Minimizing the dispersal of Asian Citrus Psyllid in California: the key role for regulating transport corridors.

A Policy briefing paper prepared by

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Introduction

Asian Citrus Psyllid (ACP) the insect vector of Huanglongbing (HLB) disease of citrus colonized Florida within a few years of arrival. When ACP began to move HLB around the state it encountered no natural barriers to dispersal and was assisted by the unintentional effect of ACP hitchhiking on fruit transport trucks and an uncontrolled nursery industry that moved ACP long distances quickly and in relatively large numbers. Given the differences in geography between California and Florida and the facts that our nursery industry plant movement is well-controlled and we are forewarned about the possibility of moving ACP along transport corridors, there is no reason to believe that California need be consigned to repeat the Florida experience. Unfortunately, the evidence to date suggests that we are doing exactly that and in the process negating a huge natural aid in the prevention of ACP dispersal.

To help guide future strategic thinking and policy formulation in this area we lay out the pieces of evidence here on the importance of managing the fruit movement between regions of California without much detailed analysis; the evidence essentially speaks for itself.

The association between transport corridors and ACP numbers: 1. Analysis from Florida

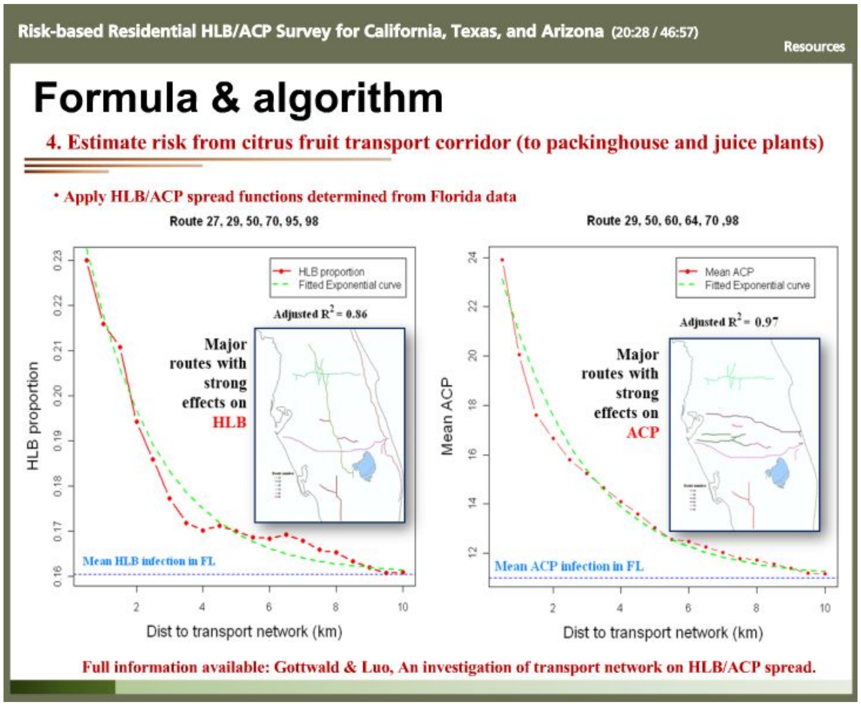

Figure 1. Observed relationships between HLB infection or ACP numbers and distance from transport corridors in Florida. ACP numbers (right panel) decline exponentially with distance from roadways over a range about about 10km.

Figure 1 is taken from a web-based paper by Gottwald et al. (2013) on the development of the risk-based survey for ACP and HLB in California, Texas and Arizona. The figures appear as item 15 in that presentation. The association between both the disease (HLB) and its vector (ACP) and roadways is clear.

Figure 2 shows the current overview for ACP treatment areas/quarantines in California. The association of a large proportion of these areas with major north-south highways, particularly HWY99 on the east side of the Central Valley, is obvious. The pattern of association between fruit transport routes and ACP populations noted in Florida does seem to be repeating in California. This perception is further strengthened by recurring finds of ACP on traps close to juice plants and packing houses in the San Joaquin Valley. It seems clear that ACP are being brought to the Central Valley on fruit deliveries from southern and coastal California

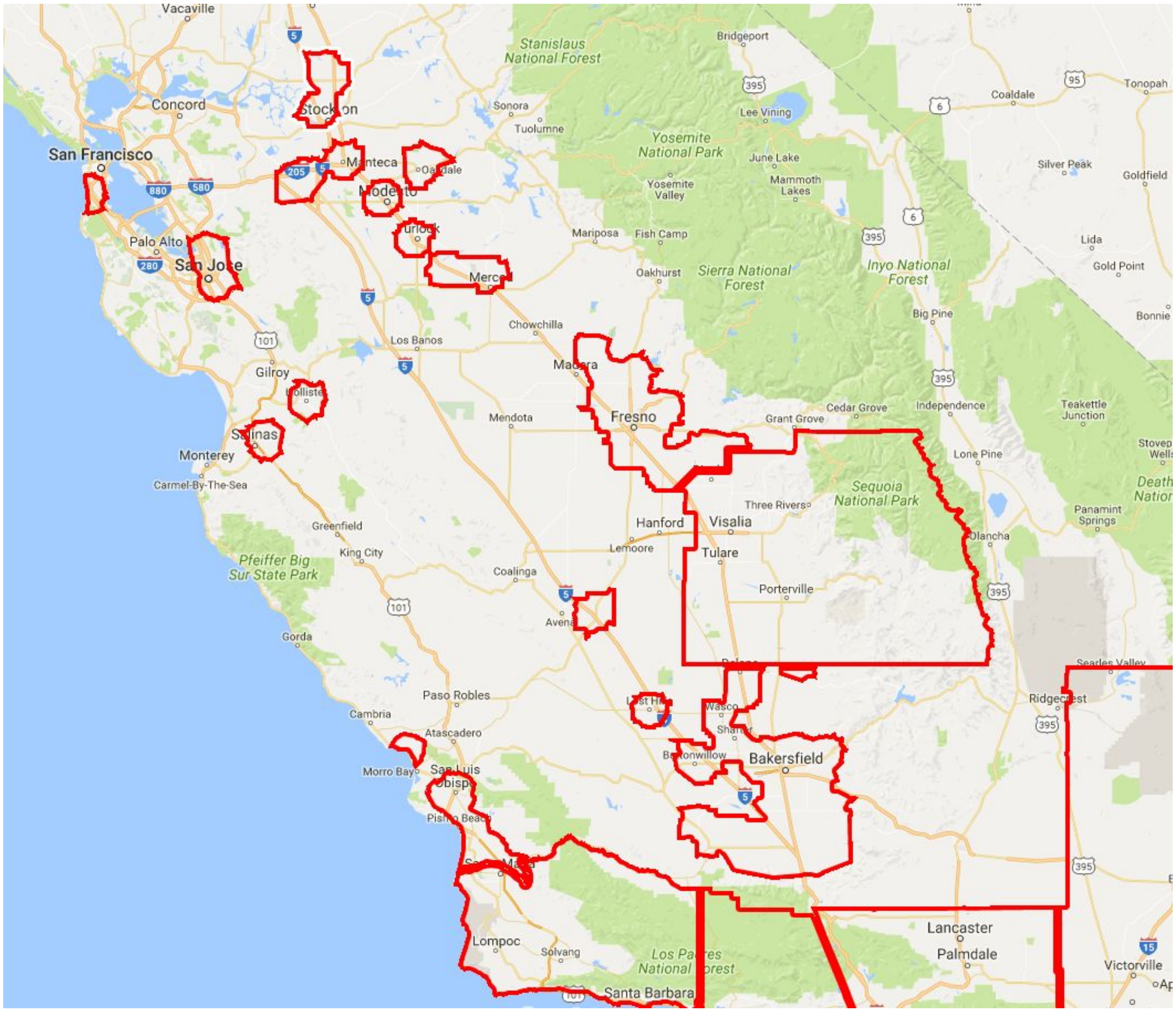

Figure 2. The current (August 2016) Asian Citrus Psyllid treatment areas in California. Note that southern California is considered to have a resident population that is no longer eradicable and CDFA no longer applies routine treatments in this region.

Why does passive transport of ACP matter?

In Florida, with a more or less flat topography, abundant citrus and Murraya (orange jasmine) hosts scattered across the landscape, favorable subtropical climates, continuous flush growth of citrus for ACP to feed and breed on, and episodic high winds to aid dispersal, it is likely that ACP would have quickly colonized the entire state even without human help. The situation is not as conducive to ACP spread in California, particularly in the case of spread northward from the L.A. basin to the Central Valley.

ACP are altitude sensitive and generally do not live for extended time at altitudes greater than 700m (approximately 2300 feet). Figure 3 shows a topographical map of California with all ground at elevation 2300 feet or higher shown in gray. The map makes it clear that the Tehachapi mountains are a significant natural barrier to the northward dispersal of ACP, forming a 30-mile wide expanse of ground above the natural altitude maximum for ACP. This barrier effect would be enhanced by the fact that thanks to its altitude it is also free from citrus hosts. Bringing ACP in trucks across this natural barrier essentially negates its potential benefit and is a major source of risk to the California citrus industry’s long term future.

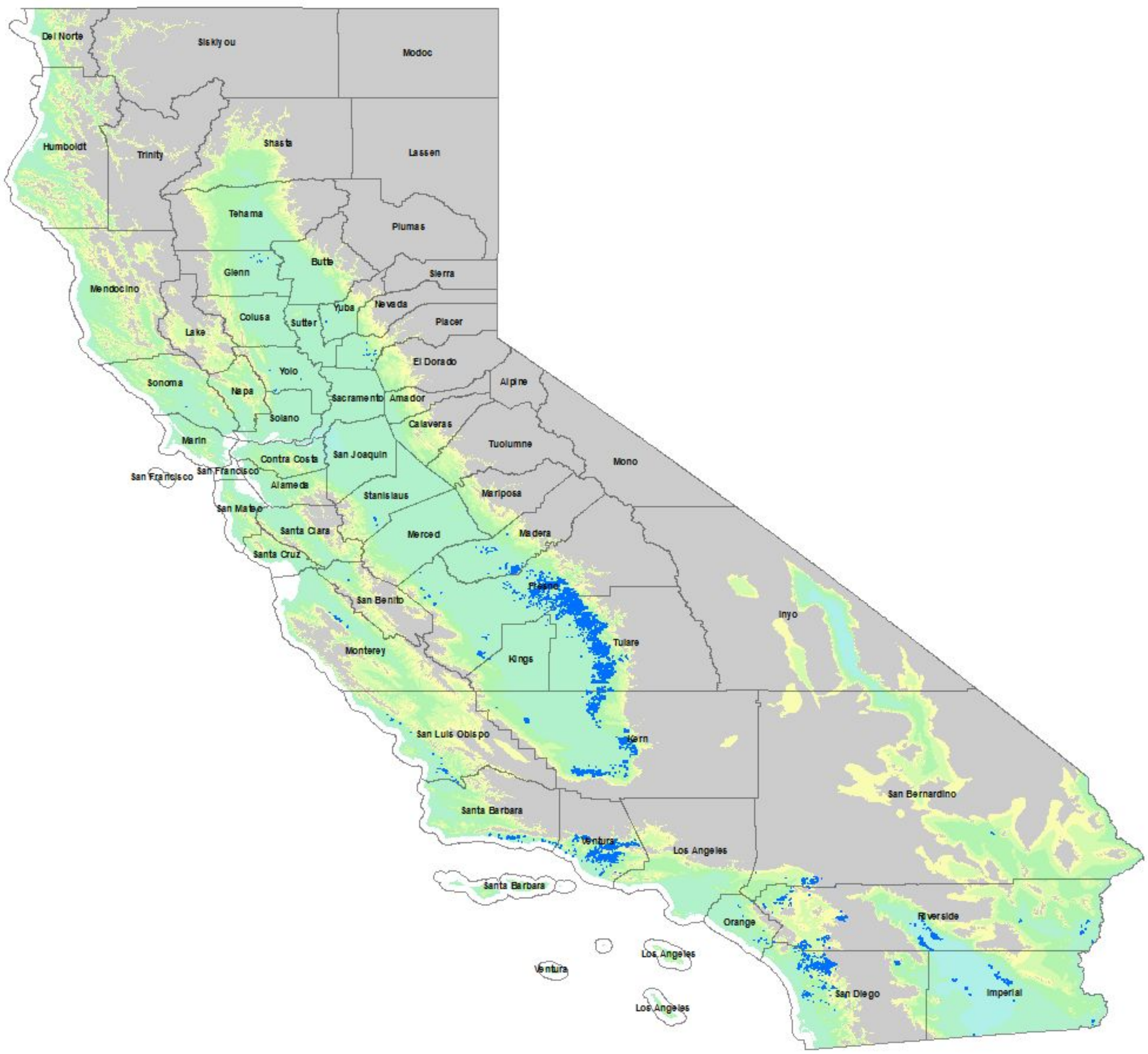

Figure 3. A topographical map of California with all ground 2300 feet or more above sea level shown in gray. This represents ground that is too high for ACP to survive.

The existence of a number of ACP outbreaks in the Central Valley already should not be used as an excuse to pursue a council of despair with respect to the value of restricting further fruit imports from southern California along the transport corridor. The fewer outbreaks there are in the Central Valley the better able to deal with those that happen the response services will be. More importantly, HLB will spread from urban areas into commercial orchards in southern California, and the psyllids that ride on fruit will be carrying the bacterium in their bodies.

It is important to consider this issue not so much in terms of quarantine regions, but more in terms of ***shutting down an avoidable dispersal mechanism*** for ACP which brings them from southern California (where overall ACP populations are higher and the risk of HLB greater) to central California, and the main region of commercial citrus in the state. ***It would be important to do this for the sustainability of the industry even if the entire state was a single quarantine zone***. The important issue is the location of the source of the risk and the at-risk crop and the fact that the transport corridor provides a connection between the two.

Making a ballpark guesstimate of the ACP transport effect

Rational policy making is at its most effective when based on hard evidence. We know from Florida that ACP are transported with fruit. We know from the accumulating evidence in California that a similar process of transport is going on here. In the absence of data to quantify how much ACP transport is occurring we can adopt an analytical approach that is simple enough to be transparent and which allows anyone who wants to be involved in the analysis to generate a personalized guesstimate[1].

We stress that the aim of this analysis is to lay out the issues involved and to stimulate the appropriate discussion on the best approach to minimizing the overall risk of ACP transport.

Since the example is intended only for illustration we have not attempted to represent California's citrus industry structure exactly. For the ACP transport equation in our hypothetical example we suggest the following parameters:

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[1] The approach is best known from the work of astrophysicist Dr Frank Drake, who proposed it as a way to think about how many intelligent life-forms capable of interplanetary communication there might be in the Milky Way galaxy (see https://en.wikipedia.org/wiki/Drake_equation)

Parameter	Symbol	Value used for illustration
Number of juice plants	J	4
Number of fresh fruit packing houses	P	6
Number of trucks per day per juice plant	T_J	40
Number of trucks per day per packing sheds	T_P	20
Probability of sufficient ACP per truck	P_A	0.30-0.7
Probability of ACP surviving transport	P_S	0.5-0.8
Probability of ACP escaping truck on arrival	P_E	0.3-0.5
Probability of escapees establishing (no flush)	P_{NF}	0.3-0.5
Probability of escapees establishing (flush)	P_F	0.5-0.7

Calculating the number of establishment events

We start by working out the total number of truck journeys which is found by multiplying the number of trucks per day going to juice plants by the number of juice plants, and the number of trucks per day going to packing sheds by the number of packing sheds, and adding the two numbers together:

$(J \times T_J)+(P \times T_P) = 160+120=280$

Next we multiply the number by journeys by the chain of probabilities for the sequence of events that would lead to establishment of ACP populations in different circumstances.

$280 \times P_A \times P_S \times P_E \times P_{NF}$ or $280 \times P_A \times P_S \times P_E \times P_F$, depending on whether the ACP encounter flush when they escape from the truck or not.

Since we do not have observed values for the probabilities, we have supplied low and high guesses for each one. Again, we stress that the calculation is intended as a guide to decision analysis not as an actual numerical prediction for California. Since we have flush/no flush and low/high distinctions we end up with 4 values:

Number of ACP establishment events per day

No flush near arrival point (low estimate)	3.78
No flush near arrival point (high estimate)	39.20
Flush near arrival point (low estimate)	6.30
Flush near arrival point (high estimate)	54.88

Note that these values are per day; corresponding values per year would be two orders of magnitude higher by the same reasoning.

Irrespective of the accuracy of the numerical values in the example, inspection of the chain of events as we have laid it out reveals that the key variable under the control of fruit growers and transporters is P_A , the probability that sufficient ACP are included in a load to make establishment of ACP if they escape , either at their final destination or along the way. We express the variable this way for two reasons. First we do not know how many ACP are typically in California fruit shipments. Secondly, in small populations random events are much more important in determining dynamics than in large populations and there is likely to be a minimum number of ACP that need to be transported in order to make the odds of escape and establishment high enough to be quantifiable beyond a simple yes/no. Under Florida conditions Halbert et al. (2010) found that 100% of 7 bulk orange transport trailers they examined had live adult ACPs in them; the number of ACP collected ranging from 23 to 268, but they did not attempt to relate ACP numbers in fruit loads to ACP populations around juice plants. In addition, the loads in question were not cleaned or treated in any way to remove ACP prior to transport.

Any treatment that significantly reduces the number of live ACP entering each load will reduce PA and have knock-on effects on all of the subsequent steps in the chain. Because at each step the ACP have to survive to proceed to the next stage there is a finite chance of none surviving to the stage of establishing colonies in the Central Valley if the number in each load is low enough. Since none of the other steps in the chain can easily be manipulated by the growers or transporters the analysis reveals both the potential of effective field treatment/washing to reduce the risk of ACP transport and also the sensitivity of the risk to lax or ineffective treatments.

What is true of movement between the L.A. basin and Central California is also true at a smaller scale within regions. The ideal situation for suppressing ACP movement would be to clean/wash fruit at a local scale before any road transport occurs, even within regional quarantine areas. The more local the suppression of passive transport can be made, the slower the spread of ACP will be.

References

Gottwald T., Luo W., McRoberts N. 2013. Risk-based residential HLB/ACP survey for California, Texas, and Arizona. *Plant Management Network*. http://www.plantmanagementnetwork.org/edcenter/seminars/outreach/Citrus/HLB/presentation.html

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