A View from the CT Foxhole: James Stack, Director, Great Plains Diagnostic Network

By Don Rassler and Kristina Hummel

James Stack, Ph.D., is an internationally recognized leader in the field of plant biosecurity. A professor in the Department of Plant Pathology at Kansas State University since 2003, Dr. Stack provided leadership in the development of the National Plant Diagnostic Network (NPDN) and became regional director of the Great Plains Diagnostic Network (GPDN), one of the five regional networks, soon after it was formed. From 2006 to 2008, he served as the director of KSU's Biosecurity Research Institute, a biocontainment facility for plant, animal, and human health.

Dr. Stack's research focuses on genome-informed diagnostics for plant-pathogenic bacteria to the subspecific and population levels of discrimination, as well as research on the epidemiology and ecology of toxigenic fungi and bacteria. He speaks regularly on plant biosecurity topics, to include at the U.S. Naval War College and the National Academy of Sciences, among other forums.

CTC: You are an internationally recognized leader in the plant biosecurity field. If you had to characterize the evolution of the plant biosecurity field, how would you describe where it has been and where it is currently?

Stack: Biosecurity in the plant world is not new. It didn't begin at 9/11. It has a history of well over 100 years, going back to the time when cherry trees were first imported into Washington, D.C. That first attempt was a total failure because the trees were heavily infested with fungi and insects, and most of the trees died or were burned. Most of the crops we grow in the U.S. are not native to North America; they were introduced by food explorers. An entomologist named Charles Marlatt was cautioning the plant explorers that were going around the world and bringing plants back to the United States. He worked with the USDA [U.S. Department of Agriculture] and was responsible for initiating the legislation around 1915 to start safe-guarding against the introduction of organisms into the United States on plants and plant materials.

With respect to plant biosecurity in the context of intentional introductions for nefarious purposes, accusations have been leveled for many years between different nations, including between the United States and Cuba, one accusing the other of intentionally introducing a plant pathogen into their agricultural systems to undermine their economy. In each case, it was very difficult to assign attribution with any degree of certainty. So, whether those were intentional or natural events is hard to determine, but accusations continued for decades between several nations. Prior to 1975, many nations, including the U.S., had biological weapons programs that included plant pathogens to target crop systems in adversarial nations.[1] Over 180 nations have signed onto the treaty to ban biological weapons, but the threats persist.

9/11 changed the whole perspective on biosecurity and preparedness because of the challenge to each federal department to assess the vulnerabilities that we have in our critical systems, food being one of them. At that point, biosecurity took on an additional meaning. In the United States, it depends on which agency you ask as to what the definition of biosecurity is. There are multiple definitions of biosecurity, and oftentimes it intersects with definitions of biosafety. But if we look at biosecurity in the sense of the unintentional or intentional introduction of an organism, we have a long history on the plant side in terms of protecting food systems and natural plant systems. But 9/11 did bring a focus on the intentional side, and we've worked on that. There are reports of documented evidence that terrorist groups like al-Qa`ida were planning to use plant pathogens to target crops.[2] We've partnered with the FBI to develop tools to help discriminate between natural and intentional introductions of pests and pathogens. However, no completely satisfying system exists.

The bottom line is that agricultural environments and natural environments have *a lot* of noise, and that background noise makes investigation and attribution a real challenge. We've actually had organisms introduced to the United States on hurricanes from South America and the Caribbean, on dust storms from Africa. Many plant pathogens and pests have been introduced through trade of plants and plant products as well as on wooden packing crates. Global trade is at astronomical levels, and we currently inspect about one percent of what comes across our borders. You're not going to find everything. USDA APHIS [Animal and Plant Health Inspection Service] does a great job; Customs and Border Protection, they do a great job. It's just that if you've ever spent time at a port of entry, you know that the volumes coming across preclude inspection at any high rate. It's just not possible. APHIS PPQ [Plant Protection and Quarantine] puts up a report every year about what they're intercepting, and the numbers of detections are very high [while] inspecting only one percent. So, we know that potentially harmful organisms are being introduced.

We have the benefit of history to know that most organisms that get introduced go to extinction; they fail. That's because the environment's a pretty tough place, and organisms have to be adapted for it in order to survive and establish. But the high numbers and the recurrent introductions are what we worry about because ultimately the numbers catch up with you. It is a numbers game, and the numbers are large. We're introducing massive amounts of material every year, and we're doing it year after year. Some of them succeed, and the consequences are quite high. Some of the consequences are tainted food; we see that with foodborne pathogens in our imported foods. Some are environmental concerns. If you just look at natural plant systems, forests, trees, they're in serious trouble right now across the United States. There is not a region of the United States that is not being seriously impacted by introductions of fungi and insects.

So, what we're seeing is a destabilization of some ecosystems. An

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analogy that I use is, if you build a house, it's more than likely going to be constructed of wood. What do you worry about when you have a house with a wooden frame and infrastructure? You worry about the big threat, fire. So, you put a lightning rod on the roof. You have fire extinguishers in the house. And then a neighbor's house burns down and you're even more concerned about this one threat—fire—so you install a sprinkler system. You're focused on this one big threat—fire—all while termites are eating out your foundation.

That is the biggest problem we have with all the threat assessments in the United States: looking for that one big organism that will have a catastrophic effect. One problem with that is the lack of an adequate definition for 'catastrophic.' So, if you're trying to develop mitigation and prevention measures, you don't have a metric by which you can measure success, because you haven't defined what catastrophic means. One definition is, 'It's something that overwhelms our system.' So, what does 'overwhelm' mean? We haven't clearly defined things to the point where we know we're making progress toward security. It's the same thing in plant systems. There's no difference: plant, animal, human. We do the same thing. We focus on the big organisms that would cause a massive effect. The real challenge is that we have many organisms attacking multiple plant systems concurrently and consistently and intersecting with other societal challenges that amplify the impacts. The challenge in plant systems could easily be generalized to include human and animal systems as well.

What I use in food security assessments is an arbitrary metric based on calorie consumption in any country and the split between calories from protein, carbohydrate, fat. If you look at the consumption needs of that country, we know—from different organizations that address food security—what the differential is for calories to support a healthy adult and then the calories that would put someone into food deprivation. We know that differential is about 30 percent displacement. So, I use 30 percent as catastrophic. If you can displace the mean by 30 percent, that's a catastrophic effect. Here's the question I pose: What's the difference between a *single* organism coming in and displacing the mean by 30 percent, or *five* organisms coming in and each displacing the mean by six percent? It's the same total effect, and that's what we cannot wrap our minds around at the federal level. We're still looking for that one big thing that causes the catastrophe. That's *not* what's going to happen on the plant side. It's multiple, continuous introductions of many different pathogens and pests that threaten plant health in natural and agricultural ecosystems. It's the constant flow of many threats. An intentional introduction could be a tipping point that pushes a system over the edge.

CTC: If you were to step back and explain the intersection between your world of plant biosecurity and its intersection with national security and terrorism, how would you recommend that our readers think about that issue? At a strategic level, I think some people might have a challenge of even connecting these different worlds and how they come together.

Stack: Remember the Arab Spring in 2010? We had a situation in Tunisia where there were fundamental challenges—cultural challenges, social challenges, political challenges. What was the proverbial last straw? The tipping point was the increase in the cost of food.[3] It was people going into the streets and waving loaves of bread that drove, in part, that food vendor [Mohamed Bouazizi] to self-immolate, that triggered the massive demonstrations that spread across North Africa into the Middle East, repercussions of which we're still facing today. It destabilized a whole region of the world. How about 2008? In 2008, we had increasing demand from China to import maize; we had the diversion of maize into biofuels; and we had the increase in cost of petroleum-based fuels that affected distribution. It spiked the price of grains. There were food riots in over 35 nations in 2008. It led to the destabilization of governments in two countries, one overthrown.[a] The food and plant systems are global networks. There are many nodes in global food distribution networks, and when you remove a node in a network, connections quickly start switching. That drives the cost of food up significantly, making it unaffordable to poverty-stricken communities in some countries. And that's what happened in 2008 and subsequently.

Fast forward, and what began just a few years ago? The Ukraine-Russia war. Many countries depend on Ukraine, a major exporter

a Editor's Note: The governments of Haiti and Cameroon experienced significant political turmoil as a result of surging global food prices in 2007 and 2008. Haiti's then prime minister, Jacques-Édouard Alexis, was forced to resign in April 2008 following riots in Port-au-Prince, and anti-government riots took place in Cameroon's capital and elsewhere in the country in late 2008. See "Haiti Senate fires prime minister over food riots," Reuters, April 12, 2008, and "Antigovernment rioting spreads in Cameroon," *New York Times*, December 7, 2008.

of agricultural products. Somewhere [around] 30-35 percent of Egypt's import of wheat comes from Ukraine. Same with Tunisia; same with Spain. People all of a sudden started looking for a source somewhere else. There are consequences to that. It drives the price up, which makes it difficult for low-income nations to import. Another consequence is when you need to move food quickly, you no longer have the same risk assessments. You're moving pests and pathogens with these products because it becomes urgent and you don't have time to do an in-depth risk assessment. We have a long history of introducing pests and pathogens in food aid, Africa being the major recipient of those.

Those are examples of how plants impact our world and intersect with national security. It's not that the introduction of one organism into the United States is going to trigger some massive crisis. But they become the tipping point in some nations. And in the United States, we need to be concerned about the multiple introductions to multiple systems simultaneously and repeatedly. To believe that what we have seen happen in other nations could not happen in the United States would be an epic mistake.

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CTC: It seems that one of the things that can make plant biosecurity threat detection and forecasting hard is that agrosecurity threats exist in a complex environment where there can be, as you just noted, a lot of 'noise' and a lot of dynamism. Similarly, terrorism threats can also be hard to identify and forecast, as they're usually embedded in a dynamic and messy information environment. In your view, when it comes to indicators and warnings and evaluation of risk, what can the counterterrorism community learn from the field of plant biosecurity, given that they both share ecosystems where there's a lot of noise?

Stack: We know from a long history in human, animal, and plant systems that early detection is really critical as is effective response, which is dependent upon early detection. You need to have a full signal-to-solution system in place, and the critical components need to be well integrated, not independent of each other. A plant disease outbreak site is initially messy, and often becomes more messy before forensic analyses begin. That is because response to minimize impacts will come first. We need rapid and effective response to contain and eradicate, if possible. In general, the greater the time between the introduction and the detection, the greater the impacts. One major weakness in the U.S., and globally, is the lack of effective plant surveillance systems to effect early detection.

We've been working on this for 23 years, and to date, we—USDA, the academic environment, FBI—have not collectively come up with a set of criteria that would allow one to say, 'This was intentional.' Unless somebody takes credit for it, which they might, you can never be 100 percent certain. I teach a one-week course in plant biosecurity every year at our biocontainment facility, and on the last day, we do a forensic desktop exercise where the group is split into four teams and I give them an evidence packet of a scenario based on a real event. The scenario is an outbreak of an organism that produced a really serious toxin. The challenge for the teams is to investigate to determine whether it was natural, accidental, or intentional. We give them an evidence packet to look at after they've seen this scenario and come back with questions for the experts. Then we give them the second set that has DNA fingerprint data, aerial photographs, and a guide to help decide whether it was intentional or not. And in the 10 years I've been doing this, only two teams have ever come back and said, 'It was intentional.' The challenge of assigning attribution in an agricultural environment with enormous background noise is exceptionally difficult.

What we've learned is that you need to get on it right away because the system's going to get *more messy* afterwards as you're trying to contain and perhaps eradicate. The current protocol is that the USDA APHIS Plant Protection and Quarantine respond and contact the FBI when they believe it was intentional; then the investigation begins. It's *the reality* that it's exceptionally difficult. Law enforcement and regulatory agencies as well as academic subject matter expert labs may all be involved to varying degrees. Having a fully integrated biosecurity system in place so that you can respond quickly is essential to positive outcomes. If you let the system or the situation evolve, it's going to be nearly impossible to determine whether it was intentional or not.

We commonly think of the biological threats at the species level, but often, the real concern is at subspecific levels of taxonomic discrimination. We're talking strains. We saw this with COVID. Whether that was a natural or manipulated strain still hasn't been fully resolved. It can be exceptionally difficult to do. The best you can do is have a fully integrated system that is going to detect it as quickly as possible and allow you to get in there before it gets even more messy. We know this with COVID, we know this with the Ebola outbreaks in West Africa. During an epidemic, the strains are evolving, and so the genotype composition at the end of the epidemic is not the same as the genotype composition at the beginning of the epidemic. It's the same thing with some pathogens in plant systems. Unless you get in there very quickly, it's going to be difficult to assign attribution. As mentioned earlier, we need to address the lack of effective plant surveillance systems to enable early detection.

CTC: You were instrumental in setting up the National Plant Diagnostic Network, "a consortium of diagnostic labs in the U.S. and its territories to protect plant health through timely diagnostics of plant pests and pathogens."[4] The NPDN was established in 2002 to address vulnerabilities in the U.S. agricultural sector following the attacks of September 11th.[5]

Can you tell us more about what the NPDN does, what entities it works with, and how it supports the U.S. government's agrosecurity efforts?

Stack: Our mission is to provide high-quality diagnostics to support plant health, whether that be in a natural plant system like a forest ecosystem or whether it's agriculture or horticulture. We serve agriculture industries, producers, regulatory agencies at both the state and federal levels, and even homeowners. The success of this has been that we have provided diagnostic services to over 97 percent of the over 3,000 counties in the United States. That's a reach that not a single state or federal regulatory agency or defense agency has. We have approximately 72 labs across all 50 states and the territories in the Caribbean and Pacific. We span seven time zones. When we have our national meeting, we typically have between 150 and 200 diagnosticians and support personnel. NPDN has its finger on the pulse of plant health in the United States.

Any of the systems that we've put in place for protecting our natural and human resources, depend upon a highly trained, educated workforce. And so that's one of the things NPDN does. We have an NPDN professional development program, and we link with USDA for advanced training for our diagnosticians. We keep them trained, and we keep them aware of what's happening and what's on the horizon.

NPDN regularly interacts with regulatory agencies. For example, during multiple incursions of the select agent *Ralstonia Solanacearum* Race 3 Biovar 2 into the United States, NPDN provided diagnostic support because when those introductions happened, many states were involved; the last one affected 26 states. When APHIS needs sample surge support, they connect with NPDN. We provide that support. We are not, nor do we wish to be, a regulatory agency. We have no regulatory authority. We have *responsibility* to provide services to our state or the nation as needed.

CTC: When you think about vulnerabilities and threats—to the extent that you can share—of plants being weaponized or used to create harm or instability intentionally, what concerns you? Can you paint a bit of that picture just so then we can drill into a case here?

Stack: One vulnerability in the plant sector, and I suspect in others as well, is that we establish programs and build infrastructure to achieve biosecurity, but then under-resource those programs to the point where they cannot fully achieve their mission. We check the box that we have done something, but we do not follow-up to ensure that the programs are at operational levels adequate to the challenges. The National Plant Diagnostic Network is an excellent example of an outstanding program that is tremendously under-resourced relative to the challenges it is being asked to address.

We talked a little bit about tipping points. There are many ways to do that. We look at Ukraine, and the disruption was war. But *anything* that disrupts that network is a potential for a national security event. We have policies that regulate trade and the safety of that trade regarding organisms that might move from one country to another. That's the International Plant Protection Convention. The World Trade Organization requires any nation that wants to enter into the global marketplace to abide by these regulations. So, if an organism is detected in a shipment, a country has a right to refuse entry and may stop trading with that nation. Whatever the disrupter, it's often the same eventual impact, and that's the way we need to look at this: Anything that disrupts those trade channels has the potential to destabilize a locale, a region, or even a nation. It only takes an organism being detected. You don't even have to be sophisticated enough to know how to cause an epidemic to disrupt trade; it can be just a detection.

If you are a terrorist and you want to make the evening news, you put a bomb on a bus. You cause some impactful event that is immediate and shocking. But if the goal is to undermine a nation, you go after more subtle targets. We have a history of what happens when you impact the cost of food or you disrupt trade. And again, if your goal is to cause an epidemic, to put an organism in place, that's *really* hard to do. It's hard to do in human systems, but it's really hard to cause an epidemic in a plant natural or agro-ecosystem; the environment is a significant regulator and quite variable. One of the most frightening things for me from the COVID experience was not the illness that it caused, but that it demonstrated we now have a really great vector, SARS-CoV-2, that will spread like wildfire around the planet. That's frightening.

From a plant health perspective, we have some high consequence pathogens we're worried about right now, including the wheat blast pathogen. It's a fungus called *Magnaporthe oryzae* Triticum that emerged in Brazil in the 1980s. It spread in Brazil, then into Bolivia, Paraguay, and now most recently Uruguay. But the big deal was in 2016, it was introduced into Bangladesh and caused a major epidemic. The following year, it was introduced into Zambia in East Africa. These are areas of the world with inherent instability vulnerable to tipping point consequences; South Asia as we just saw with Pakistan and India,[6] which are two nuclear nations, and near neighbor Bangladesh that is dependent upon wheat to maintain food security. Zambia is at the southern end of the eastern wheat belt in Africa. This organism spreads, and these are staple crops at risk. What does it take to cause civil unrest? Actually, not much. Plant health issues are perfect as tipping points, when people don't have food, they migrate or they protest. The resulting consequences can be short-term and contained (e.g., food riots of 2008) or long-lasting, disseminated, and destabilizing as in the case of the Arab Spring of 2010.

CTC: There also might be an interesting takeaway here about the types of actors that we need to be concerned about. With that 'bomb on the bus' example, for certain groups, that tactic will be 'appealing' because it's loud and has an immediate impact. But it sounds like one of the core aspects of agrosecurity threats is the danger of a quieter, more strategic, longer-term action, which might impact the types of violent extremists or terrorist groups that could be attracted to this type of activity, and which might be different than a lot of the terrorists we think about today. I also think about proxy groups and then nation-states, too, as you mentioned. Would you agree with that?

Stack: I would agree with that, most definitely. We're talking about 'intentional.' What's the first part of that? Intent. And that's the most difficult aspect to wrestle with. When thinking about intent, the nature of the event is as important as the magnitude of the event. For example, blowing up a seed factory resulting in one death and all the seed destroyed in the fire. The magnitude of the event was relatively small, one death and one destroyed building. But the

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nature of the event was to eliminate the crop seed for 50 percent of a nation's farmers—enormous impact. You want to know what keeps me up at night? Anarchists. They keep me up at night because so far, the true terrorist groups are more concerned with the bomb on the bus. Anarchists, on the other hand, are super difficult to predict, and they have multiple motivations. They're not really ideologically driven. It's hard to calculate what's going on in that community. Their common denominator seems to be disruption and destabilization.

CTC: This June, the U.S. Department of Justice announced that it had charged two Chinese nationals with smuggling "a potential agroterrorism weapon" into the United States (a fungus called *Fusarium graminearum*)—among other charges.[7] And one week later, it was announced that a third Chinese national had been charged for smuggling biological materials into the United States—among other charges.[8] Recognizing that few details from these cases are publicly available, which limits what can be known about them specifically, what did you make of that news when you first heard it? Were you surprised or concerned?

Stack: Concern that it was going to cause a major problem in the United States? No, not so much. With the caveat that few details about the case are available, it seemed if that's the best they've got, just let them keep going down that road because it's not likely to lead to something significant. That organism, *Fusarium graminearum*, exists all over the United States and all over the world; a lot of expertise exists on the pathogen and its management. Unless they figured out some way to increase its aggressiveness, virulence, and/or dispersal capability, or very specifically, enhanced its toxin production (nivalenol, deoxynivalenol), then I don't think it would make a great bioweapon. It would have to displace the pathogen populations that are already widely prevalent in the environment; that would likely take a long time without a substantial ecological advantage. In addition, there are reasonably effective mitigation measures for this pathogen (e.g., fungicides), and we have an excellent forecasting system in place developed and deployed by a scientist at Kansas State University. I didn't think that was a great pathogen to use as a bioweapon. But that event may be less about *Fusarium graminearum* and more about finding the best way to sneak an organism into the country; that could be an equally important concern. However, the most likely explanation in this case is a few scientists disregarding the established regulations on the legal movement of pathogenic organisms. Perhaps, in time we will know.

What I did worry about is putting that idea/suggestion into the minds of people or groups with intent to disrupt or cause harm: 'Isn't that interesting? I wonder if we could that type of thing.' This event drew a lot of attention, at least in the press. I worry that it raises this idea that 'maybe that's something we should be thinking about doing.' We need somebody or some entity keeping track of all these events. Following any introduction of a plant pathogen, we do two things, trace-forward and trace-back (i.e., where is going from the introduction site and where did it come from?). We need to be doing that for all of these events and have a database that we can refer to and learn from. I'm sure that this is being done.

CTC: How are advancements in technologies such as artificial intelligence lowering the barriers to entry for those less specialized individuals to engage in agroterrorism or create novel threats?

Stack: Artificial intelligence is a very big deal. Even with AI programs as simple as ChatGPT, you can ask it to write the algorithm that you need to accomplish some task. You don't need to know how to code anymore. It's the same with DNA or RNA sequencing. There are many specialized companies that do that for you. You request a sequence, and one or two days later, you receive that sequence—maybe the sequence for a virus of concern. It can be alarming without proper context.

There's a saying that 'what kills you, cures you.' It's the same in reverse. The technologies that we are developing and the research that we are conducting to make things better, of course, could be misused, but that's almost true with everything. A spoon in the wrong person's hand could be lethal. So, I think this is about anticipation. It's about preparedness in a true sense. It's about evaluating all the scenarios, the red teaming, and identifying what could be done to mitigate the consequences of an introduction of a biological agent whether that be disruption of trade or an epidemic that disrupts food production. This is where we have the challenge of this notion that certain types of research shouldn't be allowed. Do you think criminal organizations and terrorists are going to abide by those rules and regulations? This is about whether people are responsible in the way they do research. That's true for any kind of research. It's why we have biosafety protocols, why we have biosecurity protocols, why every academic institution has an Institutional Biosafety Committee, an Institutional Review Entity, and an Institutional Review Board that looks at every program to evaluate what the implications of that research are. All those are in place and functioning well from both safety and security perspectives.

CTC: What it sounds like is that while obviously there are

concerns about how advances in technologies are lowering the barriers to entry for nefarious actors to do bad things, there are opportunities to leverage those same technologies within government and across private-public partnerships to help us get ahead to monitor these threats for good. And there's a real parallel on the counterterrorism side, which has been very good at preventing different threats, but a next challenge for the counterterrorism community is how we leverage these technologies and integrate them into our ability to do things at greater speed and at scale. It sounds like there's a similar challenge in your field as well.

Stack: Absolutely. Utilizing these technologies in response offers several advantages, the computing power, the speed is just astounding. When you're dealing with the detection of something unknown, you have to make decisions on the next best steps, most often with incomplete information. And this is where some of these tools like AI modeling can really help generate your options much more quickly than with pen and paper, literature searches, and endless database queries. One important element that is not fully in place yet is the integration of networks and database systems that contain relevant information important to deriving effective solutions to unknown pathogen introductions. Even in the sequencing era, it can take time to identify an organism and its origin with the level of certainty that gives confidence to response efforts.

CTC: Is there anything else that we haven't talked about that you think would be important for our readers to know and understand?

Stack: I'll finish where I started, and that is, most people are unaware of the benefits they receive from plant systems. Plants are the foods that we consume directly and the feeds that we provide to the animals that we consume. Approximately 20-25 percent of the medicines that we depend upon come from plants. The chemistries that other medicines are built on came from plants. If you look at the history of medicine, it started with plants. While many benefits from plants are obvious (e.g., food and nutrition), some benefits are very subtle. For example, there's solid data that the more greenery you have in an urban setting, the less crime you have.[9] Psychologists did a study a number of years ago, and even people in urban center settings that don't get to travel much have psychological benefit in knowing there are national parks.[10] There's something calming about an interaction with a natural setting. Plant health underpins human health and well-being. People have not lost their connection to plants; however, most people have lost their awareness of that connection. The consequence of that is that it doesn't enter into how we formulate plant health policy nor how we fund programs that support plant health, like the National Plant Diagnostic Network. We need to recognize that just because you're not thinking about plants, doesn't mean your life isn't dependent upon them. CTC

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