MycoCast: Developing an Agent-Based Model for Mycorrhizal Network Connectivity Under Changing Environmental Conditions

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Mycorrhizal fungi establish underground networks that form symbiotic relationships with almost all plant species and facilitate crucial ecological processes, but habitat degradation is their foremost threat, contributing momentum to escalating ecosystem degradation and highlighting the need for scalable solutions for better conservation. Right now, the golden-standard surronds prevention of mycorrhizal network disruptions which is often time-intensive and costly, limiting it from widespread application. Thus, this research explored agent-based models (ABMs) as a novel, cost-effective tool for better mitigation of mycorrhizal network disruptions. The ABM was developed in NetLogo, and 500 simulations were conducted across five environmental scenarios that varied from extremely degraded to predominantly intact ecosystems. Comparison of the simulation results via heatmaps and sensitivity analysis yielded a strong data structure that was used for the calibration of MycoCast. Experimental validation with samples from two sites confirmed these results with great precision (~5% bias and >95% agreement). Then, an in-silico remediation tool, MycoCast, was created. Environmental parameters had a significant role in shaping soil health ($p<0.01$), indicating an imperative need for site-specific remediation measures to maximally achieve ecological restoration. This study is the first successful ABM for mycorrhizal fungi, bridging the critical gap by providing an adaptable, economically viable tool for environmental policy and protection. Future work will focus on enhancing model accuracy and integrating real-time monitoring with satellite data, paving the way towards dynamic, data-driven conservation strategies to combat fungal biodiversity loss and restore ecosystems globally.

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