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How "Multiple Breadbasket Failure" Became a Policy Issue

In which an agricultural scientist goes from making new squash varieties to trying to improve global food security.

On December 12, 2017, the US Congress reauthorized the National Defense Authorization Act (NDAA) for 2018. Every year, this massive bill authorizes spending for the Department of Defense. But this time, it contained a Section 1075, on page 929, really no more than a paragraph, requiring the secretary of defense to submit to Congress a "Report on the Global Food System and Vulnerabilities Relevant to Department of Defense Missions."

Whenever you eat lunch, or anything else, you partake not only in the US food system—defined as all infrastructure, material, transactions, and decisions that affect the production, delivery, and consumption of food by every person in the nation every day—but also in something much larger called the "global food system." We don't have a precise meaning for this term, or even a working representation of how today's global food system works. But we do know it is a complex, intertwined, and constantly changing system, operating at a scale and complexity way outside every historical precedent.

The government already has plenty of data on food and agriculture, which it classifies as one of the "critical infrastructure sectors" whose "assets, systems and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety or any combination thereof." But in contrast with some other essential sectors, agriculture and food manufacturing, distribution and retail is almost entirely in private hands, accounting for roughly one-fifth of the US economy. That said, the government has considerable influence on this sector through various policies that regulate food safety and incentivize the production of certain commodities. Yet the question of how risks in this big, complex global food system could threaten the security of the United States—and ways the nation might protect itself—remains wide open.

Once this question was inserted as Section 1075 in the NDAA, though, it became the DOD's job to answer it.

The path to Section 1075 had actually started a decade earlier, when I had begun to wonder about the stability and security of our vision for twenty-first century US agriculture. That quest led me to a job as deputy and acting under secretary of agriculture in 2010, which kicked off a journey that included becoming a ninja bureaucrat, learning about insurance and marketing, doing an apprenticeship among defense analysts, and finally going back to the lab to reconsider the foundations of agriculture itself. Along the way, I was helped at key moments by friends both new and old—including a US senator on a layover in the Detroit airport. Here, I will tell the story of my education in turning science into "policy," how Section 1075 came to be, and what has happened since.

From Delicata squash to acting under secretary

My great-great-grandfather and some of my great-great uncles were famous Canadian plant breeders, so I grew up thinking that plant breeders were akin to maestros or baseball players. I went off to do a biology PhD at the Massachusetts Institute of Technology and soon realized that hand sequencing one gene for my entire thesis wasn't for me. So on my first Christmas vacation during graduate school, I went home, read a book about the legendary plant breeders in my family, and decided to get a PhD in plant breeding instead. One of my favorite professors said, "What? What a shame. You showed such promise." Nevertheless, I went to Cornell University to try my luck. I dove into vegetable breeding and busted out many new types of squash, melon, and pepper that are now supermarket standards. I loved it, everything about it. Within four years, Cornell offered both me and my husband faculty jobs.

Then, in 2006 the University of Wisconsin-Madison tapped me to be the dean of its College of Agricultural and Life Sciences. As dean, I became a custodian of the commitments

that America's land-grant colleges made to citizens, and by inference, of how farming and food relate to the nation's future. Land-grant colleges originated with the Morrill Act of 1862, the same year President Lincoln established the US Department of Agriculture—and the two institutions, one to educate farmers, the other to develop seeds and technology—became the foundation of the country's agricultural policy. America's farmers rose to the challenge, producing ever more food for industrialized cities. By any measure the American agricultural project has been an extraordinary success.

But in my position as dean, I began to wonder if all this success raised the question of what success was. We were still aiming to produce more food and better food, but was more, more, more always better, better, better?

In the past century, technologies have created dramatic improvements in crop yield and overall farm productivity—while also triggering huge increases in energy and water consumption. These changes drive larger, less diverse, more specialized farming operations throughout the developed world—with monumental demographic, economic, social, and environmental effects. The abundance of commodity crops, in turn, has spurred exponential increases in human population and affluence, rising global consumption of meat and dairy, loss of biodiversity, mass species extinction, extensive habitat loss, desertification, and increases in diet-related human health issues such as diabetes, obesity, and heart disease—not to mention collateral consequences including global climate change. Thus, the extraordinary trajectories of American agriculture have driven planetary-scale changes, for good and for ill.

So, from the dean's office, I began to wonder if what we were teaching young ag students about the future was way off the mark. Furthermore, without real transformation in the systems the world uses to feed people and care for resources, my aspirations to contribute science in the service of happy humans on a healthy planet were more like inchoate delusions.

In 2009, the first Obama administration asked me to serve as deputy and acting under secretary of agriculture until a permanent appointee could be identified and confirmed. One task I assigned myself was to call colleagues across the federal government to figure out where responsibility for ensuring the short-, medium-, and long-term stability of the nation's agricultural enterprise resided. Most Americans assume that this is the purview of the Department of Agriculture, but as a newly fledged bureaucrat, I knew well that virtually all of the USDA's budget is spent in the agencies, each with its own specialized mission such as research, inspection, quarantine guidelines and enforcement, conservation, food assistance, markets, rural development, crop insurance, and so on. Add it all up and, as USDA rightly says, its work benefits every single American, every single day.

But by 2009, the result of many decades of compartmentalization coupled with a failure to look critically at the overall system was stark: in general, the public discourse about the condition of agriculture took place largely in terms of yield. At the global level, this was epitomized by a report from the United Nations' Food and Agriculture Organization called *How to Feed the World in 2050*. It estimated a 2050 human population of 9.1 billion, and then, assuming the agriculture of 2009, simply extrapolated how much food they'd need, determining that "food production (net of food used for biofuels) must increase by 70%." Taking the agriculture of 2009—or 2021 for that matter—and forcing a gain of productivity of that dimension is not only far beyond any plausible future expansion of the system's capacity; its implications for the environment were patently catastrophic.

From my new government perch, I could clearly see one reason the US food system appeared healthy when it was not: subsidies. A few years prior, during the George W. Bush administration, pressure from farm state lobbyists to improve the price of agricultural commodities—which are perennially too low to cover even highly subsidized costs of production—routed piles of taxpayer money to subsidize biofuels, which caused excess soybeans and corn to be literally burned up as fuel additives. The idea made no sense whatsoever—except as a way for taxpayers to underwrite the commodity treadmill that maintains profits for influential companies. Over the past 15 years, the ostensible beneficiaries of these policies, American farmers, have watched their plight deteriorate further.

This "commodity treadmill" describes the system of taxpayer-funded price supports that generates corporate profits regardless of the consequences of overproduction. It describes the vicious cycle where farmers, struggling with low prices and high debts, respond by producing more of the commodity to try to recoup their losses. It's a system that "works" economically only if the costs to the environment are not figured into the equation, which is like pretending that erosion, the dead zone in the Gulf of Mexico, and antibiotic resistance—among other scary things—aren't occurring.

As acting under secretary, I felt that facing these scary things was my business. But I quickly realized that the research apparatus the government had created and maintained focused primarily on enhancing crop and livestock productivity, more recently with an eye on minimizing resource use. It wasn't equipped to investigate my questions about what changes in the complex food systems would better promote dietary human health and well-being or about the limits of ecosystem resilience and potential for risk mitigation. In fact, trying to answer these questions with the system in place was like using a drill to pound a nail.

A plea from "the high side"

A short time after my successor at USDA got through her Senate confirmation hearings, as I was preparing to return to my deanship, a person in the federal intelligence community pulled me aside to say that his colleagues had

been very happy to see that I understood the relevance of the risks of the food system to national security. He asked me if I would "stay on the issues I've championed" when I returned to academia—and promised to help me if I did. I didn't commit, but it stuck in my head that this very basic question of mine might make more sense to people who think about threats than to people in USDA agencies with very different mandates.

So it was that I went home to my deanship and happily settled back into crowning that year's crop of cranberry princesses and World Dairy Expo winners, and figuring out how to set up the university's football team for another carbon-neutral season.

With the election of a new governor, I concluded my deanship in 2011. Returning to the faculty, I read widely, including a new book, *A Taste of War*, by Lizzie Collingham, about food in World War II. She mentioned a visionary group of scientists who gathered in 1943 to prepare for a postwar world. Led by John Boyd-Orr, who won the Nobel Peace Prize in 1949 for his work on nutrition, the group argued that the mutual food aid commitments that the Allied nations made to each other should be extended to the whole world. The group also envisioned a global food system whose performance *as a system* would be capable of meeting all human needs, so that no one was malnourished or hungry. Implied, but not explicit at that time, was the idea that this "food system" must be capable of providing a future for all humanity to thrive within what might be called ecological planetary boundaries.

I got interested in what comes after our focus on "sustainability." This term, applied without clear targets, can amount to slightly slowing down the car as it speeds off a cliff. What were poorly understood and rarely mentioned, I decided, were the real risks—ecological, financial, existential—embedded in the global food system.

This realization set me off on the next stage of my project, which required that I leave the halls of the academy and government to gain new skills to advance my argument. If this were a video game, this is where I began to acquire the magic talismans—the analytics, the network of allies and dear comrades, and the vocabulary—that would help me get to the next level.

Harnessing the power of networks and labels

In order to shift the conversation away from yield, I had to learn a lot more about the term "risk." I turned to the actuarial profession, reasoning that those who deal in financial risk might be interested in the large, uncharacterized risks in today's food systems. In general, I was wrong. But eventually I found my way to a cell of London actuaries who were convinced that climate change posed existential threats to the current financial system and

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David Hicks creates ceramic sculptures inspired by nature and industrial agriculture. Growing up in California's Central Valley, he was attracted to the crops that grew in the fields around his home. But he was also keenly aware of the work of migrant laborers who enable agriculture as a system, as well as the politics of their work. Hicks conceptualizes the hands of these workers, and the vegetables themselves, as elements of an increasingly standardized process.

Responding to the forms of plants and organic life, Hicks, who now lives in North Carolina, thinks of agricultural cycles as allegories for the human condition. He writes: "I am still digging in the dirt to understand my attraction to the agricultural. Shapes and themes I reference can be found in the fields surrounding my home. In the agricultural world there are cycles that feel like allegorical references to human struggle, a struggle that starts with fertilization, moves through growth and finally ends in decay."

Hicks forms his terracotta sculptures by hand, coating them with a copper luster that fuses to his glazes and results in a thin, undulating surface. He clusters his individual clay pieces to form compositions that feature an assortment of textures, colors, and shapes. The pieces are suspended from the ceiling with natural fiber twine or supported by free-standing or wall-mounted metal armatures. A single installation is very complex.

Images courtesy of the artist and Mindy Solomon Gallery.

Agricultural Cycles as Allegories

Works by David Hicks

DAVID HICKS, *Panel Composition (white and wood)*, 2015, ceramic, wood, and stainless steel, 36 x 30 x 10 inches.

that ignoring these threats was tantamount to dereliction of duty. There I started a collaboration with the head of emerging risks at Lloyd's of London, the world's iconic insurance market, to explore how instability in global food systems could affect the company's underwriting.

In order to begin quantifying this system of risks, I gathered a community of practice—scientists, engineers, and statisticians from academia, government, business, and nonprofits. In 2013, we held a summit, supported in part by the Tallberg Foundation and the Life Sciences Research Foundation, and formally became a collective, flying under the name "Knowledge Systems for Sustainability." This KSS collective has grown into an incorporated nonprofit, fostered by the US Department of Energy's National Renewable Energy Laboratory. Together we worked to explore what it would take to drive the human-planetary food system toward a "safer space" than what it is heading toward currently.

We finally began to have a conversation about risks, agreeing that the food system is highly consolidated, largely opaque, and—because it has been maximized for short-term productivity and efficiency—vulnerable to age-old issues such as fluctuating weather, environmental instability, and disease. Moreover, the system is vulnerable to new upsets, including cyberattacks, hijacking, created biological agents, and biological contamination, to name a few. These risks are all potentially magnified by the interconnection of markets, finance, and information. A report we did with Lloyd's envisioned that even a relatively small decline in production of multiple crops could trigger significant increases in prices—almost certainly leading to hunger, riots and political instability, and financial panic in different parts of the globe.

I realized that to impel new analyses, we needed labels for these new risks. With KSS colleagues and other friends in London, we made up the terms "food system shock" and "multiple breadbasket failure." At the time, we didn't know what "shock "meant, nor did we have precision on what "breadbaskets" were or what "failure" meant. What was important was that these terms gave an almost visceral credibility to the juxtaposition of multiple risks that had previously been considered separately. For example, multiple breadbasket failure called attention to the reality that interconnected weather events, such as El Niño and La Niña (periodic changes in Pacific Ocean sea surface temperatures), could create shortages of multiple agricultural commodities at the same time.

Making up labels wouldn't have occurred to me when I was a researcher, but the articles we have published using those labels have probably had more impact than the hundred-plus peer-reviewed papers I'd previously published. In 2015, Trevor Maynard of Lloyd's commissioned a study that led to a report published that year titled *Food System Shock: The Insurance Impacts of Acute Disruption to the Global Food Supply*, and to a follow-up report published in 2019 called *Evolving Risk in the Global Food System*. The 2015 study caught the attention of the US Department of Defense—which took the issue to the next level.

Making the "narrow military case" with a lucky layover

During the summer of 2016, I met with a senior official in the Pentagon's Office of Net Assessment. The ONA, founded in 1973, was authorized to imagine how the United States might fare against adversaries in the future. The official said he was interested in my concerns, but he needed to understand the "narrow military case." This led me to find a very important collaborator (who will remain nameless) who taught me how to talk like—and think like—people involved in national security.

To make the term *multiple breadbasket failure* more visible, I began to use speaking invitations to test the message, which is how I met members of the US National Geospatial Intelligence Agency. As a result, the NGA initiated a zero-dollar Cooperative Research and Development Agreement with the University of Wisconsin-Madison on food security, food systems, and national security interests. Where I might once have judged a relationship that carried no funding as pointless, I now understood that this relationship gave me an invaluable partnership that would allow me to rigorously explore my concerns, while introducing the term *food system* into general discourse.

Most of our progress has been the result of deliberate study and strategy, but luck favors the prepared. On a layover in Detroit, I ran into Wisconsin senator Tammy Baldwin, who asked me what I was doing these days. During that time I had taken to carrying around two or three copies of *A Taste of War*. I handed one to the senator and told her about our current work with the NGA. A member of the Senate Defense Appropriations Subcommittee, Baldwin is well aware that the nature of war is changing, from the twentieth century's open warfare to a twenty-first century model that must consider nonmilitary threats to US national and economic security. In this emerging reality, adversaries may disrupt everyday life through disinformation and by acquiring control and power through critical infrastructure such as financial systems, power grids, and navigation systems. And it's not impossible to imagine that the nation's food systems are soft targets—along with other everyday things such as your bank account or favorite streaming service.

Before I boarded my second flight, Senator Baldwin contacted the staff in her office who work with the Defense Subcommittee of Appropriations, who in turn reached out to me.

Always save emails from a general

In conversation with the senator's staff, the idea came up that Congress should order DOD to conduct a study on the global food system's vulnerabilities. Since it was already June 2017, the only way to accomplish this was to introduce an amendment to the National Defense Authorization Act, which was then

in front of the Senate Armed Services Committee. We took weeks crafting a four-page document for the committee's senior staff, who condensed it into less than a page of superbly structured prose. Staff members then approached the office of Senator John McCain (R-AZ), who chaired the committee, and got an answer: no. Greg Treverton, past chair of the National Intelligence Council, sent a quick email asking the senator's office to reconsider, and got back another no.

At this point, I went to my email and found a note I'd gotten from General Martin Dempsey, who had recently retired as chair of the Joint Chiefs of Staff. I cut out a phrase he'd written to me, precisely for this purpose: "As you well know, there is no extant doctrine to address this looming issue. Thank you for your work on this important subject. Please let me know if I can be of any further assistance. Cheers, Marty." I pasted it into a reply. And with this message, opposition at the committee staff level ended, and Section 1075's amendment to the NDAA was accepted, bundled, and passed.

DAVID HICKS, *SL (nucleus)*, 2013, ceramic and steel armature, 30 x 25 x 16.5 inches.

Tactics for productive waiting

Of course, getting this issue in front of the Pentagon was not the end of my journey, but just another beginning. I have learned that there are many different ways to advocate for important and subversive ideas—and I would try them all. While we were initially confident that the person tasked by DOD to do this report would give the topic serious attention, multiple changes in leadership during 2018 brought this assumption into question. As time has passed, I have also realized that while it may feel like victory to an academic to successfully describe a vexing problem, the really interesting task is to imagine how it might be solved.

But the waiting has been productive. In mid-December 2017, an officer of the Wisconsin National Guard and a fellow at the US Army War College, back home in Madison for the holidays, called me and asked if we could talk for half an hour. He and his colleagues at the War College had read the NDAA front to back, he said, noticing our particular clause with great interest. They traced the clause, which they considered odd, back to the amendment from Senator Baldwin, and called her office and asked where the amendment came from. Our 30-minute talk turned into half a day with my team. The officer, a seasoned leader with many disasters under his belt, shared my concerns. We discussed the sort of trouble the United States would be in if somebody took out the software and navigational systems that control the nation's soybean combines for three weeks during harvest, destroying a significant part of the world's food. We agreed that it would be all the more devastating if it happened during a flood or other extreme weather event.

In the past decade, I've adopted a strategy of using every publication to throw carefully designed vocabulary into a space that was blank before. Now, having invented the term multiple breadbasket failure, we could sit down with the officer and his cohort of War College fellows to jointly imagine whole new classes of threats and how the country might begin to prepare for them. As a result of that afternoon, we began to

work with the fellows on General Milley's study, which led to a report called *Implications of Climate Change for the US Army*.

Around this time, the National Aeronautics and Space Administration emerged as the generalist science funder that understands this intersection between science and major national strategic concerns such as water and food. In fact, NASA, which in one way or another funds the foundational data collection for all geospatial work, began funding a consortium, led by the University of Maryland, called NASA Harvest, for which I became director of strategic outreach. During this process I've come to appreciate how individuals in federal organizations can really make all the difference. Just a couple of people at NASA have steadily built the case and buy-in for funding in this area.

Making a missing report appear

By early 2019, when no report from DOD had appeared, it was clear we had to up the ante. With the help of Michael Puma, the director of the Center for Climate Systems Research at Columbia University, we convened a roundtable with representatives from NASA, USDA, DOD, the Defense Advanced Research Projects Agency (DARPA), the Gates Foundation, and others, in the Thompson-Reuters Board Room in New York City's Times Square. We used that as a springboard to convene a larger meeting in May 2019, jointly hosted with the Woodrow Wilson Center, titled "Food Systems and National Security: The Science in Strategy." We tracked down the person who was writing the DOD's still-unpublished report, extending an invitation to present it.

This tactic worked magnificently. The meeting took shape, with all the right people: uniformed and civilian federal leaders, a few leading academics, congressional staff, and activated younger people. We distributed the report commissioned by General Milley. A few days before the meeting, the DOD's response to Sec 1075 appeared. Just eight pages in length, it was hastily written, maintaining that food systems were not an issue of concern for DOD. It earned a sharp letter back from Senator Baldwin, pointing out its shortfalls and asking that it be rewritten.

Thinking outside the field

In the meantime, COVID-19 demonstrated conclusively that major disruptions can pile on top of each other to collapse networks designed for efficiency rather than resilience. The world had already witnessed this when the 2014 Ebola outbreak caused crops to fail in West Africa, triggering a second crisis, this one of famine and food insecurity. But COVID showed a different type of disruption in the United States, as interdependencies in supply chains and consumer buying, sometimes driven by intentional misinformation, exacerbated shortages and price fluctuations.

It gets easier to imagine new dangers almost daily: when American shoppers raced to buy vitamin D, few were aware that China is the world's only manufacturer of the supplement.

As I considered the obvious implications of such vulnerabilities, I reconnected with a program manager at DARPA who was developing an initiative on food. Around March, I got a call from DARPA's acting director, asking if I'd consider becoming a program manager. I hadn't considered this for even a second. I said, dumbly, "Me?" and hung up the phone.

But I do love a challenge. And so, what I did on my pandemic was write a white paper for DARPA. I thought about what could really change the game for food security, in all its aspects, avoiding ideas that would merely fix the current system. I thought about everything I had learned—the environmental risks, the security issues, and that old postwar ambition to feed the entire world.

Ten thousand years ago, humans learned how to more efficiently capture the sun's energy by organizing the spatial distribution of a few species of plants in Mesopotamia. And so agriculture ("field" + "grow or tend") was born—and from that grew civilizations, and the billions of people on the planet today. Still, photosynthesis has biological limits. Today, photovoltaics are nearly 50 times more efficient than photosynthesis at harnessing solar energy to split water.

Building on insights from some start-up companies trying to turn air and water into food, I had an idea: what if, after all these millennia, we changed our food paradigm from agri-culture to ubiqui-culture? Could we harness the strength of solar PVs or other sources of electricity to unhook food supply from the bottleneck of photosynthesis? Could the relatively unexplored universe of microbes, bacteria, and fungi produce nutrients in hours or days—far more quickly than it takes to grow crops in a field? And what if everyone could produce basic ingredients for household needs? What if food was more like air—so no one could easily control it and everyone could be a farmer in a pinch? If we really want to make the world better, then giving individuals more agency over their food is not only safer but also empowering.

At the start of 2021, I took a leave from academia to join DARPA, returning to my desire to use science to create solutions for a global food system that more closely matches human needs (maybe not all human wants, but that's another story). I think that if Americans—or anyone in the world—are going to be insulated against hunger and attacks on the food system, we need to be able to make our food very close to home. Right in our homes, actually: maybe everyone should have a gizmo that can turn air and water into basic sustenance, or at least back up food systems when they fail.

I know our collective human and planetary future cannot depend on endlessly trying to amp up production of corn and beans. Maybe someday we'll find an alternative in a gizmo that can sit next to your washing machine.

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