two-thirds of calories eaten by US children come from ultra-processed foods. These include the new generation of lab-made meats.

Hahn Niman accepts that moving to a healthier, low-carbon food system, when global capitalism is still pushing production in the opposite direction, is a challenge that can seem as overwhelming as the climate crisis. She believes it requires government legislation as well as consumers choosing to eat locally produced food. And eating locally requires more food production close to people's homes and a demographic shift to the countryside.

Ross Rutherford

ESR Newsletter Editor

8 September 2021