Box 1 Asymptotic and transient analysis of the Rosenzweig-MacArthur predator-prey model (option 2)

The Rosenzweig-MacArthur model describes the dynamics between prey species with density-dependent population growth and a specialist predator with a saturating consumption rate. A non-dimensionalized version of this model with linear closure terms is given as

predator and prey can be described as: $\begin{aligned}\frac{dn}{dt} &= n\left(1-\frac{n}{k}\right)-\frac{np}{n+1}\\ \frac{dp}{dt} &= ap\left(\frac{n}{n+1}-m\right)\end{aligned}$. There is a unique positive equilibrium at $p^* = (1+n^*)\left(1-\frac{n^*}{k}\right),\ n^* = \frac{m}{1-m}$. Linearizing about this equilibrium we find it is locally stable when $\frac{k-1}{2} < n^* < k$. If the left-hand inequality is violated, the eigenvalues cross the imaginary axis as a complex conjugate pair, and the equilibrium gives way to a stable predator-prey cycle. Violation of the right-hand inequality produces real eigenvalues, one of which is positive, and results in extinction of the predator. We can also calculate the conditions for the stable interior equilibrium to be a stable focus, and therefore approached via damped oscillations, or a stable node with a monotonic approach. However, if the largest eigenvalue of the Jacobian matrix is negative, while the largest eigenvalue of the Hermitian matrix is positive, the equilibrium will be stable but reactive, and some perturbations, no matter how small, will initially grow in magnitude (Neubert and Caswell 1997). Further, Neubert and Caswell (1997), demonstrate that the resilience and reactivity of this system change at different rates with a change in parameters.

Uncertainty in the parameters that determine the asymptotic and transient dynamics of this system will determine how likely some qualitative behaviors are for our particular system. Certainly, timeseries analysis without a concurrent assessment of the probability of particular parameter values is unlikely to be very informative because of the wide variety of possible behaviours and the potential for reactivity to disturbance.