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Simulation and Latin Hypercube Sampling of Mixed-Time Models in a Consumer-Resource Relationship

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Many species have a consumer-resource relationship in which the resource species serve as food to the consumer species, causing death for the resource and growth for the consumer species. This relationship can involve a consumer and a resource, or multiple consumers and a resource. In the case of multiple consumers, competition for a resource is possible, and this can lead to death in any of the consumers. These processes can be continuous (which monitors populations of the consumer and resource at every time), or discrete (which monitors the populations yearly). Models that are only continuous or discrete may fail to take on the various workings of the species. Hence, this work combines continuous and discrete approaches to model consumer-resource interactions. For this model, it is vital to understand what leads to the death of the species, the survival of either, or the coexistence of both. However, identifying and understanding the behaviors possible require careful analysis and computations due to the model approach. In the case of competing consumers, we establish necessary conditions on model parameters for the existence of a coexistence fixed point. For the rest of our parameter space, we use a numerical approach to create a bifurcation-like image that shows the possible behaviors this model can exhibit. This is accomplished by testing the model over a wide span of parameters and varying initial conditions using Latin Hypercube Sampling. We identify parameters and initial conditions that produce the persistence of both species. In the case of a single consumer, we compare the behavior in different regions to existing bifurcation curves and obtain a better understanding of parameter regions without analytic results.