CHOICES
The magazine of food, farm, and resource issues
A publication of AAEA Agricultural & Applied Economics Association
VOLUME 39 QUARTER 4

The Perfect Storm That Hit Florida Citrus

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JEL Classifications: Q1, Q18
Keywords: Collective action, Invasive species, Pest management

Citrus production in Florida has decreased by more than 90% since 2005 (USDA-NASS, 2024a). Such a decline in the state that used to be the top citrus-producer nationwide is mainly the consequence of the impact of a bacterial disease called Huanglongbing (HLB) or citrus greening. In recent years, the cumulative impact of HLB on Florida citrus has been compounded by additional challenges, including weather shocks, rock-bottom fruit prices, and skyrocketing input prices. Also, in 2016, the policy decision to approve the use of foliar antibiotic sprays to combat the disease, without any scientific evidence on their effectiveness, can sensibly be argued to have contributed to weakening the only voluntary collective action effort that was in place. As a consequence of those challenges, the entire Florida citrus industry has downsized significantly, and it is unlikely to make a comeback.

The marked increase in international trade starting in the twentieth century has unintendedly contributed to the spread of invasive species worldwide (Epanchin-Niell et al., 2021). But it is hard to find another example in recent history of an industry as iconic as Florida citrus that has declined so significantly in such a relatively short period of time primarily due to an invasive plant disease. There are, however, other orchard plant diseases that currently pose a looming threat to other crops. Panama disease, for example, can cause a 100% yield loss on banana farms (FAO, 2023), jeopardizing worldwide production of Cavendish bananas. Such a cultivar represents over 40% of global bananas production and virtually all exports (Dale et al., 2017). Also, the impact of the olive quick decline syndrome on the historical Italian olive-producing region of Puglia (Schneider et al., 2020) potentially represents a case as significant as that of HLB in Florida. The disease is expected to cause olive yield losses of 35% in trees younger than 30 years and 69% in older trees (Bragard et al., 2019).

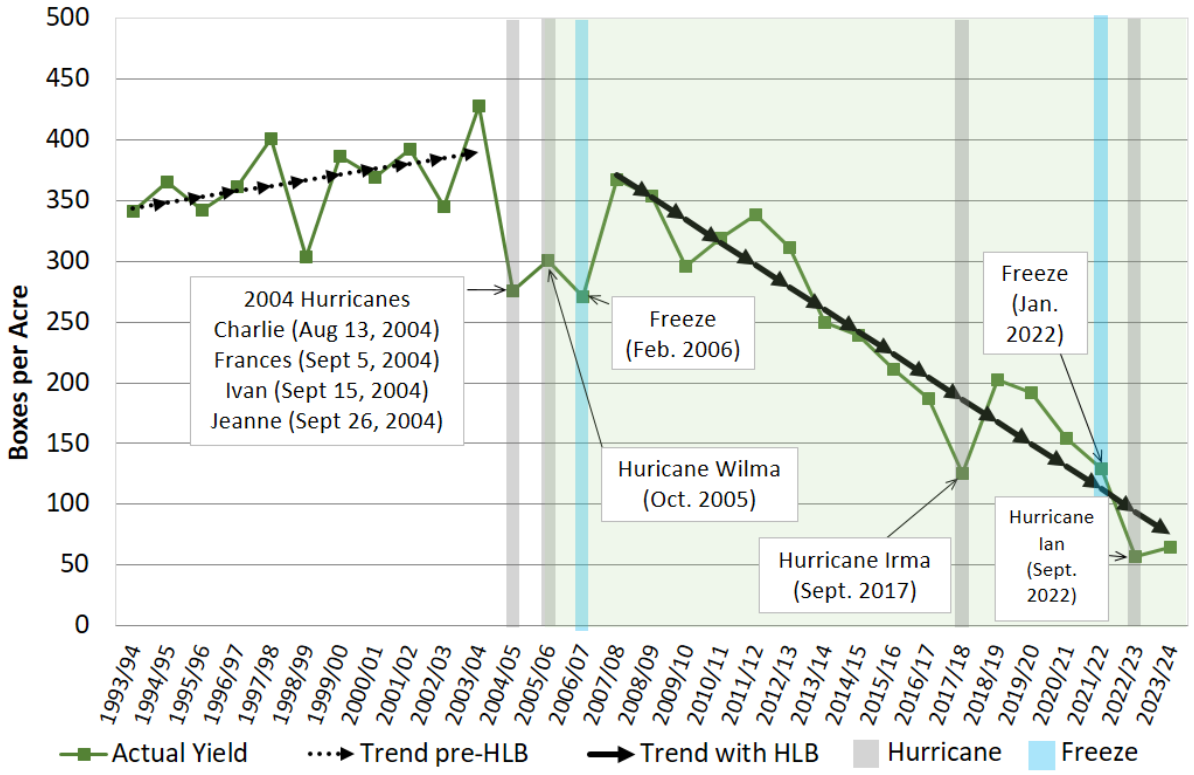
The Devastating Impact of Citrus Greening Disease

Figure 1 shows the average orange yield per acre from 1993/94 to 2023/24 in Florida, where 90% of citrus production is devoted to processed oranges. The figure illustrates how yield and its trend have changed over the last 30 years. In fact, the figure shows two distinct trend periods. During the period from 1993/94 to 2003/04 (before HLB was found), the trend in yield was increasing. In the mid-2000s, three major weather events hit Florida, including back-to-back hurricanes in 2004, another hurricane in 2005, and a freeze in 2006. Those weather shocks caused yield to decrease significantly, albeit temporarily. In fact, production recovered substantially in 2007/08 but, as denoted by the shaded area in Figure 1, HLB had been found in the state in 2005. Consequently, beginning in 2007/08 the average yield per acre statewide (and its trend) began a period of marked continuous decline. Given that from 2007/08 to 2016/17 there were no weather shocks, it can be sensibly argued that the 55% decrease in yield per acre during such a period was due to the spread and progression of HLB throughout the state.

To try to manage the disease, Florida citrus growers adopted multiple cultural practices, including foliar nutritional sprays, the spray of foliar antibiotics, and a voluntary area-wide pest management program by which neighboring growers coordinated insecticide sprays to control the vector of the disease. The adoption of those practices resulted in a sizable increase in the real cost of production per acre, reaching a peak of 75% in 2015. Importantly, however, due to the simultaneous increase in cost per acre and decrease in yield per acre, the increase in the real cost of production per box was 283% (Singerman, 2019). While fruit price did increase due to the leftward shift in supply generated by the impact of HLB, it did so by a smaller percentage, resulting in losses for the average grower and causing many of them to exit the industry. According to census data from the USDA, the number of citrus growers in Florida decreased by 69% from 2002 to 2022.

As a consequence of the decrease in domestic supply of orange juice driven by the decline in orange production in Florida, U.S. imports, which are primarily from Brazil and Mexico, have increased by roughly 50% since HLB was first found (Figure 2). In fact, as shown in Figure 2,

Figure 1. Average Orange Yield per Acre and Trend in Florida



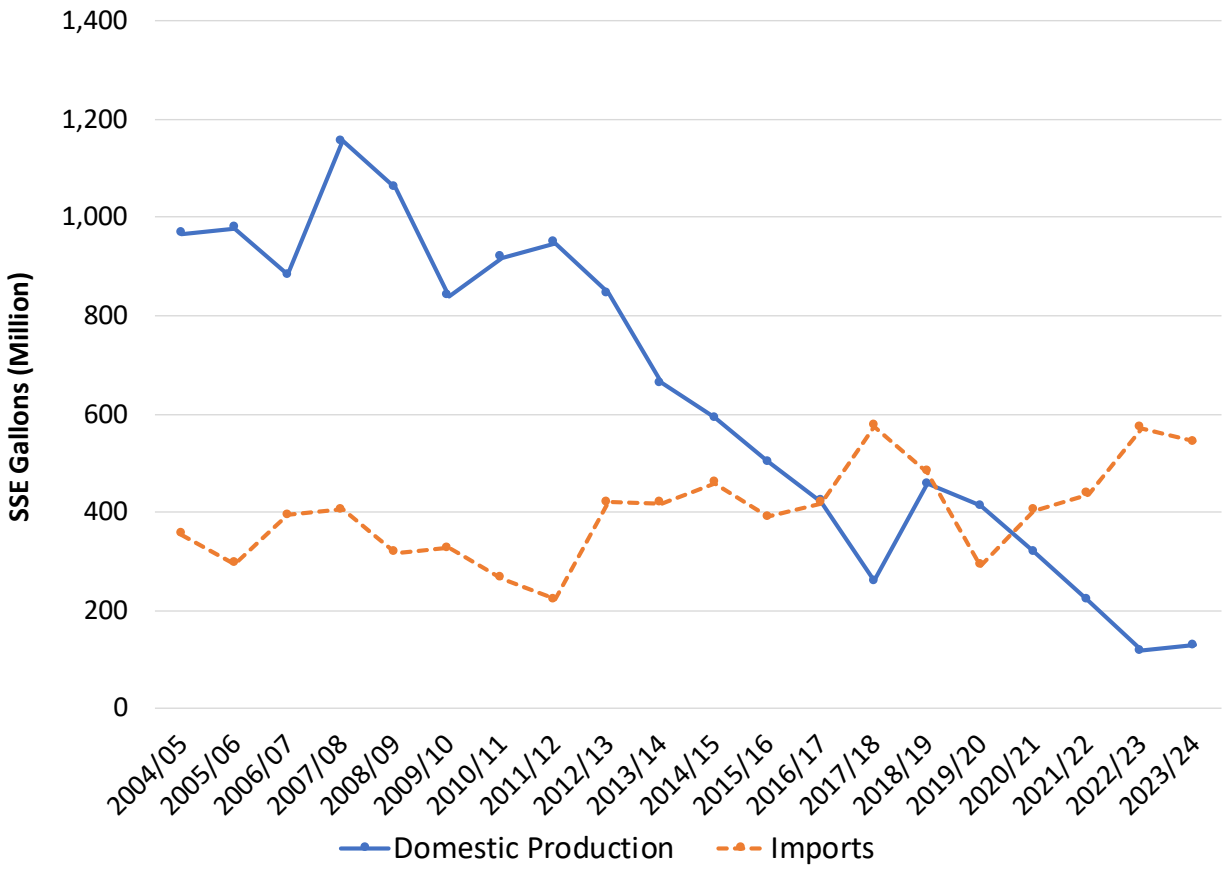
Note: Shaded area denotes Huaglongbing (HLB) disease (found in 2005).
Source: USDA-NASS and author's calculations.

orange juice imports surpassed domestic production during the last four seasons because, while orange production in California—historically the second-largest orange producing state and now the first—has not yet been significantly affected by HLB, most of the crop in that state is commercialized in the fresh market (USDA-NASS, 2024b). The increase in orange juice imports in recent years can also be attributed to the impact that HLB has had on the quality of Florida oranges, which is measured in dissolved sugar solids. The decrease in quality started to make it more challenging for processors to meet the USDA standard for not-from-concentrate orange juice of 10.5 brix when sourcing oranges from Florida (Neff, 2021). While there is a heated debate about the impact of imports on Florida growers' profitability for crops such as tomatoes and blueberries (FDACS, 2022), orange juice imports have not only been necessary for processors but also beneficial to growers to some extent. This is because higher-quality imported juice is blended with Florida juice to improve quality and meet the USDA standard. Had imports been restricted, the quantity of orange juice that processors would have been able to sell as not-from-concentrate would have been lower, and the lower quality fruit from Florida would have received a lower price (i.e., that for concentrate juice).

A Questionable Policy: The Approval of Foliar Antibiotics Sprays

Invasive species like HLB pose a collective-action problem because the ability of individual farmers to effectively control such pests depends critically on the actions of neighboring farmers, creating a public-good dilemma (Lazarus and Dixon, 1984; Perrings et al., 2002; Florec et al., 2013). Importantly, the negative spatial externalities from the lack of collective action in pest and disease control can be more severe and difficult to deal with for the case of perennial crops. This is because (1) cultural practices that are effective at reducing disease inoculum in annual crops, such as crop rotation, delayed fall planting, and tillage are not feasible in perennial crops; (2) the spatial externality also acquires a time dimension because perennial plants do not start anew every year; and (3) in some cases, the plant is infected prior to the canopy showing any symptoms, which prevents growers from removing all sources of inoculum. For example, according to Bové (2006), the incubation period of HLB symptoms lasts 6 to 12 months, causing the spread and impact of the disease to occur over multiple years. Moreover, the latency period together with the typical recommendation by plant pathologists to remove symptomatic trees is problematic from an economic perspective because

Figure 2. Orange Juice Production and Imports in the United States



Source: USDA-FAS.

trees can still be productive during that stage, making growers reluctant to eradicate them.

It would be reasonable then to expect that policy makers take the aforementioned considerations into account when making decisions regarding how to address invasive species. But neither at the state or federal governmental level there have been significant efforts to develop policies, institutions, or incentives to address the issues derived from the public-good nature of HLB in Florida. Even if policy makers were unaware of the considerations listed above on invasive species, it would at least be reasonable to expect that any approval decision to attempt to address an agricultural disease by the use of antibiotics—particularly if those compounds are also used to treat bacteria affecting humans and, therefore, could potentially involve externalities—be based on scientific findings. The most basic finding being that the antibiotic and its application method be effective against the bacteria they will be used against. But that was not the case in the approval of foliar applications of antibiotics against HLB in Florida citrus groves.

The Florida Commissioner of Agriculture at the time approved the use of antibiotic foliar sprays in commercial citrus groves throughout the state in 2016 (FDACS, 2016). But the expected improvement of spraying antibiotics on HLB-affected trees in the field had not been scientifically proven; there was only some evidence regarding their effectiveness in a lab setting (Zhang et al., 2014). Despite the lack of evidence, most growers in Florida adopted their use; in approximately half of the cases, they did so at the expense of voluntary coordinated insecticide sprays that targeted the vector of the disease, which had been found to be effective and profitable (Singerman, 2017; Singerman, Lence and Useche, 2017). Eventually, antibiotic foliar sprays were found to be ineffective in improving the health of HLB-affected trees in the field (Li et al., 2019). Their widespread adoption, paradoxically enough, had already worsened the problem because growers' decisions to adopt antibiotic foliar sprays weakened their participation in the voluntary collective action involving coordinated insecticide sprays (Singerman, Lence and Useche, 2017). Moreover, the use of antibiotic foliar sprays also contributed to increase the population of the disease vector and reduce its susceptibility to insecticides (i.e., increasing resistance) owing to an increase in the variability of growers' insecticide use statewide (Chen et al., 2018).

Weather Shocks and Market Swings

Starting in 2017/18, multiple factors combined to compound the impact of HLB on orange yield in Florida. Hurricane Irma hit Florida in September of 2017. Yield that season decreased by 33% relative to the previous one, mainly due to sustained high winds that blew the crop off the trees. But the storm also impacted yield in the medium term due to the uprooting of trees in some groves and flooding in others. While orange yield recovered the following season, processors (who had been concerned about the potential speed of recovery from the hurricane) had signed multiyear contracts for importing juice from Brazil and Mexico. The impact of those commitments caused price to decrease by approximately 50% in 2019/20, making it impossible for the vast majority of growers to break even. Despite that price increased in 2020/21 driven by the surge in demand due to the COVID pandemic, on average, growers responded to the previous season market swing in orange price by reducing expenditures in almost all grove caretaking programs (Singerman, 2022), which can be reasonably argued to have contributed to the yield decrease that occurred that season.

In 2021/22, the lack of profitability of citrus production in Florida was worsened by the dramatic increase in input prices—the price of fertilizer roughly doubled in 2021 triggered by the outbreak of the war in Ukraine—which affected most agricultural producers. Florida citrus growers responded to the price increase by buying cheaper alternatives to the chemicals they had been using and by cutting back on other cultural programs. Those changes in practices can also be argued to have contributed to the decline in yield that season (Figure 1).

In addition, in January of 2022 there was a freeze that affected late-season oranges in some parts of Florida. Later that same year, hurricane Ian hit Florida and many citrus groves across the state were affected. Thus, as illustrated in Figure 1, the endemic state of the disease in combination with other factors in recent seasons, has caused a 30% decrease in orange yield per acre in Florida since 2018/19.

Why Is the Florida Citrus Industry Unlikely to Make a Comeback?

HLB has been the major driver of the decline not only in citrus yield in Florida but also in acreage. Citrus-bearing acreage statewide has decreased by approximately 50% since the outbreak of the disease (USDA-NASS, 2024b). The decline in acreage started a few years earlier due to the combined impact of the state's canker eradication program in the late 1990s (Singerman and Rogers, 2020), the increase in real estate development across the state (Zhao and Bakshi, 2024), and the decrease in demand for orange juice (USDA-NASS, 2007). But HLB made citrus production in Florida much more challenging, requiring the implementation of intensive grove management and adaptive caretaking practices each season. Many growers who were not able to keep up with the increase in expenses associated with those practices, or that experienced continuous losses season after season despite incurring in the additional costs, exited the industry. The lack of alternative crops that growers could plant to replace citrus (due to soil, weather, and market considerations) have resulted in much of the land that had been devoted to citrus production across the state to be converted to other uses.

Figure 3. Citrus Acreage Attrition (percentage) by County in Florida, 2004–2022

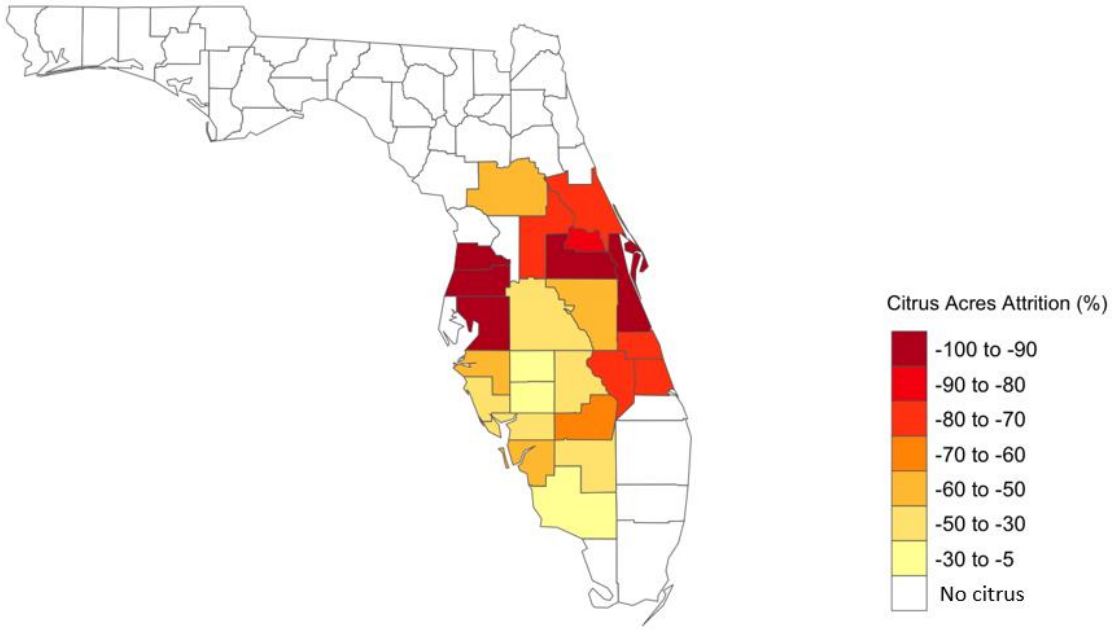
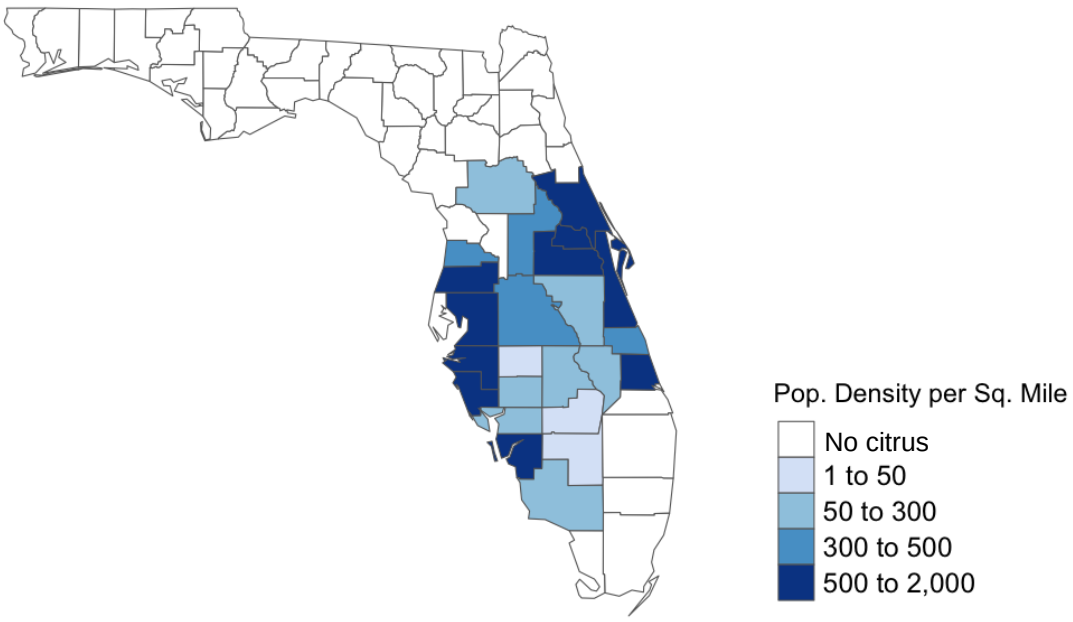


Figure 4. Population Density (per square mile) in Florida Citrus-Growing Counties, 2020



Some counties in Florida had over 70,000 acres committed to citrus production in 2004. Even counties with large urban centers had at least some acreage dedicated to citrus production at that time. For example, in 2004, Hillsborough, Orange, and Sarasota Counties—where the cities of Tampa, Orlando, and Sarasota are located—had 20,000, 5,600, and 1,700 citrus acres, respectively. But by 2022, citrus acreage had declined in all Florida citrus-producing counties, and in some of them, it had mostly vanished. Figure 3 shows the percentage of citrus acreage attrition by county from 2004 to 2022. Five counties experienced a decrease in citrus acreage equal to or greater than 90%. The decrease in acreage has been driven by the lack of citrus production profitability combined with the increase in the state's population.

According to data from the U.S. Census Bureau, the population in Florida increased by 18% from 2010 to 2022. With a population estimated at 22.2 million, Florida became the third most populous U.S. state and, in 2022, it was also the state with the fastest-growing population. The increase in population requires building additional housing and infrastructure to accommodate new residents. Figure 4 shows the population density in citrus-growing counties in 2020. It should be readily apparent that the darker-colored counties in Figure 4 (that is, where most people live) mostly coincide with the counties in which the percentage of citrus area lost is the greatest in Figure 3. This provides evidence that the demand for land is higher in those counties and, thus, exerts more pressure on citrus land because they (most likely) offer a higher opportunity cost to growers.

Another contributor to the change in the use of citrus land has been the development of solar farms. Florida ranked as the state with the highest number of solar panel installations in the third quarter of 2023 (SEIA, 2023). While in some cases the land converted to solar farms is leased, the contracts are typically for multiple years. Therefore, even if a cure to HLB were to be found tomorrow, much of the area that had been devoted to citrus production in the past is no longer available.

Importantly, the number of orange juice-processing facilities (packinghouses) decreased by 83% (78%) from 2005 to the present, and it is very unlikely that such infrastructure would be rebuilt. Having fewer processors and packers creates concerns about the potential increase in market power but, perhaps more importantly, may further compromise growers' profitability due to the higher cost that they may need to incur in to ship their crop to more distant facilities.

Conclusions

Invasive species can be more challenging and costlier to manage in perennial crops because the damage they cause often persists in subsequent production years. In addition, incentives to find solutions can be limited by the size of their markets. In the case of HLB, while public and private funds for research are estimated to total $750 million so far, no economically feasible management strategy or cure has yet been found (USDA-APHIS, 2024). To some extent, this may be due to the fact that it generally takes a few years to obtain a crop out of a perennial plant, making it more arduous for scientists to come up with solutions in the short and

medium term. But HLB is a particularly difficult pathogen to conduct research on. For example, researchers have only recently made progress in obtaining a culture of the suspected causal agent of the disease in vitro (Zheng et al., 2024).

Importantly, a distinctive characteristic of the effective management of invasive species like HLB is addressing the public-good nature of the problem they pose. But there have been no significant efforts at either the state or federal level to develop policies, institutions, or incentives to address such an issue in Florida. On the contrary, the approval of the use of antibiotic foliar sprays—without scientific evidence on their effectiveness, and the eventual finding of them being ineffective—together with their widespread adoption by growers weakened the only voluntary collective action effort that had been in place.

Given that farmers' pest control and disease management decisions can have impacts beyond their own farms and that invasive species present a problem that may best be addressed through collective action, there are important roles to be played by land-grant university research and extension personnel. Those include making policy makers aware of the consequences of farmers' preferences for technologies that present different sources of uncertainty when externalities on the environment and human health are involved, disseminating science-based findings that underpin technological and policy approaches to address the collective nature of the problem that invasive species pose, and engaging stakeholders to achieve common-good goals.

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