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Biosecurity Vulnerabilities in Crop Monocultures

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In the early summer of 1968, a farmer in Louisiana stirred at

sun-up, fixed a pot of coffee and headed out to check his crops. Like a handful of others in the southern United States, this farmer noticed for the first time small, elongated brown lesions running up and down the leaves of his corn. Eventually, these plants would wilt and die, or experience extensive rot that would render the vegetable inedible. By 1970, thousands of farmers from Florida to North Dakota witnessed the same symptoms on row after row, and acre after acre of corn. The disease soon had a name: southern corn leaf blight (SCLB).

The fungal pathogen that causes SCLB, although virulent, could only infect a specific hybrid of corn. This hybrid of corn, which was bred to develop a more efficient ear, was one of the most planted seeds in the United States at the time. Once the

cause of the vulnerability was discovered, seed companies simply switched hybrids. By 1972, the U.S. corn market rebounded and SCLB was suddenly a thing of the past -- though not before billions of dollars in economic losses and countless farm foreclosures.

The 1970 SCLB epidemic is a prime example of a fast moving crop disease that can inflict sudden and significant damage to the U.S. agricultural industry. Countless other crop pathogens and pests find their way onto American soils each year, and many of them lack proven methods to mitigate them.

Due to the ever-increasing demand for food on a global scale, and the emergence of significant threats against major U.S. staple crops like corn, wheat and soybean, Propagate Ventures

conducted a brief analysis of bio-security vulnerabilities in crop monocultures. This analysis explores possible solutions related to agroforestry in order to mitigate threats and vulnerabilities.

THE COST OF PLANT DISEASE

Before diving into specific threats and vulnerabilities, it's useful to look at the scale of the current U.S. crop market, as well as some rough estimates of crop losses due to disease. Intensification of the modern agricultural industry has garnered unprecedented yields; the United States enjoys the largest shares of corn, wheat and soybean markets, both domestically and internationally. In its entirety, the US agricultural industry produces approximately

$200 billion worth of crops annually. Total agricultural services are typically near $1 trillion.

In any particular year, flooding, severe storms, drought, weeds, disease, and a confluence of other factors cause crop losses. Consequently, it can be difficult to separate losses exclusively due to disease and pest infestation on a national level. Nonetheless, researchers have attempted to conduct crop loss assessments, with estimations of 20-40% total crop loss due to pathogens, pests and weeds. On a more granular level, annual wheat losses due to wheat rusts, a prominent fungal infection, are estimated at $5 billion, with wheat losses due to Fusarium head blight estimated at $3 billion annually. Soybean rust, another fungal infection, causes several billion dollars in soybean damage a year in Brazil and has been projected to do as much in America in the near future. As highlighted, the outcomes of plant pathogen epidemics can be large and economically consequential.

TRANSMISSION VULNERABILITIES

The most concerning issue regarding crop biosecurity is the relative ease of introduction, transport and transmission of plant pathogens. The introduction of these pathogens, accidental or otherwise, poses a seemingly insurmountable security threat.

American farms are constantly exposed to new plant pathogens and pests through international trade. Some pests are especially hearty. For example, the khapra

beetle, which feeds on wheat stores, can survive without water for years at a time, allowing it to travel long distances in search of food stores. Furthermore, its diminutive stature makes it incredibly difficult to detect. The USDA has intercepted hundreds of cases of khapra infestations at border inspections over the past decade, but it’s a near certainty that this nonnative pest and others have established small populations in the country. In such cases, unfavorable environmental conditions are the only barriers to the development of large-scale epidemics.

Plant pathogens such as the aforementioned southern corn late blight have highly evolved methods of dispersal that hamper eradication. Pathogen spores can travel many miles via wind; soybean rust is theorized to have made its way to America from Colombia on the winds of several hurricanes, especially Hurricane Ivan, during the 2004 storm season. Ug99 wheat stem rust, a feared fungus that 80-90% of wheat plants are extremely susceptible to, has travelled thousands of miles from Africa to Europe via wind. The relative monoculture that extends through the Corn Belt and beyond provides a robust corridor for pathogens such as Ug99 to move efficiently across the country. Crops can also contract disease simply through contact with infected farming equipment or leaf splash during a storm. Indeed, citrus canker quickly devastated the Florida citrus industry in part by using these dispersal mechanisms.

Traditionally, the country's best defense against plant pathogen transmission is its climate. Plant pathogens typically require

warm, wet weather to reproduce at high levels. Although a disease might wreak havoc in a given year, winter temperatures in

North America have provided an opportunity to recover by killing remaining pathogen inoculum, thereby limiting year over year losses. Disease and pest epidemics are particularly finicky because environmental conditions such as extended drought can curb even the most potent fungal infections. Unfortunately, this natural defense system has recently been and will continue to be compromised by the burgeoning effects of climate change. Rising temperatures and shifting precipitation patterns indicate hotter, wetter conditions in the Midwest, with a severe decrease in freezing days in winter. Consequently, pathogens that have historically failed to

establish reproductive populations in the country, especially tropical pathogens, will now be more likely to thrive.

BIOLOGICAL

VULNERABILITIES

Monocultures are exceptionally vulnerable to disease. An epidemic starts when a disease can exploit a genetic trait that allows unprecedented access to a crop's core functions, usually to the great detriment of the crop's health. SCLB exploited a genetic vulnerability found in the hybrid corn used in America in 1970, causing billions of dollars in damage. Luckily, agricultural scientists were able to quickly mitigate the vulnerability by using a different hybrid. But not all weaknesses are so easily diminished. Currently, the fungal

diseases black sigatoka and fusarium oxysporum TR4 have infected a majority of the world's banana trees, which lack resistance, literally endangering the global banana stock. In general, the introduction of a pathogen that can effectively exploit a genetic vulnerability of a major staple crop can create immediate and pressing food security issues. In the current agricultural context, it's easy to see how a monoculture comprised of genetically similar plants grown by the majority of American farmers can endanger food security.

SUPPLY CHAIN VULNERABILITIES

The success of the modern agricultural industry has multiple roots, including but not limited

to: increased fertilizer and pesticide use, efficient irrigation, enhanced storage and improved farming equipment. Perhaps most importantly, farm management practices have become streamlined, with an emphasis on specialization. Farmers no longer produce their own seed, nor do they have the equipment to clean it. Instead they almost exclusively buy seed from agriculture tech companies, and for good reason. These companies, through economies of scale, provide seed that boasts germination rates of 95% and antifungal coatings that provide adequate protection against many serious pathogens.

Unfortunately, this consolidation of power has a serious drawback. A main tenet of resiliency is a sensible decentralization of resources and knowledge. At the moment, the industry has

incrementally bred out the individual farmer's ability to self-sustain, perhaps even at the community level. A significant security breach in a major agricultural technology company, or the development of another exploitable genetic vulnerability, could result in considerable losses if seed were recalled or susceptible to novel pathogens.

SOLUTIONS

Plant security may be at risk, but there are several actionable ways to protect against and mitigate

damage from plant pathogen and pest epidemics.

1) Convert conventional farms

into agroforestry farms. The conversion of conventional farms into agroforestry operations mitigates several important issues outlined above. Primarily, conversion physically helps break up the monoculture, which leads to a smaller, less connected population of host crops available for disease transmission. The addition of trees to cropland also increases sequestration of carbon, decreases erosion, and serves as heat sinks (through evapotranspiration), all of which are proven approaches to help mitigate the effects of climate change. This, in turn, mitigates the spread of diseases that benefit from increased temperatures. Finally, the diversification of revenue streams created through agroforestry can help mitigate economic losses in times of drought and disease.

2) Plant a variety of seeds, and support local seed companies. Planting genetically distinct seeds, including heirlooms, provides some protection against epidemics because certain varieties have developed or maintain a natural resistance to pathogens. Furthermore, purchasing seed through local seed companies ensures decentralization of resources, which enhances resiliency. Any future incident that occurs at a major agricultural tech company can then be mitigated through such redundancies.

3) Create robust surveillance systems that catch infestations and epidemics early. To an extent, this already exists. The USDA created the iPIPE (Integrated

Pest Information Platform for Extension and Education) system to help farmers share on-the-ground data via an online geographic platform that maps pathogen incidence in near real-time. This collaboration is a considerable step towards effective surveillance in the agricultural industry, but it's still a relatively nascent system that is underutilized. A strong push to enhance collaboration amongst farmers will help to bolster crop biosecurity in America.

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