BRIGHAM AND WOMEN'S HOSPITAL
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Channing Microbiome Seminar

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Identifying sensor species to predict critical transitions in complex ecosystems

Ecological systems can undergo sudden, catastrophic changes known as critical transitions. Anticipating these critical transitions remains challenging in systems with many species because the associated early warning signals can be weakly present or even absent in some species, depending on the system dynamics. Therefore, our limited knowledge of ecological dynamics may suggest that it is hard to identify those species in the system that display early warning signals. Here, we show that, in mutualistic ecological systems, it is possible to identify species that early anticipate critical transitions by knowing only the system structure—that is, the network topology of plant–animal interactions. Specifically, we leverage the mathematical theory of structural observability of dynamical systems to identify a minimum set of "sensor species," whose measurement guarantees that we can infer changes in the abundance of all other species. Importantly, such a minimum set of sensor species can be identified by using the system structure only. We analyzed the performance of such minimum sets of sensor species for detecting early warnings using a large dataset of empirical plant–pollinator and seed-dispersal networks. We found that species that are more likely to be sensors tend to anticipate earlier critical transitions than other species. Our results underscore how knowing the structure of multispecies systems can improve our ability to anticipate critical transitions.

Hosted by Yang-Yu Liu