Biological Design Doctoral Defense

Modeling Coffee Leaf Rust epidemics in response to shading and other farm management strategies: a spatially explicit and process-based approach

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Abstract

Coffee leaf rust (CLR) is an aggressive disease that has caused devastating production losses around the world. While coffee productivity under shade conditions has been simulated in sufficient detail, explicit modeling of the interactions between shading levels, microclimate, coffee plant physiology, and CLR progression remains largely unexplored, despite the recognized influence of shade on CLR epidemics. This dissertation introduces a new model, SpatialRust, as an initial approximation to an integrative simulation framework where farm design and management strategies can be linked to coffee production and CLR epidemic outcomes. SpatialRust considers stylized processes describing the dynamics of shade trees, coffee plants, and CLR and their interactions within a spatially explicit context. The dissertation then presents three experiments conducted using SpatialRust simulations. The first experiment investigates the role of shading as a mitigation tool for CLR outbreaks. It demonstrates that shade can effectively mitigate CLR epidemics when the conditions are otherwise conducive to a major CLR epidemic. Additionally, the experiment reveals complex effects of different shade management approaches, underscoring the potential value of future empirical studies that consider temporal and spatial shade dynamics in relation to CLR outcomes. The second experiment focuses on the financial balance of farms and examines how farmer preferences and needs influence farm management strategies. The findings indicate that incorporating CLR mitigation as part of the strategy's goals leads to positive long-term farm performance, even when planning for the short term. In the third experiment, the scope of the simulations are expanded to include neighboring coffee farms. The results demonstrate that the strategies adopted by immediate neighbors can affect the performance of individual farms, emphasizing the importance of considering the broader coffee-growing landscape context.

This work shows that the integration of farm management practices and the resulting shading effects into a spatially explicit framework can provide valuable insights into the dynamics of CLR epidemics and how they respond to farmers' decisions.

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Zoom Link: https://asu.zoom.us/j/89689680240?pwd=UFFiQjViSFd1Nm45VjdMaVVCUEI4UT09