Logic Model -- *Ecology and Integrated Management of Ambrosia Beetles in Eastern US Orchard and Ornamental Tree Crops*

Situation	Inputs	Outputs		Outcomes		
		Activities	Participants	Short Term	Medium Term	Long Term
Non-native ambrosia beetles damage and kill fruit, nut, and ornamental tree crops Optimization of agrichemical applications and repellent technologies based on key ambrosia beetle species, beetle phenology, and plant stress indicators is needed The diversity, pathogenicity, and virulence of auxiliary fungi associated with ambrosia beetles is unknown Reliable ambrosia beetle monitoring systems are needed that are low maintenance and that accurately reflect the risk of host crop attack Indicators (ethanol production of physiological) of host stress are not apparent prior beetle attack or host decline Little economic data on ambrosia beetle associated losses nor on cost inputs for the comparative scenarios of disease prevention versus disease clean-up.	Trans-disciplinary team with extensive experience in IPM, ambrosia beetle biology and management, applied phytopathology, agricultural economics, and extension Stakeholder input (e.g. growers, consultants, cooperative extension, industry) USDA SCRI Funds Platforms for dissemination of information (e.g. Southern Appalachian Extension Portal) Research, extension and education expertise and technical support Field research and laboratory facilities of PD, co-PDs, and collaborators at UGA, NCSU, Cornell Univ., USDA-ARS, Clemson Univ, UF, PSU, Tenn. St. Univ., and Virginia Tech Supplies and laboratory equipment Online trainings and additional extension deliverables Graduate students, postdocs and technicians Advisory Panel	Predict the risk of ambrosia beetle infestation in high value orchard and nursery crop systems through improved understanding of beetle biology and ecology Develop new tools and technologies to enhance the accuracy and precision of host and beetle monitoring strategies Develop and optimize integrated management strategies for ambrosia beetles that include conventional insecticides and fungicides, plant growth regulators, host defense inducers, biological control agents, and behavioral modification compounds Conduct robust extension programming to advise stakeholders on novel ambrosia beetle management paradigms based on economic analyses and research generated data Develop economic models for each cropping system to identify profit maximizing and risk minimizing ambrosia beetle control strategies	Extension educators Apple growers Pear growers Crop consultants Extension specialists Researchers: Plant Pathology, Plant breeding and genetics, Entomology, Horticultural Science, and Agricultural Economics University research station managers and staff Undergraduate and graduate researchers Agrichemical companies	Enhanced stakeholder awareness of ambrosia beetle associated tree decline and factors contributing to their attack Stakeholder knowledge on ineffective management paradigms for ambrosia beetle management is improved The risk of phytopathogen introduction by ambrosia beetles and its contribution to tree decline is defined The relative risk of ambrosia beetle infestation due to abiotic and biotic stress events to host trees is developed Novel diverse management strategies for ambrosia beetle management are identified Early tree stress is identified through improved ethanol detection technologies and ambrosia beetle monitoring systems Stakeholder cost/benefit analyses for ambrosia beetles is improved through the development economic models in each cropping system	Attacks by and tree decline due to ambrosia beetles and associated auxiliarly phytopathogens will be reduced as growers mitigate host stress by implementing cultural strategies and improving disease management programs Growers diversify ambrosia beetle management programs to include repellents, phytohormones, resistance inducers, biologicals, and cultural practices Stakeholders deploy novel technologies and traps to monitor host stress and ambrosia beetles, ultimately reducing host decline and death that is related to ambrosia beetle infestation The application frequency of ineffective insecticides for ambrosia beetle management decreases resulting in cost-savings for stakeholders	Increased profits of the ornamental, nut, and fruit tree industries due to a reduction in tree loss and an increase in crop yields Improved productivity with less input costs and reduced environmental and non-target organism impact Maintenance of the eastern US ornamental nurseries and fruit and nut commercial orchards as leaders in production and host quality Additional funding opportunities to continue the development of sustainable management paradigms for ambrosia beetles in the United States

Assumptions

Stakeholders want to more effectively manage ambrosia beetles
Period of project is sufficient to successfully improve ambrosia beetle management
Reduced reliance on insecticides and sustainability of ornamental nurseries and orchard systems are desired goals

External Factors

Continued support from universities, field stations and grower organizations.
Rate of industry adoption of new, integrated practices for ambrosia beetle management.
Unforeseen events/complications including weather, regulatory aspects of pesticides