

Jason Clay, Ph.D.  
Feeding the World, Sustaining the Planet  
Henry C. Gardiner Global Food Systems Lecture  
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**Transcript of the Fourth**

**Henry C. Gardiner Global Food Systems Lecture**

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**McCain Auditorium  
Kansas State University**

**“Feeding the World, Sustaining the Planet”**

**Dr. Jason Clay  
Senior Vice President for Markets and Food  
World Wildlife Fund  
Washington, D.C.**

**Henry C. Gardiner Global Food Systems Lecture Series  
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So, you may be wondering why there's this kid from northwest Missouri here talking to you about agriculture. I want to talk a little bit about my background. I also want to talk about why an organization like the World Wildlife Fund – the world's largest environmental group – cares so much about food. But I really want to make sure you understand that what we're talking about – or what I'm going to be talking about – is a global perspective. It's not about Missouri. It's not about Kansas. It's not about the U.S. It's about agriculture and food on this planet, and what are the key trends, etcetera.

As was said, I grew up on a very small farm in northwest Missouri. It was 156 acres. There were eight kids in the family in a four-room house without indoor plumbing. I slept on a screened-in porch for fifteen years in winter and summer. We lived on less than a dollar a day per person. We had a garden, an orchard, we raised animals, and we hunted and fished, etcetera. We were poor, but everybody was poor, so it didn't seem to make any difference.

But when I was fifteen my father was killed in an accident and I had to run the farm at that point because I was the oldest son and the oldest child still at home. And I came to realize that growing up on a farm was a great experience. Running a farm that a family depended on was a very different experience. And I knew at that point that I needed to figure out a way to start thinking about what was next after farming. My options were three. I took the SAT – the first kid in the town to have taken the SAT. I had three choices: I could play football at Nebraska, I could go to the Air Force Academy, or I could go to Harvard. And the community was evenly divided between whether it was better to go to the Air Force Academy or play football at Nebraska so, of course, I went to Harvard.

There wasn't another farmer in the class. I don't think there was another farmer in any of the four classes. There were lots of landowners. There were lots of people who owned farms. But no real farmers. Now for me probably being an outsider in that environment is why I became an anthropologist. Because I had to figure out why I was so different from everybody I was with every day. And I was reminded of it continuously. My freshman year my writing teacher asked me if English was my native language. I kind of thought it was but I wasn't going to argue with her. So, I just buckled down and started trying to write a little better.

So, I want to – I'm going to give you a lot of information in the talk tonight. And I want all of you to – any questions you have, write them down and send them to Steven Graham – and I'm not doing this facetiously. Send them to Steven Graham, [sgraham@ksu.edu](mailto:sgraham@ksu.edu), and I will answer them between now and the weekend. Because I know a lot of people don't like to go up to mics. A lot of people are a little hesitant to do that. So just write it down, send it off, and we'll get your questions answered.

So, I became an anthropologist. And the first thing I found out was that most of the people that anthropologists think about – other cultures, indigenous societies around the world, etcetera – are actually farmers. I went to southern Mexico and planted corn with Mayan Indians – planted corn in a way that we hadn't planted corn in the Midwest for 50 years – by using handheld planters that went along the side of your leg – to actually plant individual hills of corn. And then I ended up in refugee camps and I became one of the world's experts in predicting how many body bags you would need. Because that many people were going to die rather than be going home. And that's not really something that you want to become an expert in.

And so, a year or two later, the Grateful Dead did a benefit for the group that I worked for to help save the rainforest. And afterwards I met a guy who wanted to know what he could do to save the rainforest. And I said, "Who are you and what do you do?" And he says, "I'm Ben and I make ice cream." So, we ended up making Rainforest Crunch ice cream that was their number five bestseller. We made Chubby Hubby. We made a lot of publicity. It was their fifth-leading sales flavor. And I created a trading company to buy and sell these products for them and 50 other companies that I began to develop markets for, and realized I had a kind of knack for doing business.

But what I found at the end of the day was we could prove that the rainforest was worth six times more as a rainforest providing nuts and berries and fruits and oils than it could either beef or soy. But the people producing beef and soy didn't care. Because their model was to clear the forest and plant soy. And so that's when I realized that creating markets for these kinds of products wasn't really going to either save the communities I was working with and provide them with a viable alternative or actually generate the benefits we needed for the environment. And what I realized also is that, like a person I was interviewing during a famine in Ethiopia said, "You can't wake a person who's pretending to sleep."

We have to wake up to the fact that producing food has had the biggest impact on the planet of any human activity. And there's going to be more people with more income. How are we going to do that sustainably by 2050? That's the biggest challenge in the 21<sup>st</sup> Century. And it's all happening at a speed and a scale that we're not responding to quickly enough. There's 30 to 40 years today between when we see a problem and when we actually see a result begin to hit the ground. We need to be working in a 5 to 10-year timeframe, not 30 to 40 years.

So how do we begin to do that? That's the journey that I set out with the World Wildlife Fund, was to get them to realize that if they simply worked on biodiversity, bringing back endangered species, setting up protected areas – national parks, etcetera – if it comes down to a choice of feeding a child or cutting a tree, the tree's going to lose every time. So, we have to come up with other ways to produce food that don't make that choice. And organizations that care about biodiversity need to also care about where and how we produce food.

So, putting it simply, food production is the biggest threat on the planet. It's responsible for 70 percent of all biodiversity loss over the last 8,000 – 10,000 years. It uses – 70 percent of the fresh water that's used by people for producing food. 85 percent of marine fish stocks are fished at or beyond capacity. It's responsible for 24 or 25 percent of greenhouse emissions directly, and that doesn't include refrigeration and transport and all the things in your own home, etcetera. It uses more chemicals than any other human activity. And it's responsible for about half of topsoil loss in the planet in the last 150 years.

So, the issue of where are we going to produce food and how much more land do we have? And what I would say is how to think about food production in terms of the land is really more about agricultural sprawl. How can we begin to intensify food more sustainably? How can we do that? How can we produce more with less?

Today we use about 40 percent of the planet's frost-free land surface area to produce food. There's about 5 percent that's desert, about 18 percent that's mountains, lakes, rivers, and streams. About 2 percent that's city and infrastructure and highways. About 12 percent that's in parks and protected areas. And about 23 percent that is left. Now this 23 percent is where most biodiversity is on the planet

today. So, taking the 40 percent that we already use for food production, we couldn't double it if we wanted to.

So, the question is how do we produce more with less? And that's what I want to spend tonight talking about. Because if we don't, then this is what's going to happen. The hundred countries that are here that are highlighted in gold as opposed to brown have taken land out of protection in the last 25 years. So, they've downgraded national parks. That's what we don't want to see as an environmental organization. We think that we can have nature and we can have food. And that's what our goal is. But it's not actually just about the land. This is the change in the biomass of mammals on the planet at this point in time. Look at what the biomass is of cattle; people in the center – in orange; and then sheep, pigs, goats, and horses. One little green dot – and this slide is about 8 years old or so – one little green dot is elephants. Now, in fact, that green dot is about half that size now because of poaching.

The question is, "Is there room on the planet for anything else?" And this is where we are today. And this is where we need to be in 40 years. In the next 40 years, we have to produce as much food as we have in the last 8,000. How are we going to do that? So today we have 7 billion (people) – let's just round it down – 7 billion instead of 7.4. They consume one unit's-worth of consumption – 7 billion units of consumption on the planet. By 2050, we're going to have 9 billion, conservatively. Maybe more. They're going to consume twice as much because they're going to have 2.9 times as much income. They're going to be consuming more animal protein, more fresh fruits and vegetables, etcetera. They're going to consume 18 billion units of consumption. How do we fit that 18 billion units of consumption on the planet? We need to use 65 to 70 percent less land, less water, less inputs to produce each calorie, each unit of production, to make it fit within the planet. That's the challenge.

Now population is probably going to peak. Most people think it will peak between 2050 – 2060 – 2070 – somewhere around then. Somewhere around 9.5 – 10.5 – 11 billion. There's no end in sight on consumption. It is just taking off. And we don't know how that is going to be resolved. So we're trying to buy time here by simply leaving some of the planet intact.

So why is this happening? Well, this is what I would call the China phenomenon. It took Britain 155 years to double the GDP of 9 million people. It took the U.S. 53 years to double the GDP of 10 million people. It took China 12 years to double the GDP of a billion people. It took India 17 years to double the GDP of 822 million people. China did that in a 12-year-period ending in 1993. China's doubling was 12 times the speed of Britain and 100 times the scale.

China lifted 400 million people out of poverty. Every government should be doing that. That is what we want to see happen. But it has consequences and we've got to anticipate those in order to try to address them. And we didn't very well in China. And so when China's economy heated up, the Chinese didn't immediately start buying things. It took 12 years before they trusted their new money. They saved money. They had a 25 – 35 percent savings rate during that period. And then they started spending money on food – on animal protein. And then you started seeing price spikes. And you had food riots in 25 countries where people were killed. And this is what, in fact, helped contribute to the Arab Spring and all of the aftermath that's happened later.

And yet food prices in the U.S. go down. I'd say it's in part because we're not paying the true cost of food. We're not paying for the cost of soil erosion. We're not paying for the cost of making our

production systems more sustainable over time. We need to figure out how to incorporate that. And while food is cheap, 800 million people on the planet can't afford it. And the irony is that half of farm families don't produce enough to feed themselves and have to get off-farm income or other sources of income. Most of malnutrition – most of stunting around the world is in farming communities themselves. It's not in cities.

So how do we produce more with less? We think there are four ways we need to focus on. Productivity – looking at things like genetics and soil health. Efficiency – looking at how we use water, how we use pesticides, fertilizers, other inputs. Waste – how much food we waste that could be eaten. And then consumption. None of these are going to get us to 2050 by themselves but all of them – if we pursue all of them – will get us well beyond 2050. So, the issue going forward isn't what to think, it's how to think.

For example, on a finite planet should consumers have a choice about more sustainable products? Or should all the products on the shelf be more sustainable? And if we want to make all the products on the shelf more sustainable, how do we do that? At that point sustainability isn't a marketing angle. It's not a certification or a positioning thing. It's not a B to C thing. It's a pre-competitive thing. How do all the products on the shelf become sustainable? Companies have to make choices. They have to work with their supply chains. They need to develop partnerships to make them more sustainable.

Today we waste one out of every three calories that's produced on the planet. And it varies a little bit between developed countries and developing countries as to whether it's post-harvest loss or post-consumer loss, but we waste it all over the planet. Instead of expanding into forests and grasslands and wetlands, can we rehabilitate land that has been used, degraded, and abandoned or put into unproductive pasture? Can we bring back those soils? Can we rehabilitate 250 million hectares by 2030? This is the target that we've set with the World Bank to actually figure out how to do that and to create a fund that would actually help kick that off.

It's not a question of if genetics, but which genetics? We had a saying in northwest Missouri where I grew up – dance with the one that brung you. Genetics got us here, guys. It's going to get us where we need to go. Now we may have a difference of opinions about which genetics are going to be acceptable in some European countries or not but, if you look at where we need to go, productivity is one of the things that we need to focus on and genetics is the key there. But we've got to be more thoughtful about it than today. So, for example, corn produces 1/20<sup>th</sup> as many calories per acre in Iowa as an acre of bananas in Costa Rica. An acre of bananas in Costa Rica produces a third as many calories as an acre of sugarcane in Brazil. Why are we spending so much money on corn genetics? Is that really going to feed the world? If we double corn production is that going to feed the world? Why can't – with the new technologies we have – we figure out how to put more nutrients into bananas? Can we put proteins into sugarcane? Is there a way we can begin to use this technology to produce the food that would actually nourish people using less land, less water, etcetera?

Also, if we know that the place where there's going to be more population growth – and in fact more per-capita income increase – if that's going to be Africa, why don't we focus on the crops that are in Africa that have never benefitted from any kind of modern plant breeding? So, we've done a project now with the Mars Company, with the Beijing Genomic Institute, and with NEPAD in Africa to identify the 100 most important food crops in Africa, map the genomes of all of them, put the information all in

the public domain, and train 35 plant breeders every year to do marker-assisted breeding. To do CRISPR technologies to actually get planting materials in farmers' hands that produce more. We can double – triple – quadruple the productivity of these crops that have never been worked on much easier than we can double corn. So why aren't we doing it?

On a water-stressed planet and with water becoming more and more of an issue, today it takes about one liter of water on average to produce one calorie of food. These are global numbers. By 2050, we're going to need to produce two calories with half a liter. That's what a 75 percent increase in efficiency means. So which crops can we do that with? Where can we do that? We need to start planning and thinking about these issues this way.

We also need to think about where are the gains going to actually come from? Are they going to come from moving the best producers and rewarding them through market access, through premiums, through certification programs, etcetera? Or is it actually from moving the bottom? We've come to believe that the bottom 25 percent of producers produce about 50 percent of the environmental impacts and only about 10 percent of the product. If you want to increase food availability – if you want to reduce environmental impacts – you work with the bottom, not the top. You either help them get better or you help them find better jobs. Either way it's a net gain for them and for the planet. We've got to figure out how to do that.

And then there are challenges for animal protein. We live on a planet where there's decreasing per-capita – this line – arable land available to produce food and there's increasing consumption. So we've got to become much more efficient in each of these forms of animal protein that we're consuming. And we're seeing that consumers are beginning to drive markets in different ways. We now have more production from aquaculture globally than we have from beef. If we want to address some climate change issues, aquaculture would be a great way to do it. In oceans – not on land, not with freshwater, but in saltwater where we have a lot.

But I think the one – the kind of posterchild for efficiency over the last 50 years or so has really been with poultry. And you can see looking at this chart between 1925 and 2005, they've made incredible gains in feed-conversion efficiency, in terms of reducing mortality, in terms of the days – the times to market, and in terms of live commercial weight at the time of slaughter. But what this chart doesn't tell you is that it's a different world out there now. What about animal welfare? How does that affect these numbers? They all go down. So what about water use? What about using medicines and other kinds of inputs? If you start measuring those things and you start managing them then you've got to figure out how to optimize all these things rather than maximize just one or two of them. It's going to be hard to do that across all the different commodities, and yet that's the kind of thinking that we need to move forward.

And then there's climate change and food production. And it's funny, I would say climate change is one of those things where the impacts have come much faster than people expected. And they're still anecdotal but they are much, much faster. The projections are pretty interesting though. So, here's a projection of where cotton is currently grown, where it's going to be grown in 2040, in 2070, and in 2100. Think about the implications of that. If this is cotton, where's the corn belt? It's north – it's north of cotton. Wherever cotton is, it's north of it.

And that raises two important issues. Part of it is the expansion into new areas where people have never produced cotton and the contraction on the other side – so you have one expanding edge and one waning edge. And both are not terribly efficient just at a time when we need to be more efficient. Now multiply that by every other commodity where they're going to start shifting where they're being produced. The U.S. does not produce oats anymore at a commercial scale. They're in Canada now. They're in Scandinavia. I grew up near St. Joe. That was the last Quaker Oats plant in the U.S. It closed.

But maybe cotton isn't your thing. Maybe you like chocolate. This is where 70 percent of the world's cocoa is produced. And this is where the land is suitable to produce it in 2000. This is where the land will be suitable to produce it in 2030. In Côte d'Ivoire which produces 42 percent of the world's cocoa – one of those two countries – last year 30 percent – a third of production in Côte d'Ivoire was 90 percent down because of diseases due to stress from temperature, from water, etcetera. Another third was down by 10 percent. And the third that was up by the most of actually cocoa that was planted inside national parks. Those are the kinds of stress that we're starting to see today.

So, in the short term, climate-smart agriculture is going to be about farmers trying to simply be as efficient as possible to maintain levels of production. In the medium-term – and I'm saying 6 to 10 years here is the medium term – it's going to be about changing crops or changing genetics. And that's another reason why genetics is going to be so important. If we have to re-plant tree crops every 10 to 15 years, how do you do that with conventional breeding? You don't. You cannot do tree crops in 10 to 15 years where you have a whole new crop with different traits – drought tolerance, disease resistance, etcetera.

So, here's a takeaway from this. I'm guilty of it – I think most of us are. We have a kind of notion that business as usual is what we get by doing nothing. It's what we get by doing nothing different than what we're doing today, right? That's business as usual. You just – whatever you're doing – just keep it up. What we're finding though is that the projections of genetic gains, for example, in many crops are not keeping up with what the actuality is – or the actuality is not keeping up with what the projections were. That it's actually not as good as we thought. And in some cases, they're actually going the wrong direction. I think business as usual – with a lot of the variables that we have today – is going to be a stretch goal. It's not going to be a given. We're going to have to work very hard to maintain business as usual.

And then there's another context in which all of this is happening. I go around the world. I talk to group like you all many times. The biggest reality I think that we have to confront is that we have 7.4 billion food experts on the planet. They're all experts. Just ask them – every one of them. Because they all eat food. Maybe not as much as they want every day or maybe not as many meals as they want but they know what they like and they know what they want. We're seeing a situation where social media trumps science. Extremes are dominating discussion. They're not defining the parameters of discussion – they're actually drowning out discussion. We're seeing a situation where traceability is not the same as transparency. Where something is not produced, is not the same, as how it was produced and what the impacts of producing it were. And we're also seeing a world in which there's a lot more distrust. Trade, globalization, experts, etcetera.

So, in this context, where WWF is coming from is that we decided to look at the 35 most important places for biodiversity. And we did surveys of them to define what the most significant impacts to those places were from food crops. And we came up with these 15 food crops. And you'll see that many of them are animal proteins or feeds for animal proteins. Now we don't buy and sell food. And we don't grow food. We don't make policy about food. We're not experts in food production, and we're never going to be experts in food production. But we have a finger on the pulse of what's happening in different parts of the planet – many parts of the planet at the same time – and we see patterns often before other people do. And, so, what we've decided is that we have to switch our approach from doing – you know 10,000 projects isn't going to save the Amazon – to influencing. And by influencing – by having information, by having an analysis, by having a business case that will get somebody's attention who has the potential to move a company, to move a government, to move a policy – that's where we think we need to be playing.

And so, as we begin to look at those 15 commodities, what we found is that 300 to 500 companies touch 70 to 80 percent of each of those commodities. That's it. Globally. But when we looked closer we found that only 100 companies touched 25 percent of all 15 commodities. And so those 100 companies became the companies that we needed to begin to talk to about their supply chains. About individually how they could work with suppliers, but also collectively how they could begin to work with suppliers. There are 7.4 billion consumers, 1.5 billion producers and their families, and about 300 to 500 companies in the middle. So that's the pinch point. That's the leverage point. And that was our strategy and still is.

But then we have to figure out what it is we want those companies to do. And that means we have to figure out what is more sustainable. What are standards that are better than others? What we found as we looked around at a lot of the existing work on sustainability was that they were based on practices, not results. And we know that, if you give 1,000 farmers the same practice, you'll get 1,000 results. And it's not very predictable as to what you really need. They're based on complying with standards – do this, don't do that, etcetera. They're not based on trying to find ways to get innovation – to get way beyond what is necessary to something that would be even more important. They're focused on marketing, they're focused on selling products, not on creating a supply of raw materials from now on. Premiums, rather than efficiencies. Producers want premiums. They don't look at costs saved, they look at how much extra they got. And we reward the best rather than moving the rest.

So, we had to figure out how to define more sustainable for these 15 commodities and we decided we can't do that. This isn't our expertise. But we can bring together multi-stakeholder groups – those that are willing – starting with producers. Also bring in traders, and retailers, and brands, and extension agents, and researchers, and universities, and NGOs - bring them all together. Be science-based. Build global consensus. Figure out what you agree on, what you disagree on, and what you don't know enough about to have an opinion, and start moving. And it's surprising how quickly you get to 6 to 8 key issues. And really focus on metrics rather than practices. Because practices inevitably don't work for everybody or they discriminate against some. Some producers have more money than time. Others have a lot more time than money or land. And, so, you need to accommodate those kinds of things.

We also were trying to figure out what are the key impacts across these 15. And what we settled on was that really habitat, biodiversity, and land use is one cluster of impacts. Soil health – soil carbon is



another kind of cluster. Water take and effluent is another. Greenhouse gas emissions and chemicals, medicines, and toxicities. And there's the same kind of mirror set of issues for social issues. For economic issues for farmers and producers, etcetera.

So, using this information, we launched roundtables around these different commodities, created standards, and I'll talk a little bit about how we tried to – using standards – move sustainability from a niche issue to become the norm, and where we've had successes and where not.

We launched the better cotton initiative in 2004 and by 2013 we had about 1.6 million producers that met the standards and they represented about 13 percent of global production. That's up to about 20 percent today. But here's the thing that was interesting about that. We didn't give them a target for where they needed to be in terms of input use. But rather had them start measuring it so they showed continuous improvement over time. And by not having a target we actually found that we had much bigger impacts on the ground. So with those 1.6 million producers, they use 50 percent fewer pesticides because they started measuring it. They use 40 percent less water. They use 30 percent less synthetic fertilizer. And they made 15 to 20 percent more money and had higher productivity. That's the kind of thing that wasn't just in India and Pakistan where we started, but also now has proven to be true in Brazil and Australia as well in terms of efficiency. And these are countries where people already think they're efficient. But as soon as they start measuring, as soon as they start managing it, they get even more efficient.

We started a salmon aquaculture dialogue. 17 of the world's largest salmon producers representing 70 percent of global production all agreed to become certified, to share their data, to create a common database, and to work together to reduce their impacts. The data they shared were what were the key impacts, what was the cost to reduce them, what was the payback period, what was the return on investment, what didn't work, etcetera. I don't know of a single other sector where the entire sector has shared data at 70 percent of the global production.

Based on the work that we were doing around beef, Ireland launched its Origin Green program, Bord Bia, and Ireland became the first country to set a target of 100 percent of its food exports being certified sustainable by 2016. They didn't make it. They only got about 80 percent of their beef into the verification program and about 70 percent of their dairy. But it was a good start and it's more than any other country has ever done. All those farmers that put their information into that system got to see how they did, compared to their neighbors. And that was a very important motivating tool for these farmers. It's kind of like – I don't know how many of you listen to Garrison Keillor – but it's like Lake Wobegone out there – everybody is above average, just ask them. They're all above average. And yet it can't quite work that way. And so, when you see where you stand versus others, it makes you want to get better. And you can also then see how other people got better.

And then there are groups of companies that decided that, for them, the biggest reputational risk was not about the certification system itself or the unsustainability but it was really a key issue like deforestation. And, so, 70 companies agreed to take deforestation out of their supply chains, starting with 4 commodities. And then Cargill and ADM and other traders agreed to take deforestation out of their supply chains. And, so, you begin to see some of these knock-on impacts.

But I think one of the things that, for me, is interesting is with climate change, weather variability, with the movement of where crops can be produced and then having them produced longer maybe where it's not optimal to be produced. We need to have a system for defining when a commodity is broken. And I think the poster child right now for a broken commodity is cocoa. Where if you look at these 8 indicators – yield per hectare, illegal deforestation, the number of pods on a tree that actually mature versus fall off, the percentage of producers above the poverty level, the percentage of trees infected with a virus that basically knocks 90 percent of production down, the percentage of carbon in the soil, number of farmers under 40, and the use of child labor – all of these are headed in the wrong direction. To me that commodity is broken. It needs to be fixed. And fortunately, there's enough money in cocoa that companies want to invest.

So, Barry Callebaut – not a household name I know – it's a company behind companies. It buys 22 percent of the world's cocoa and it sells it to Mars, and Hershey's, and Mondelez, and others. They have just agreed to re-plant a million hectares of cocoa using better genetics and using grafting. They've also set a target of zero deforestation from their suppliers and zero child labor. And they're moving in a system of long-term contracts – 10-year contracts actually – where they will provide a contract to a producer who can then go to a bank and borrow money at lower rates. And the money that they borrow actually pays the salary for the first three years while the tree is growing, before it starts to produce, so that they actually have the ability to stay on their farms, continue to work their farms, etcetera. These long-term contracts are actually going to be very important. They're sharing data and the lessons learned with all the other cocoa companies. That's pre-competitive behavior. That's very important for fixing the sector.

We first negotiated long-term contracts between 600 producers of beef in Paraguay and the world's largest hamburger company. The hamburger company had two requirements for a 10-year contract. One: zero deforestation from day one. And two: best efforts to double the intensity of production over the next 10 years. On the strength of that contract those 600 ranchers were able to walk into a bank and get financing at 2 to 3 percent below market rate. So, they made money on the finance. They're making money on the efficiency. But they're not probably going to get a premium in the marketplace. But they're still going to be better off because of it.

We started the global roundtable for sustainable beef much like these other roundtables. It's now got work going on in 5 different continents and in a dozen or so countries. And the key areas of focus for this work – although there's different permutations and it plays out differently in each context because beef production is very different around the world – is a focus on natural resources, a focus on people and communities, a focus on animal health and welfare, on food safety and food quality, and on efficiency and innovation.

So why are all of these sectors – all of these companies – all these different producer groups, etcetera, focusing on this? And I think the answer is pretty simple. It's about risk. It's about risk both of long-term availability of supply and about the reputation because of how that product is produced in the country of origin. And this is what's driving some of that risk. In S&P 500 market valuations in 1975, 83 percent of a company's value was based on tangible assets – buildings, properties, etcetera. By 2009, 81 percent was based on intangible – your reputation, your brand, what you stand for as a company. Things that you can't really put a number to, people are putting numbers to.

Now there's a few other issues that I'd just like to point out that are trends that I think are going to start touching or affecting the debate on food. One is illegality in food production. I started picking up about 5 – 6 years ago a lot of references to illegality in production from many different types of food – fisheries; aquaculture; livestock; food crops; non-food crops like paper, cotton, rubber, etcetera. And as we looked at those sources of illegality, what we found is they fell into five different categories. One was around – did the producer actually have legal access to the resource they were using or selling? The second was about labor, about social issues – were they obeying the law? Was there child labor? Was there slave labor? Was there bonded labor? Were there undocumented workers? Other laws and regulations – Brazil you can own the land but there's a forest code. If you don't comply with that, you're not in compliance with the law. And then fraud and corruption.

We looked at 8 companies' supply chains – an equal number in North America and Europe. We looked at 9 commodities produced in 8 countries. All the data that we used came out of the public domain so anybody who cares about this information can find it. It's all out there. We drafted a white paper. I've made it available – I've just submitted it to *Nature* for publication. And our goal is to create awareness about illegality to make it a pre-competitive issue. Because what we found, when we talked to all the different retailers and brands, is nobody wanted to talk to us. Because under U.S. law, anything they say to us is discoverable. And so, once it's in the public domain, then it's something that people can talk about and you can figure out how to address the issue.

But here's – just looking at one commodity, one country – what we found is that between 4 and 44 percent of each globally-traded commodity was not produced legally. One country – one form of illegality – one commodity. If you take all the exporting countries, all the different forms of illegality, it's probably half is our estimate of food that's not produced legally in the country of origin that's actually traded. And that's true not just of developing countries but also the U.S. That's true of European countries as well.

Here are some of the implications of that work. If a product is produced illegally, can it ever be traded as legal? If a raw material is produced illegally, can a product made from that or with it be legal? And these are things that you can talk about. I mean reasonable people can actually disagree on this. If a feed ingredient is produced illegally, can the animal protein made from it be legal?

And then there's the issue of traceability versus transparency. Increasingly it isn't just about where a product is produced, it's about how it's produced. And what we're seeing is that 19<sup>th</sup> and 20<sup>th</sup> century models of commodity trading are not keeping up with what the buyers want to know. So, in the 19<sup>th</sup> and 20<sup>th</sup> century – in fact it's interesting. Historically, commodities as a category of interchangeable products – one ton of number 2 yellow corn equal one ton of number 2 yellow corn wherever it's produced in the world – happened about 15 years after interchangeable parts. That's when it was created. Okay, all of those properties were pretty physical – weights, measure, brokenness, quality, foreign matter – all of that. In the 21<sup>st</sup> century, people want to know, is it organic? Is it GMO? Was there deforestation involved? Was there child labor? How much water was used to produce it? Was it a water-scarce area? What's the income of the producers? You can't tell this by looking at a product. This actually requires a lot more embedded information. And yet, that's what traders are being asked to do now.

And habitat conversion – especially in this area and further north and into Canada – is not just about deforestation. It's about grassland conversion too. In 2014, the U.S. and Canada converted more grassland than Brazil cut down forest. In the last 15 to 20 years, we've converted 50 million acres of grasslands. A lot of this land is not suitable for farming. It's being done because of high commodity prices and because of crop insurance programs. We've got to figure out where we can do farming more sustainably and zone areas for it. And as agriculture moves north into Canada and into parts of the northern Midwest, we have to really be aware of this issue of grassland conversion.

So, where I come from, we have a saying, "If you don't know where you're going, any road will get you there." We're going to have 9 to 10 billion people. They're going to have 2.9 times as much income. They're going to buy more food, more animal protein, depend on more feed production. We have got to figure out how to get that equation right, if we want to pass on a planet that has biodiversity, that has critical natural habitat, and that has vital ecosystem services to our children. Nobody can do everything here but everybody can do something. Start with waste – figure out how to reduce it – and go from there.

Thank you very much.

End of Transcript