Predict likelihood of ACP/HLB dispersal into CA commercial citrus under different control protocols

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Year 3 of 2 (100% Complete)

Objectives

1. Analyze the existing, California-recommended management approaches in mitigating ACP/HLB spread and preventing invasions into commercial citrus
2. Run scenario-based simulations to investigate alternative strategies with consideration of cost, sustainability, and location
3. Evaluate management protocols at different ACP/HLB epidemic phases
4. Evaluate the impact of social perspectives on management protocols
5. Ongoing, updated analyses and addressing other questions/scenarios posed by California citrus growers, regulatory agencies, and stakeholders

Problem and Significance

Each California landscape presents different drivers of Asian citrus psyllid (ACP) and huanglongbing (HLB) development and dispersal. Our stochastic simulation model readily analyzes ACP and HLB management practices in any California citrus landscape with consideration of different epidemic pressures, resource capacities and social-economic perspectives from both growers and residents through scenario-based simulations and cost-benefit analyses. These complex relationships and interactions signify that each landscape may require different strategies or phased management programs for sustainable control. Cost-effective management programs tailored to the landscape, infestation situation, and available resources are critical to have any success in slowing the spread and preserving commercial citrus.

Benefit to Industry

As the ACP/HLB situation evolves, there is an urgent need for cost-effective interventions to manage ACP/HLB, deterring further spread and maintaining the viability of commercial citrus. The simulation model assists California growers and regulatory agencies with analyzing and refining response guidelines for each California landscape to optimize available resources and mitigation efforts. These analyses provide growers with timely information about the efficacy of management strategies in preserving commercial citrus and swift updates when situations and guidelines evolve. We have also developed a web-based tool for users (growers, decision makers, and researchers) to assess comprehensive dynamic management protocols anywhere in California (Figure 1).

Progress Summary

We have finalized construction of a spatially explicit agent-based simulation model to investigate how ACP/HLB spread in actual, large-scale California citrus landscapes, evaluate the efficacy of management strategies, and analyze risk of invasion into commercial citrus. The robust model incorporates any combination of ACP/HLB survey, chemical control, biological control, removal/cull, replantation, and delimiting response protocols with consideration of social, economic and risk perceptions of the residents and growers in the landscape. The integration of these control measures and human behavior aspects allow for comprehensive scenario construction to analyze existing strategies in California, alternative approaches, management efficiency at different

epidemic phases, compliance or cooperation with area-wide programs, and how risk perception can influence mitigation.

We investigated current management programs (including delimit responses) in urban epicenters in Los Angeles and Orange Counties and mixed residential and commercial citrus areas in Riverside, San Bernardino, and Ventura Counties. In comparison, we evaluated alternative approaches in these landscapes to check if any improvements in mitigation with consideration of sustainability could be uncovered. Current strategies should be continuously evaluated as well as potential new approaches to strive for cost-effective programs as the situation changes. We highlight results from the simulation analyses: delimitation scenarios in Los Angeles (Figure 2), spread dynamics in Southern California (Figure 3), and residential buffer treatments in San Diego (Figure 4). Conducting these scenarios at different epidemic phases and ACP infestations are required to identify when programs should adjust to maintain optimal mitigation and disease suppression.

We have also completed development on a web-based tool for users to run different scenarios in California citrus landscapes using the model and readily explore the output. We have trained researchers at UC-Davis, Data Analysis and Tactical Operations Center, California Department of Food and Agriculture, U.S. Department of Agriculture, and NCSU on model components and how to use the tool to run their own scenario-based simulations. These initial users also have provided helpful feedback to refine the web-based interface for ease-of-use, clarity and documentation refinement. Regular meetings and training sessions were held as the online interface was developed and new features were added. The tool provides preliminary results and interactive visualizations from single stochastic runs as designed, but we conduct thousands of simulations with quick turnaround timeframes to support current users' requests for robust analyses.

Conclusions

Conducting scenario-based simulations analyzing the effectiveness of current and proposed control strategies in California citrus landscapes as the ACP/HLB situation evolves is essential. Each landscape provides different pathways for ACP/HLB progression which may require different strategies for effective and sustainable mitigation. Agent-based modeling provides a highly flexible and dynamic framework to investigate complex management programs on real-world, large-scale landscapes in an efficient manner which can assist in devising control guidelines and analyzing risk of invasion in commercial citrus.

The comprehensive model and web-based interactive interface provides a tool that can analyze complex scenarios in real-world citrus landscapes and investigate a multitude of wide-ranging questions posed by California growers, regulatory agencies, decision makers and other researchers. For example:

- What is the probability of ACP/HLB establishment in different California landscapes?
- How effective (and sustainable) are current ACP/HLB mitigation programs in each landscape? Can these programs be improved?
- As the epidemic evolves, should priority be given to chemical applications or tree removal among residential citrus, in order to protect commercial citrus?
- How can delimitation responses be optimized in different landscapes?
- What are the expected costs associated with each protocol? What contingency plans provide improved short- and long-term mitigation performance?
- What are the consequences/benefits of different levels of grower compliance or residential participation in area-wide protocols?

Moreover, these modeling outputs and scenario analyses provide growers with timely information

regarding the short- and long-term performance and sustainability of different management programs. Several Citrus Research Board projects have used this model and associated tool to address priority concerns and questions regarding current programs in California and area-wide management. The model will continue to provide rapid, comprehensive analyses to assist in guiding effective, spatiotemporal ACP/HLB-targeted management strategies to the California citrus industry.

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Publications and Presentations

Posny, D., Luo, W., McRoberts, N. 2021. A decision-support simulation model for analyzing management of citrus huanglongbing and its vector in Southern California. APS Plant Health, E-Poster.

Manuscripts in Progress:

Posny, D., Luo, W., McRoberts, N., Gottwald,T. Agent-based model for analyzing management of citrus huanglongbing and its vector in Southern California via scenario-based simulations.

Luo, W., Posny, D., McRoberts, N., Gottwald,T. Extending HLB simulation model to investigate social-economic perspectives on management practices.

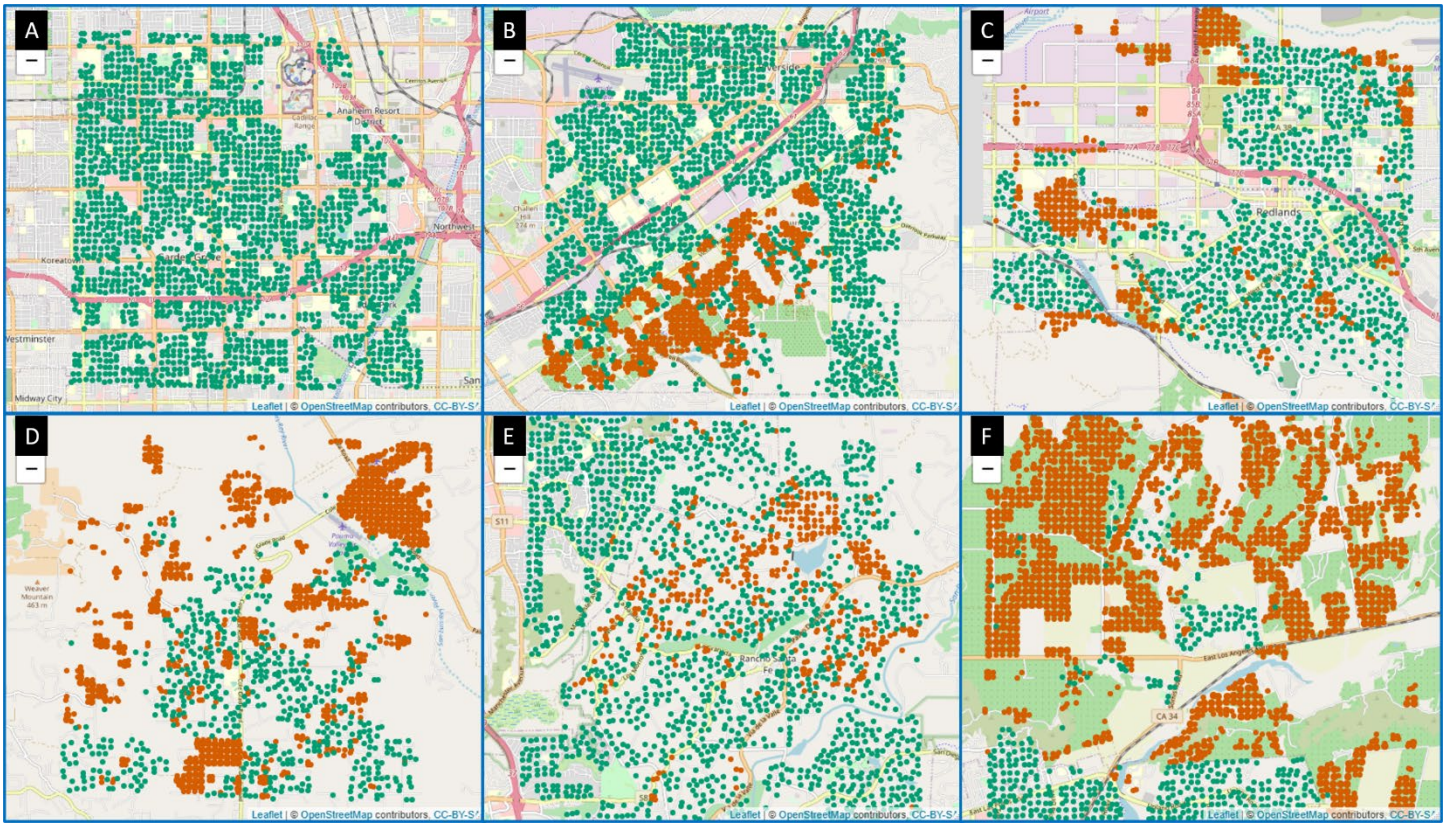

Figure 1 California citrus landscapes of approximately 25-square miles with residential or urban citrus (green) and commercial blocks (orange) for case studies in model development and analysis: (A) Orange, (B) Riverside, (C) San Bernardino, (D-E) San Diego, and (F) Ventura.

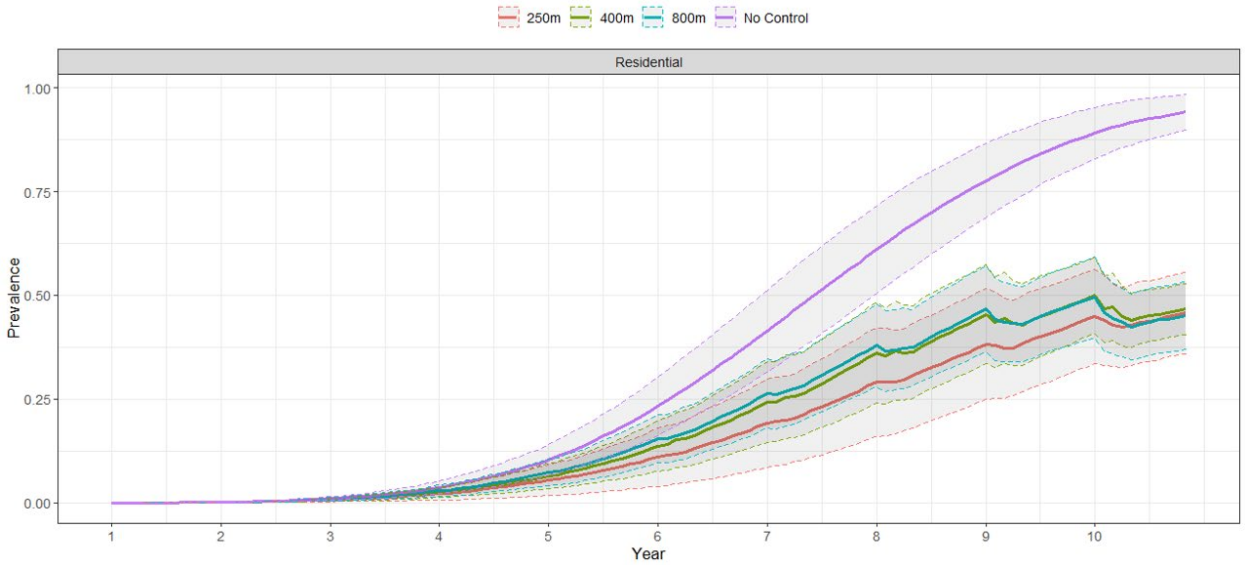

Figure 2. Delimitation radius scenarios in Los Angeles indicate that reductions in the response radius from 800m to 400m to 250m can assist in the efficient use of available resources without significant losses in control performance.

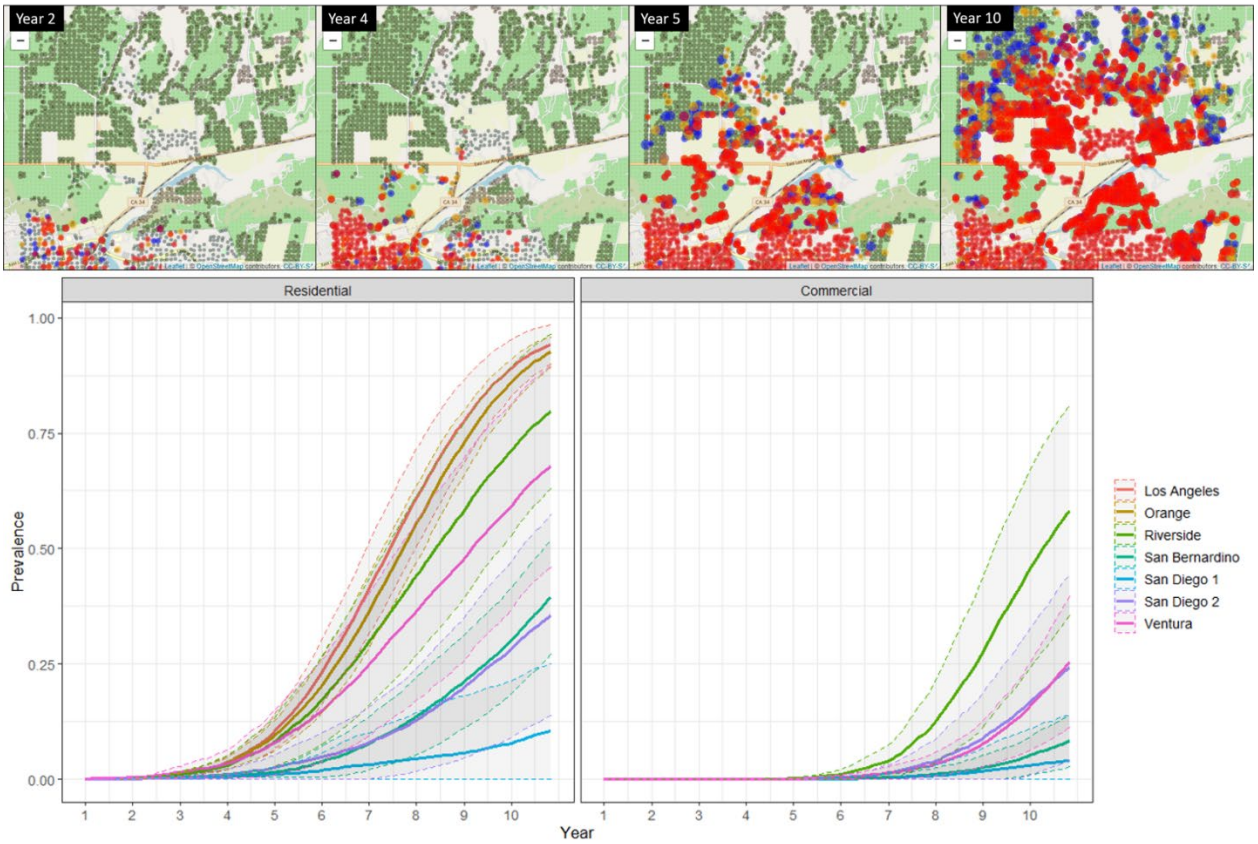

Figure 3. Spatiotemporal spread dynamics of HLB in Southern California landscapes with simulation snapshots in the Ventura landscapes from one run. The properties are color-coded by infection status: Exposed hosts (blue), Cryptic hosts (orange), and Symptomatic hosts (red).

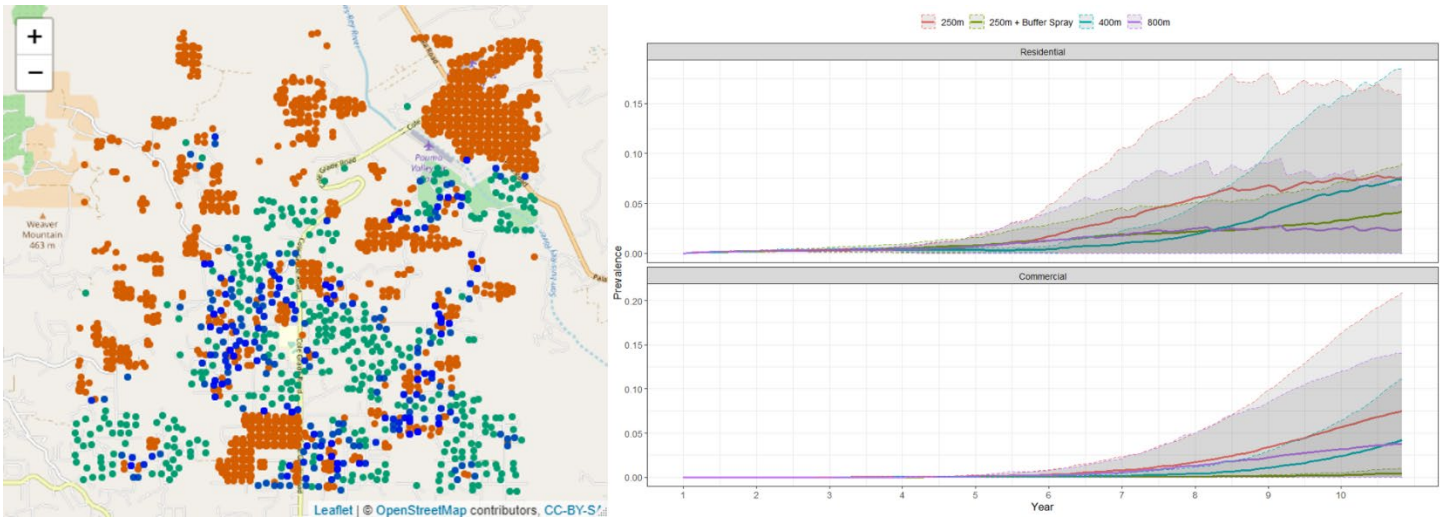

Figure 4. Incorporating 200m residential buffer treatments (properties indicated in blue) can aid in protecting nearby commercial citrus in San Diego when paired with the 250m delimitation response and complete cooperation from residents.