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When Google meets Lotka-Volterra

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In his theoretical work of the 70's, Robert May introduced a Random Matrix Theory (RMT) approach for studying the stability of large complex biological systems. Unlike the established paradigm, May demonstrated that complexity leads to instability in generic models of biological networks having random interaction matrices A. Similar random matrix models have since been applied in many disciplines. Central to assessing stability is the "circular law" since it describes the eigenvalue distribution for an important class of random matrices, A. However, despite widespread adoption, the "circular law" does not apply for ecological systems in which density-dependence operates (i.e., where a species growth is determined by its density). Instead one needs to study the far more complicated eigenvalue distribution of the community matrix $S = DA$, where D is a diagonal matrix of population equilibrium values. Here we obtain this eigenvalue distribution. We show that if the random matrix, A, is locally stable, the community matrix, $S = DA$, will also be locally stable, providing the system is feasible (i.e., all species have positive equilibria $D > 0$). This helps explain why, unusually, nearly all feasible systems studied here are locally stable. Large complex systems may thus be even more fragile than May predicted, given the difficulty of assembling a feasible system. The degree of stability, or resilience, was found to depend on the minimum equilibrium population, rather than factors such as network topology. For studying competitive and mutualistic systems, our analysis is only achievable upon introducing a simplifying "Google-matrix" reduction scheme. In this talk we will explain what happens "when Google meets Lotka-Volterra."

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