Critical assessment of factors that determine how effectively areawide buffer treatments mitigate ACP and HLB risk in commercial citrus groves

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Background

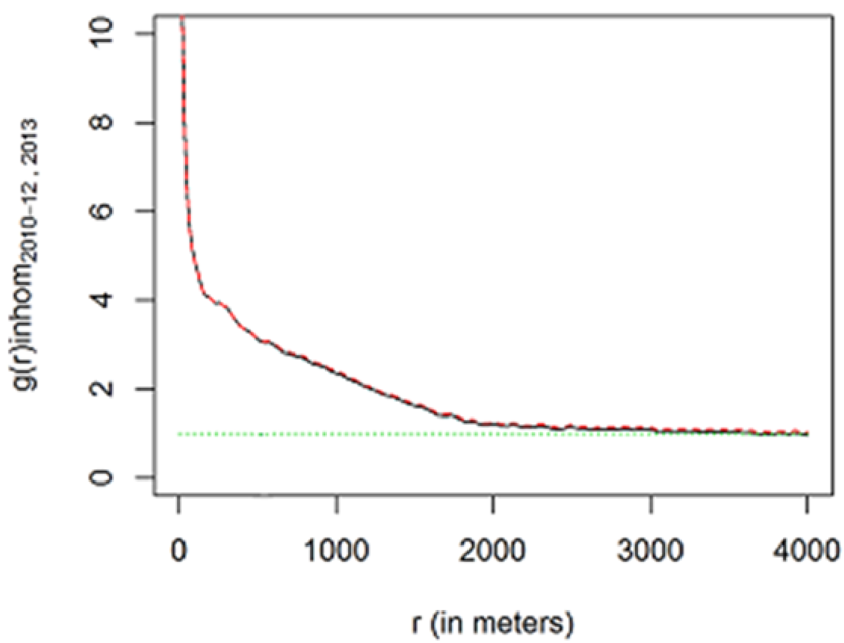
Areawide buffer treatments are a key tactic being employed in the effort to limit the impact of residential Asian citrus psyllid (*Diaphorina citri*; ACP) populations and Huanglongbing (HLB) on California commercial citrus. Insecticides are applied by CDFA to residential citrus trees in a 400 meter (1/4 mile) band (i.e., buffer) around commercial citrus groves in areas of Southern California that are widely infested with ACP and where growers are conducting areawide treatments (CDFA 2017), including portions of Ventura, Santa Barbara, San Bernardino, Riverside, San Diego, and Imperial counties. One purpose of the program is to provide an incentive for growers to participate in areawide insecticide applications. Neighboring residential properties will only be treated if 90% of the commercial citrus acreage in a PMA (psyllid management area) or pest control district has sprayed an ACP-effective insecticide during the most recent areawide treatment. Under this program, more than 31,000 residential properties were treated in six counties between January 2016 and June 2017.

Despite the substantial resources invested in this program, it is unclear what impact buffer treatments have on limiting ACP incursion into commercial groves to help reduce the risk of HLB establishment. There has been no direct evaluation of their effectiveness. The central goal of this briefing paper is to provide an indirect evaluation by: (1) defining the critical factors that influence whether or not buffer treatments would be effective, and (2) describing current best evidence from California for each of these factors. We then make recommendations on next steps, and on specific needs for further evaluation and improvements to the program.

Available evidence on factors contributing to areawide buffer treatment effectiveness

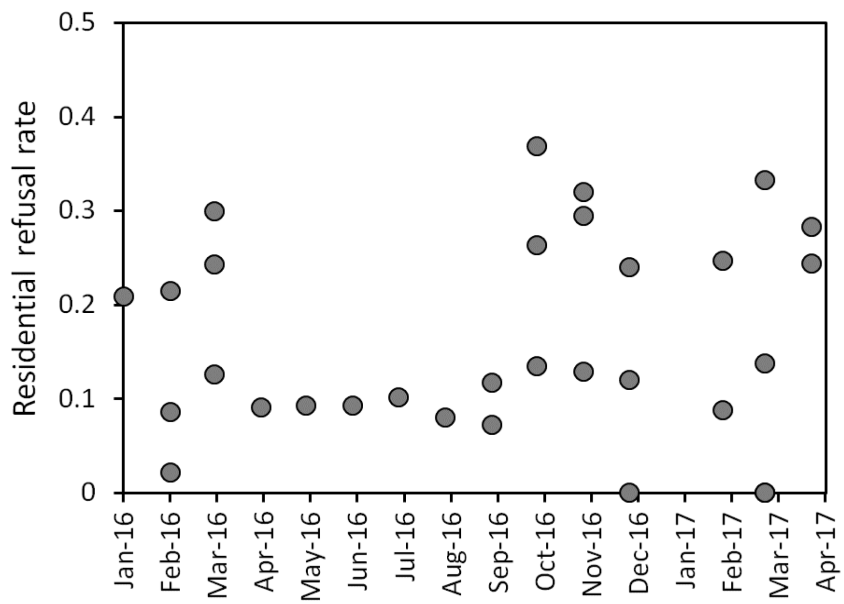
Asian citrus psyllid movement. ACP movement is characterized by frequent short-distance flights, but with potential for much longer dispersal events. Movement of two kilometers in less than two weeks has been documented in mark-release-recapture experiments (Lewis-Rosenblum, *et al*. 2015). In the context of residential areas in Southern California, a spatial analysis (Thomas, *et al*. 2017) of ACP trap catches compared catches in one year with catches in previous years to determine how similar ACP counts were (i.e., how strongly correlated) at various distances. It thus provides an indication of how the ACP population changed across space over time, and the strength of the correlation can be interpreted as how likely movement was at various distances. Although the observed correlation of ACP counts was strongest at distances less than a few hundred meters, suggesting frequent short-duration movements, there is still significant correlation beyond 2 kilometers (Figure 1). This conclusion is further supported by preliminary analyses of initial ACP detections in Southern California commercial groves, which indicate a high likelihood that invasions resulted from residential infestations several kilometers away (MP Daugherty, unpublished results). Together these empirical findings suggest that buffer treatments alone are insufficient to eliminate ACP and HLB spillover from surrounding residential areas. Although 400 meter treatments may cover the majority of ACP movement events and reduce local populations, buffers only act as a partial barrier. Substantial risk may still exist from further afield. This is particularly likely to be the case in areas where there is a high abundance of ACP in residential areas.

Figure 1. Strength of spatial relationships between Southern California residential ACP trap counts in 2010-2012 and in 2013. Distance (in meters) is on the horizontal axis and the correlation coefficient (a measure of the strength of association) is on the vertical axis. Statistically significant relationships are above the horizontal dotted line.



Residential participation. An important aspect of the buffer treatment program is that it relies on resident cooperation. Residents can opt out of their property being treated. Generally, participation rates appear to be high. Average participation in all regions over a 16-month period in 2016 and 2017 was nearly 84%. However, participation varied widely. Over the same 16-month period, refusals ranged between 0% and nearly 37% of properties in a given county in a given month, with some of the highest refusal rates occurring during the fall and early spring months when ACP populations are highest and commercial citrus areawide treatments are being conducted (Figure 2, Table 1). Untreated properties are problematic because they can serve as refuges for ACP. Thus, the effectiveness of PMA buffer treatments may depend on the homeowner participation rate, although the threshold number of properties that need to be treated per area is not known. For those areas or time periods with low participation rates, there is increased risk of the buffer treatments not controlling ACP enough to limit movement into adjacent commercial groves. Grower areawide treatment timings vary between regions, but are generally applied in the late winter (December-March) and fall (August-November). Figure 2 shows that residential treatments have occurred at other months, suggesting that there has been a significant mismatch between the timing of residential buffer and commercial areawide treatments, further reducing effectiveness. The goal of the program is to provide simultaneous treatment of both commercial and residential citrus.

Figure 2. Proportion of properties refusing treatment in five Southern California counties. Multiple points in a given month represent multiple counties. (Data source: CDFA).



Grower and residential participation combined. In addition to the ACP/HLB control value of the treatments themselves, residential buffer treatments act as an incentive for growers to participate in the areawide treatments within each PMA. Table 1 shows that some regions, such as Imperial, have had exceptionally high participation by both growers and homeowners. Other regions, such as Santa Barbara, San Bernardino, and Riverside, have struggled to achieve 90% grower cooperation in many of their PMAs and have much more variable participation by homeowners. An additional issue is that there may be a significant time lag between grower areawide treatments and residential buffer treatments. The purpose of these treatments is to cover a wide area with insecticides and locally suppress ACP during a short, coordinated treatment period. A high level of coordination and participation by both groups is needed to achieve this goal. It should be noted that San Diego and San Bernardino have only recently begun forming commercial citrus pest control districts and conducting areawide treatments. The levels of participation are likely to increase in these regions.

Table 1. Average grower participation in areawide treatments and average residential participation in accompanying buffer treatment areas. Minimum and maximum values are shown in parentheses. (Data source: CDFA)

	Winter 2016		Fall 2016		Winter 2017	
	Grower	Residential	Grower	Residential	Grower	Residential
Area						
Ventura	**90%** (20–100%)	**86%** (56–100%)	**87%** (41–100%)	**90%** (73–100%)	**84%** (37–100%)	**86%** (67–100%)
Imperial	*	*	**97%** (82–100%)	**99%** (95–100%)	**97%** (82–100%)	**99%** (95–100%)
Santa Barbara	**94%** (76–100%)	**78%** (60–95%)	**97%** (90–100%)	**75%** (64–92%)	**94%** (78–100%)	**78%** (64–100%)
San Diego	*	70% **	*	63% **	*	NA
San Bernardino	**44%** (0–100%)	**91%** (90–91%)	**35%** (0–100%)	**89%** (86–93%)	**42%** (0 –100%)	NA
Riverside	**75%** (0–100%)	**89%** (87–91%)	**45%** (0–100%)	**79%** (71–88%)	**75%** (0–100%)	**81%** (76–86%)

* Incomplete data available as of September 2017.

** One month and/or one PMA reported; no minimum and maximum.

***Effectiveness of residential insecticide applications*.** Even when the residential participation rate is high, limitations exist on how well buffer treatments suppress ACP populations. Residential treatments consist of a combination of a foliar pyrethroid insecticide (Tempo, beta cyfluthrin), typically applied in the winter and fall, and a soil application of a systemic neonicotinoid (Merit 2F^{tm} or CorTect^{tm}, imidacloprid) applied in the fall. Only the foliar is applied during winter treatments because uptake of systemic insecticides is poor at that time of year. A number of factors in residential citrus may undermine systemic insecticide uptake and retention compared to a commercial setting, including improper soil conditions, poor horticultural practices, and incompatible irrigation regimes. A survey of imidacloprid residues in nearly 200 sites treated at various times during the early phase of the residential treatment program in Southern California found ACP present on the majority of trees (52%), even those treated within the prior few months. Overall, just 25% of trees had ACP-effective residues of imidacloprid, including the minority of trees that had recently been treated (MP Daugherty, unpublished results). The foliar treatment is likely to be more effective, but its duration of control is approximately a month. In other words, given two treatment timings a year, trees may be protected for as little as two months, with the potential for poor control of ACP during the summer and late fall months, when *Candidatus* Liberibacter asiaticus (CLas) titer in trees tends to peak. Thus, even if the vast majority of properties participate in the buffer treatments, only a minority are likely to be protected for a sufficient time to disrupt CLas acquisition by ACP or to reduce ACP incursion into nearby groves.

***Regional ACP populations and HLB risk*.** The various citrus growing regions of southern California have different ACP pressure (Table 2) due to climate, citrus varieties grown, and management practices applied. The Imperial and Coachella valleys have hot, dry climates that cause flush to harden off for long periods of time, growers treat with broad spectrum insecticides, and commercial groves tend to be grouped and separated from urban areas. The pressure from residential areas is relatively low and, as discussed above, participation of both growers and homeowners is high. In contract, along the coast (Ventura) and inland areas (Riverside city and San Bernardino) the climate generates more continuous flushing of trees that is ideal for psyllids, residential participation is weak in many areas, grower participation varies from PMA to PMA, and there is an extensive urban-agriculture interface. Thus the ACP pressure from residential citrus is very high, necessitating greater buffer treatment participation in these residential areas. The cost of those residential treatments, however, is astronomical because of the small size of many groves, the distance that psyllids can move (see above), and the proximity and density of residential citrus. In the Riverside city area, there is the added factor of HLB-positive trees (Table 2). These regional differences in vector and disease pressure should be considered in decisions about buffer treatments and baseline expectations for the efficacy of the treatments.

Table 2. MAC grant-funded commercial grove scouting indicating levels of psyllid and HLB pressure in southern California during Jun-Sept 2017.

	Coachella/ Imperial	San Diego	Ventura	Riverside/ San Bernardino
Number of groves scouted	50	41	49	39
# suitable leaf flushes per 1/4m^2	2	2	2	5
# Sites with >1 nymph/flush	0	5 (12%)	16 (33%)	28 (72%)
HLB+ tree removal	0	0	0	2

Conclusions and recommendations

We have identified a suite of factors that are critical for determining how effective areawide buffer treatments are in mitigating the risk that residential citrus poses to nearby commercial citrus groves. Empirical findings presented above describe why and how each factor must be considered in order to make an evidence-based decision about the future of buffer treatments. Given the near ubiquitous distribution of ACP in Southern California, and in the absence of direct, concrete information about what impact buffer treatments have on ACP invasion dynamics, further consideration of the value of this program is clearly warranted.

Moving forward, program options include:

1. Eliminate areawide buffer treatments completely in Southern California; or reduce them by prioritizing high-risk areas (e.g., near HLB-positive cases or close to packing houses or transport

corridors) and/or prioritizing where positive outcomes are most likely. We recommend that if buffer treatments are eliminated or reduced, the resources made available by that action would be redirected toward increased HLB surveillance and/or alternative ACP management efforts in the 400 meter residential buffer area. We further recommend that any decision about reallocation of newly available resources be guided by formal cost-benefit analyses of those alternative approaches relative to the existing buffer treatment program.

2. If the buffer treatment program continues as it currently exists, its effectiveness in reducing ACP must be quantified and a formal cost-benefit analysis must be conducted. Evidence is needed that the buffer treatments reduce neighboring commercial citrus populations, and details are needed on the residential participation rate, treatment type, and timing of treatments. We further recommend that these evaluation efforts be focused on areas where ACP has been present for the shortest amount of time or where HLB is present, and so will have the greatest impact on slowing HLB spread.

Priority activities needed for future decision-making

1. Identify and obtain data needed to quantify the effect residential buffer treatments have on ACP control and the probability of HLB spread.
2. Determine the level of participation needed by residences in order to limit ACP incursion from residential to commercial citrus
3. Determine if additional foliar treatments would make the program more effective.
4. Evaluate additional citrus insecticides for residential use, including organic materials, for possible adoption by the CDFA program.
5. Continue research to test effectiveness of ACP attract and kill devices.
6. Assess the potential impact of non-chemical barriers such as windbreaks and repellents on ACP spread from residences into commercial citrus
7. Evaluate the efficacy of natural enemy releases in buffer areas for the control and spread of ACP.
8. Conduct a cost-benefit analysis for the buffer treatment program.

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