Cost-benefit analysis of area-wide management of Laurel wilt disease in Florida commercial avocado production area

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Laurel wilt (LW), caused by *Raffaelea lauricola*, is an invasive, lethal disease of members of the Lauraceae plant family in the southeastern United States. Since 2003, it has killed millions of native forest trees and has impacted commercial avocado production in South Florida. Given the destructive nature of this disease, there are major concerns over the future of the Florida avocado industry, which provides an annual economic impact of nearly $100 million (USD). Cost-effective management of LW remains an elusive goal. In 2012, an area-wide management program centered on early detection and destruction of affected trees, funded largely through a combination of industry, state, and federal sources, was implemented with the aim of preventing or drastically slowing the spread of the disease in the commercial avocado production areas. However, given that the disease is now endemic within the production area, some of the stakeholders have begun questioning the wisdom of maintaining the program. Given these developments, this study assesses the potential net benefit of the area-wide management programs. The results of the analysis indicate that the benefits of the program far exceed the costs, suggesting that while not ideal, the program has played a significant role in minimizing the rate of spread, thus providing time for scientists working around the clock to continue their effort towards developing a cost-effective treatment.

Keywords: Invasive Species, Ambrosia beetle, Gompertz function, *Persea americana*, *Raffaelea lauricola*

INTRODUCTION

The United States (USA) is the seventh largest producer of avocados worldwide, following Mexico, Dominican Republic, Colombia, Peru, Indonesia, and Kenya (FAOSTAT, 2013). Total US production for 2013 was about 175.2 thousand tons. There are two main commercial avocado regions in the USA, namely southern California and southern Florida. The former has about ten times the production area of the latter and produces approximately 90% of domestic production. While production in California is based largely on the Guatemalan and Mexican races of avocados, in particular the Hass variety, production in Florida is based primarily on the West Indies varieties. Florida is the only area of the continental USA where West Indian and Guatemalan-West Indian cultivars can be grown commercially; thus, to a certain extent, the two regions complement each other.

Despite only accounting for about 10% of local avocado production, the Florida avocado industry is of considerable importance to the state. It is the state's third largest fruit industry after citrus and blueberry, with a farm gate value of $24 million (all currency is USD) annually, wholesale value upwards of $35 million annually, and a regional impact of $100 million (Evans & Lozano, 2014). There are more than 500 registered commercial avocado producers operating on about 7,000 acres (2,833 hectares), with the bulk (close to 99%) of the production occurring in Miami-Dade County (USDA, 2007), which is located in the southern part of the Florida peninsula. The industry employs over 1,000 people directly and indirectly and is a major underpinning for the packinghouses, chemical companies, and irrigation companies in the area (Evans *et al.,* 2010). Avocado groves also provide important non-market benefits such as retention of open space/landscaping; recreation/relaxation; wildlife habitats; canopy cover; and carbon sequestration. It is estimated that the tree replacement costs alone for commercial orchards would exceed $200 million (Evans & Crane, 2010).

Threat to the Florida Avocado Industry

Laurel wilt (LW) has recently emerged as a lethal threat to plants in the Lauraceae plant family in the southeastern USA, including important native trees and the significant commercial crop avocado, *Persea americana* (Fraedrich *et al.,* 2008; Kendra *et al.,* 2012). It is caused by the fungus *Raffaelea lauricola*, which has an invasive ambrosia beetle vector, *Xyleborus glabratus*. Symptoms of LW begin with sections of the tree canopy wilting, followed by leaf desiccation and stem dieback. As the disease progresses, tree limbs and eventually the trunk are affected, resulting in a dead tree. The time from beetle infestation to LW symptoms ranges from 1 to 3 months.

LW was first recognized around Savannah, Georgia, in 2003, and has since decimated native populations of redbay (P. borbonia) and other species in the family in the southeastern USA. As the disease began making its way down the southeastern corridors of the USA, the alarm was sounded that it posed an imminent threat to commercial avocado production in Florida and, depending on how it spread, could also affect important production in other US states (e.g., California and Hawaii), US protectorates (Puerto Rico), and other countries. This prompted scientists to begin working around the clock to develop an effective treatment.

In 2006, the first Florida avocado tree was killed by laurel wilt in Jacksonville, Florida. Soon after, a southward swath of host trees began to die down the eastern flank of the state. In February 2011, the disease was confirmed in the Everglades in stands of native swampbay (*P. palustris*). By March 2012, LW was detected in the Florida's commercial avocado production area (CAPA) in southeastern Miami-Dade County, where it began spreading at an alarming rate (Ploetz *et al.,* 2011a).

Although initial infections in a given grove were presumed to involve beetle dispersion of the pathogen, secondary spread within a planting was discovered to occur via root grafts between infected and healthy trees. Effective management of root graft transmission was therefore identified as a primary concern in LW-affected groves. Moreover, in light of the fact that a cost effective treatment had not yet been identified, the emerging recommendations to stem or decelerate the spread of the disease called for the prompt diagnosis of affected trees, rapid removal and destruction of the affected trees (sanitation), and chemical treatment of the adjacent trees (Ploetz *et al.,* 2011b). However, the problem was that it is extremely costly to identify (sampling and testing), eradicate, and properly dispose of infected trees.

Area wide Plan

Given that the overall benefit to the state of the avocado industry, the modes of dispersal of the disease, and the high cost of treatment relative to current profit margins, it was felt that an area-wide management program should be implemented to assist with controlling the spread of LWD. Among other things, the view was expressed that such a coordinated approach would reduce the shared risk posed by the disease complex and make overall treatment more cost effective. The area-wide management program suggestion revolved around the adoption of an early detection and suppression strategy to prevent LW from becoming established in unaffected production areas. The program consisted of a five-part strategy involving the provision of financial assistance to facilitate 1) conducting visual aerial survey and ground trothing; 2) removal and proper disposal of infested/infected trees; 3) fungicidal application to reduce the infield transmission of the pathogen; 4) chemical and non-chemical means to reduce and suppress ambrosias beetles population; and 5) intensive ground scouting. In addition, funds were set aside to continue research. The program was initially funded through a combination of industry, county, state, and federal sources.

However, in spite of the program and the best efforts of scientists, the disease continued to spread within the CAPA. By 2014, two years after the first tree within the production area was diagnosed, an additional 131 commercial avocado groves became infected, resulting in the destruction of more than 6,000 trees. This led to the inevitable conclusion that the disease had become endemic in the CAPA and engendered concern on the part of some stakeholders regarding the effectiveness of the program. A discussion ensued about modifying the program funding. In light of this discussion, an economic analysis was carried out to assess the potential net benefits of the program were it to have been extended over a five-year period.

METHOD

The methodology used to assess the desirability of the program was benefit-cost analysis. The fundamental principle guiding the benefit-cost analysis of the program was that as long as the benefits exceeded the costs, then the particular program was worth pursuing. In other words, any plan with positive net benefits would be an improvement over the baseline (do-nothing scenario) since the damages avoided would outweigh the management costs. To carry out such an analysis, it would be necessary to identify and, where possible, quantify the additional benefits and costs resulting from implementation of the program.

To do so, we define the benefit as the damage avoidance cost (DAC) of having the program in place. The DAC can be further defined as the costs/damages that would have occurred had the treatment /strategy not been in place (referred to as the do-nothing scenario), minus the cost of the control strategy, minus the damages that still occurred in spite of the control strategy.

Calculation of the damages that would likely have occurred without the program requires a counterfactual analysis of the existing situation. One way to do this is to create an epidemiological model capable of simulating the spread of LWD over the avocado groves for a sequence of years in the absence of the program. Specifically, we needed an epidemiological model that would allow us to predict the spread of the pest population (and more importantly tree mortality) in the absence of any management plan. Such a model should also be capable of being manipulated in such a way as to simulate the efficacy of a particular control strategy. This model would then be combined with the economic model that determines the corresponding yearly costs and benefits.

The particular epidemiological model chosen to represent the spread of the disease is the Gompertz function.

$$Y_t = e^{(\ln(y_0) e^{(-\beta t)})}$$

Where:

Yt	=	number of trees infected at time t
Y0	=	number of trees infected when disease is first detected expressed as a percentage of total available
β	=	the annual spread rate of the disease, expressed as a percentage
t	=	time
e	=	exponential symbol
ln	=	natural log

The above equation contains two important parameters. The first is the rate of disease spread (β) which is also known as the effective contact rate. Based on actual field observations it was determined that in the "do nothing situation" the rate of spread of the disease varies between 300% and 400%. For this analysis, a value of 350% was chosen. It was further determined, based on a survey of growers who had adopted the sanitation program, that the spread rate could fall as low as 10% per year. However, given that by the end of 2014 a total of 6,000 trees had been removed, the effective spread rate in the presence of the program was assessed to be 35% per annum. This rate was used to predict tree mortality, assuming the program remained in placed over a five-year period. The second parameter (Y0) represents the number of trees (usually expressed as a percentage of the total) that were infected when the disease was first detected. For the analysis, it was assumed that only 1 out of the 650,000 commercial trees was infected at first detection in the 2012 base year. To monetize the damage that occurred, each mature tree was valued at $350 (Evans *et al.,* 2010). The costs of administering the program were obtained from researchers and industry personnel and projected over a five-year period. The benefit-cost analysis was conducted over a five-year period, assuming funds committed in the first and second year would continue over the five-year period. A discount rate of 10% was chosen to convert future streams of net benefits to present value.

RESULTS AND DISCUSSION

Table 1 shows the predictions of the model with regard to the number of trees that would have become infected under the “do nothing situation” and in the presence of the program for a five-year period. Among other things, Table 1 indicates that under the current assumptions and in the “do nothing situation” the entire stand of commercial avocado trees would be wiped out within a five-year timeframe if the disease were allowed to spread unabated. In contrast, the program, along with efforts of the growers, has managed to substantially decelerate the rate of spread and the demise of the Florida avocado industry. At the current rate of spread, the model predicts that by the fifth year, a total of 63,501 trees, or about 10% of commercial stand, would have succumbed to the disease. Hence, while not being ideal, the program did decelerate the spread of the disease and buy additional time for scientists to develop a more cost-effective treatment.

Table 1. Predicted tree mortality without and with the program

Year	Without Program (Do-Nothing) Rate of Spread (350%)	With Program Rate of Spread (35%)
2011	1	1
2012	433,889	52
2013	642,115	844
2014	649,760	6,008
2015	649,993	23,959
2016	650,000	63,501

With regard to the benefit-cost analysis, Table 2 shows a summary of the costs involved and the results of the analysis. As mentioned earlier, each mature tree is valued at $350. Information contained in Table 2 indicates that over the five-year period, the total loss without the program (do-nothing scenario) would have been $227.5 million, the equivalent of $200.4 million in present value terms. The total cost with the program in present value over the five-year period would have been $12.9 million dollars. The total cost with the program includes the cost of surveillance and monitoring, destruction and proper disposal of infected trees, and research. Based on the model prediction of the number of trees that would still have become infected over the five-year period and had to be destroyed despite implementation of the program is 63,501; the loss calculated in present value terms would have been $6.2 million. Calculation of this amount is based on the number of trees the model predicted would die, multiplied by the value of a mature tree at $350 each less $200 that would have been provided under the program for the destruction and proper disposal of each infected tree. Hence, the total cost of the program is estimated at $19.1 million; representing the costs of administering the program, material plus the losses that would have occurred in spite of the program being in placed.

Table 2. Benefit-cost analysis of LWD area-wide management program

Benefit-Cost		Interest	Present Value	Year					Total
				1	2	3	4	5	
Cost of Do-Nothing $’000		0.10	200,353	151,861	72,879	2,676	82	2	227,500
Cost of Program $’000			12,952	1,458	1,556	2,285	4,633	8,793	18,725
Aerial survey			167	44	44	44	44	44	220
Sampling			929	245	245	245	245	245	1,225
Testing of samples			1,061	280	280	280	280	280	1,400
Tree destruction & removal			8,279	10	158	1,033	3,590	7,908	12,700
Traps			758	200	200	200	200	200	1,000
Research			1,758	679	629	484	274	116	2,180
Loss in spite of program $’000			6,209	8	119	775	2,693	5,931	9,525
Total Cost	$’000		19,161						
Benefit	$’00		181,192						
B:C			9						

The benefit the program defined as the damage avoidance cost is calculated as $181.2 million, representing the difference between the estimated damages that would have occurred had the program not been in place less the total cost of the program as defined earlier. This implies a benefit to cost ratio of 9:1, suggesting that it would be worthwhile to continue implementation of the program.

CONCLUSIONS

Laurel wilt (LW) has recently emerged as a lethal threat to plants in the Lauraceae plant family in the southeastern USA, including important native trees and the significant commercial crops such as avocado. The disease has become endemic in the commercial avocado production area of Florida and now threatens other US states (especially California) and potentially the whole Western Hemisphere. Excluding the disease from healthy orchards and managing it in affected orchards is a major, ongoing challenge.

In 2012, an area-wide management program centered on early detection and destruction of affected trees, funded largely through a combination of industry, state, and federal sources, was implemented with the aim of preventing or substantially decelerating the spread of the disease in the commercial avocado production areas in Florida. However, given that the disease is now endemic within the production area, support for the program has waned.

We conducted a benefit-cost analysis to assess the desirability of maintaining the program over a five-year period. To facilitate prediction of tree mortality "with" and "without" the program, we modeled the spread of the disease using the Gompertz function, supplemented with interviews of industry experts, researchers, and growers. The results of our analysis indicated that in the absence of the program, the disease would have spread at a rate of about 350% per annum. Implementation of the program together with efforts of growers would have decelerated the spread of the disease to about 35% per annum, which should be viewed as being successful. In present value terms, the total cost of the program, including expected tree loss in spite of implementation of the program over the five-year period, was determined to be about $19.1 million. The net benefit from implementing the program was about $181.1 million, resulting in a benefit to cost ratio of 9:1. This provided further evidence of the desirability of the program.

While the exact dollar value might be questionable, the study does indicate the benefit of decelerating the spread of the disease and supporting the continuation of the program. First, the program provides scientists with critical time to continue their research toward developing a cost-effective treatment. Second, given the mode of spread of the disease by a mobile pest, there is the need for an organized and coordinated attack on the disease over a large area rather than relying on the field-by-field approach. As shown, the area-wide approach stands a better chance of being cost effective.

REFERENCES

Evans E; Crane J. 2009. Estimates of the replacement costs of commercial and backyard avocado trees in South Florida, EDIS #FE825, UF/IFAS Extension, Gainesville, FL

Evans E; Crane J; Hodges A; Osborne J. 2010. Potential economic impact of laurel wilt disease on the Florida avocado industry, HortTechology, Vol. 20, no. 1, pp. 234-238.

Evans E; Lozano IB. 2014. Sample avocado production costs and profitability analysis for Florida, EDIS #FE837, UF/IFAS Extension, Gainesville, FL.

Food and Agriculture Organization of the United Nation (FAOSTAT). 2013. Crops: Production. Retrieved: May 5, 2015, of http://faostat.fao.org/site/567/default.aspx#ancor

Fraedrich SW; Harrington TC; Rabaglia RJ; Ulyshen MD; Mayfield AE III; Hanula JL; Eickwort JM; Miller DR. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern USA, Plant Disease, Vol. 92, pp. 215-224.

Kendra PE; Niogret J; Montgomery WS; Sanchez JS; Deyrup MA; Pruett GE; Ploetz RC; Epsky ND; Heath RR. 2012. Temporal analysis of sesquiterpene emissions from manuka and phoebe oil lures and efficacy for attraction of *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae), Journal of Economic Entomology, Vol. 105, pp. 659-669.

Ploetz RC; Pérez-Martínez JM; Evans EA; Inch SA. 2011a. Toward fungicidal management of laurel wilt of avocado, Plant Disease, Vol. 95, pp. 977-982.

Ploetz RC; Pena JE; Smith JA; Dreaden TL; Crane JH; Schubert T; Dixon W. 2011b. Laurel wilt is confirmed in Miami-Dade County, center of Florida's commercial avocado production, Plant Disease, Vol. 95, p. 1599

United States Department of Agriculture (USDA) 2007, Agricultural census, United States Department of Agriculture, Washington, DC.

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