Risk-based survey for decision making in the management of Huanglongbing: Phase II

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Year 2 of 5 (41% Complete)

Objectives

1. Model refinement through continuous validation, data reevaluation (e.g. new HLB/ACP finds), and adaptation to optimize early detection
2. Conduct spatiotemporal analyses of data collected to-date from the risk-based surveys
3. Perform interim analyses to examine risk map accuracy and model validation
4. Integrate risk map with sampling density to estimate HLB incidence across California at STR level (1-sq. mile)
5. Incorporate EDT deployment strategies, balanced with regulatory resources, into the risk-based survey design to augment early detection
6. Develop commercial citrus-specific risk-based survey protocols

Problem and Significance

The key to control of huanglongbing (HLB) is early detection. During Phase I of the risk-based survey implementation, the model predicted high-risk areas to target, which led to HLB discoveries (>2000 *'Candidatus* Liberibacter asiaticus' [*C*Las]+ trees/Asian citrus psyllid [ACP] as of 01/2020) in Southern California. In Phase II, we continue to refine the early detection/prediction model of HLB/ACP for residential and commercial citrus and develop survey protocols to improve evidence-based decision-making for ACP/HLB management. Subsequently, with consideration of resource and manpower availability, we investigate different parameter settings for the risk-based survey selection procedure to provide more flexible survey deployment options (in particular, during the COVID-19 pandemic environment). We extend the model via spatiotemporal analyses of collected survey data and integration of early detection technologies (EDTs). This will allow us to predict, and regulatory agencies to combat, HLB outbreaks (fires) not only where we see the flames but also where the burning embers are most likely to establish new HLB outbreaks.

Benefit to Industry

We produce ACP/HLB early detection/prediction surveys for urban and commercial citrus throughout California as well as efficacious delimitation response protocols. Risk maps are implemented by CDFA each survey cycle with support on effective and efficient deployment. These model predictions and risk maps are valuable and effective approaches in finding *CLas* early (i.e. in a manageable phase) prior to epidemic establishment and severe spread. With exceedingly early model-directed surveillance, regulatory agencies in combination with California growers can effectively target eradication/management efforts, maintaining low incidence and suppressing outbreaks.

Progress Summary

Numerous factors and model components are likely to change through time as the epidemic evolves, and therefore, require frequent processing and maintenance to ensure data quality and model reliability via up-to-date, accurate representation of ACP/HLB risk in California. We work closely with CDFA and DATOC to maintain extensive data mining and exploratory analysis tools to ensure risk mapping accuracy and predictive power. Figure 1 illustrates the major risk factors included in the risk map calculation. The risk modeling includes estimation of risk due to:

a) Updated introduction risk from foreign travelers
b) Spatiotemporal analysis of ACP distribution and spread using data 2012-2019

c) Risk of confirmed HLB positive find(s) and potential *C*Las+ locations with Ct<38.5 PCR diagnosis
d) Potential ACP spread from commercial nurseries, home centers, etc.
e) Citrus transportation networks
f) Packing houses
g) Farmers markets, other citrus production or commercial vendors and green waste facilities
h) Military installations and Indian reservations
i) Proximity risk from organic citrus due to less chemical control applications/treatments

We used retrospective longitudinal analysis to evaluate the evolving prediction power of each risk factor in the model (i.e. primary and secondary spread in different areas). The predictability of each risk factor is used to estimate the weights for each model component in the full model construction, so as to improve the risk model accuracy along with the changing ACP/HLB epidemic. Figure 2 illustrates the predictive power of the comprehensive risk map in finding new HLB+ locations in Southern California. The majority of the recent HLB finds are strongly related to high risk STRs (1 sq-mile grids) in previous years. There are many high-risk STRs without HLB detection, currently, which is likely due to sampling issues and detection accuracy. Therefore, it is necessary to increase the weighting of risk components to represent the extended HLB infection area. Risk maps (including documentation and presentations) have been used as regional early warning systems for growers and regulatory agencies for improved survey resource allocation tools.

We share an updated and refined statewide risk-based survey with CDFA regularly to prioritize surveillance for ACP/HLB in residential/urban areas as well as commercial citrus. Commercial risk-based surveys include additional risk factors to reflect the impact of nearby urban populations and activities on

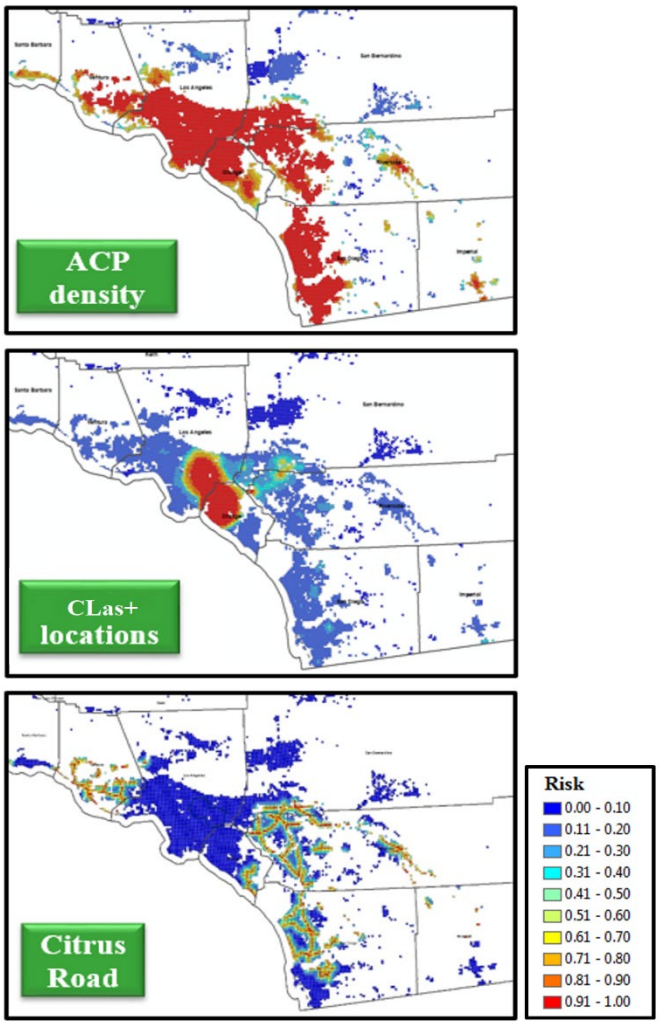

Figure 1. Three of the major risk factors (ACP density, confirmed CLas+ locations, and citrus roads) in Southern California.

commercial plantings. The sampling prioritization is determined via calculated risk with consideration of resource or manpower availability and the current survey capabilities (e.g. sampling effort and efficiency, detection technique). We have adjusted the risk-based survey accordingly to accommodate CPDPC Science committee suggestions as well as incorporate EDT deployment into the risk-based survey designs (Figure 3). For example, there were requests from CPDPC Science committee to bias 25% more sampling effort on STRs with close proximity to commercial citrus, and increase sampling efforts to major commercial citrus areas in Central Valley. Furthermore, the statewide survey

will not select STRs with over 20% overlap with delimitation survey areas.

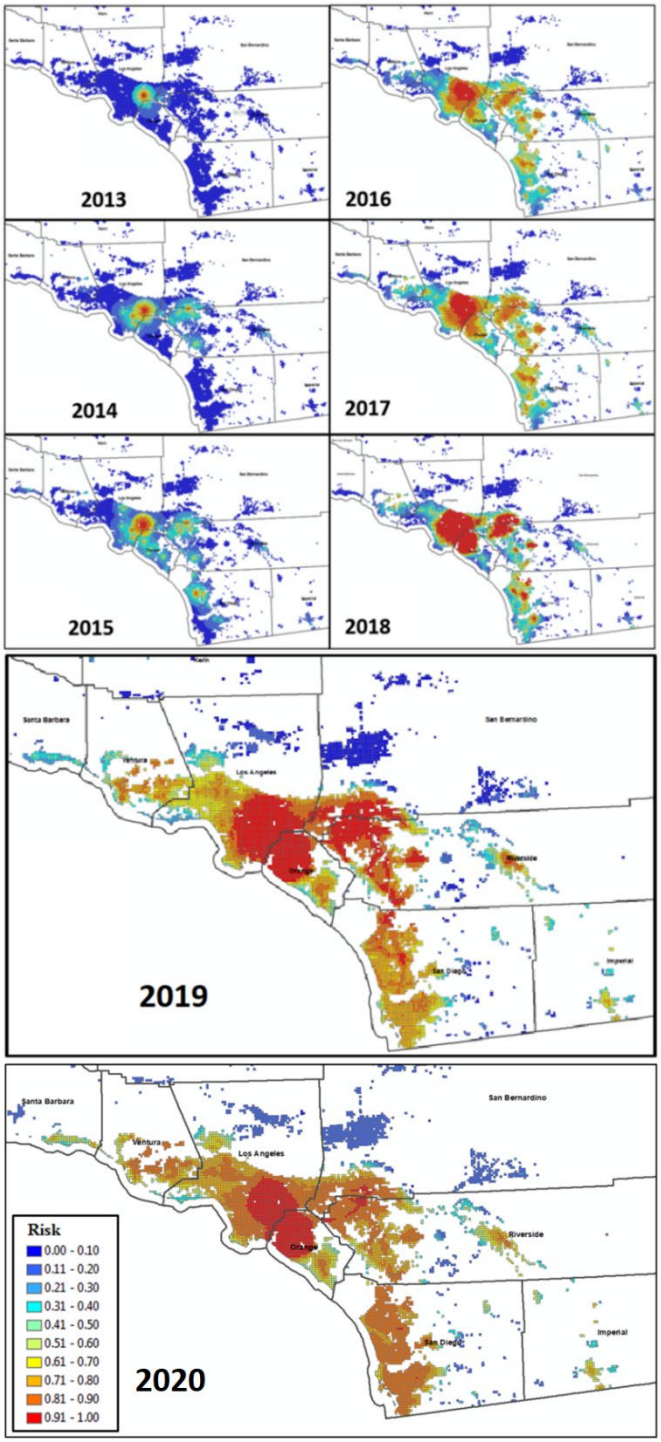

Figure 2. Annual HLB/ACP risk maps generated between 2013 and 2020 where all HLB+ confirmations are observed in our high risk STRs.

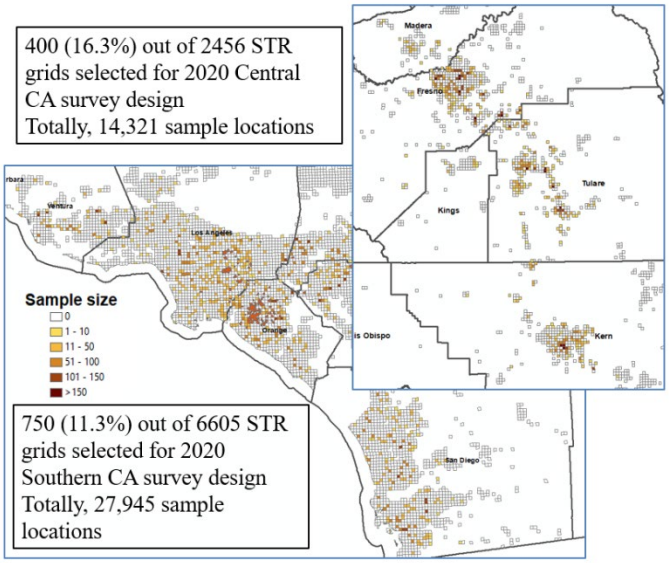

Figure 3. HLB/ACP STR selection design for 2020 with more sampling bias integrating CPDPC Science committee suggestions.

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Publications and Presentations

Luo, W., Posny, D., Sitler, L., Gottwald, T., Louws, F. 2020. Risk-based and infectious disease epidemiological modelling (RIDEM) – A case study of ACP/HLB dispersal into CA commercial citrus under different control protocols. CIPM Seminars Plus, Raleigh NC, Presentation.

Gottwald, T., Luo, W., Posny, D., Riley, T., Louws, F. (2019) A probabilistic census travel model to predict introduction sites of exotic plant, animal and human pathogens. Phil. Trans. R. Soc. B 20180260. http://dx.doi.org/10.1098/rstb.2018.0260

McRoberts, N., Garcia Figuera, S., Olkowski, S., McGuire, B., Luo, W., Posny, D., Gottwald, T. 2019. Using models to provide rapid programme support for California's efforts to suppress Huanglongbing disease of citrus. Phil Trans R Soc B 374: 20180281