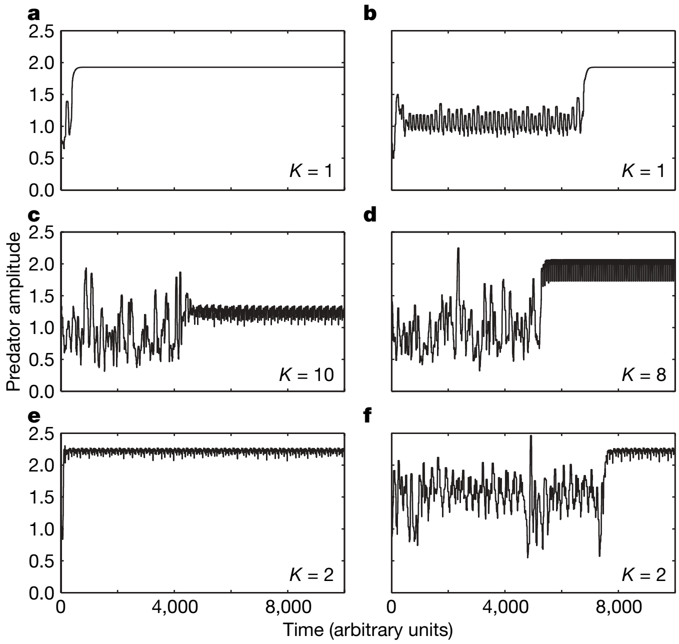

Figure 2 | Total predator amplitude (summed over all patches) as a function of time for cluster solutions. Local dynamics are characterized by strong prey density dependence ($\theta = 0.3$), predator mortality rates ($\eta = 1$) comparable to prey birth rates, moderate predator dispersal ($d_p = 2^{-7}$) and slower prey dispersal ($d_h = 2^{-9}$). **a**, **b**, Weak predation ($\phi = 2.75$) and regular networks. **c**–**f**, Strong predation ($\phi = 6$) and rewired networks ($m = 2$). All initial conditions and rewired networks were independently generated (see Methods). Each panel is labelled with the asymptotic number of clusters (K) observed in the simulation.

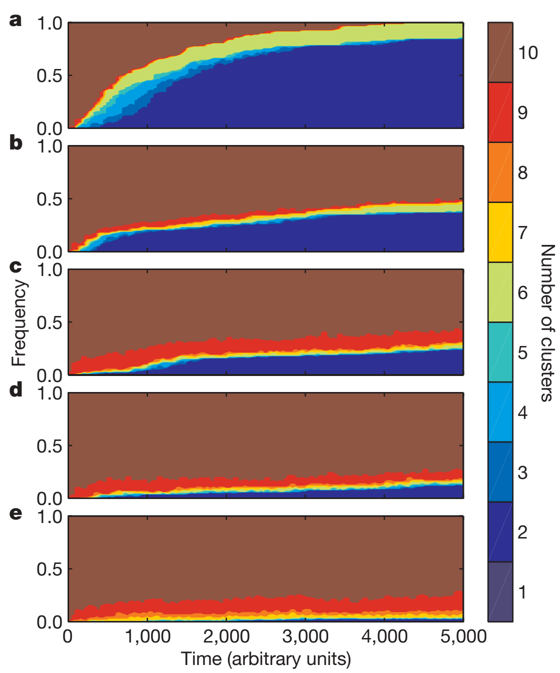

Figure 3 | Distribution of cluster states as a function of time. We consider systems with moderate dispersal rates ($d_h = 2^{-9}$, $d_p = 2^{-7}$) and ordered to random dispersal networks. **a**, Regular lattice; **b**, $m = 1$; **c**, $m = 2$; **d**, $m = 3$; **e**, random network. Regular networks converge to two- and six-cluster solutions, whereas irregular networks produce more eight-, nine- and ten-cluster solutions. Most of these large-k-cluster states are transient solutions. Local dynamics correspond to strong predation ($\phi = 5$), strongly self-regulating prey ($\theta = 0.3$) and predator mortality rates ($\eta = 1$) comparable to prey birth rates. Each panel summarizes 100 independent simulations.

patches in different clusters may vary among k-cluster solutions and over time for a single k-cluster solution. Thus, even 'globally asynchronous' n-cluster solutions may display considerable synchrony and, hence, larger amplitudes at various times during the solution. Furthermore, large-k-cluster classes can contain complex transient solutions resembling chaotic saddles, as well as asymptotic solutions displaying chaotic, quasi-periodic or periodic behaviour.

We find consistent and striking differences between dynamics with regular and irregular topologies for a broad range of underlying local dynamics. Looking at the distribution of cluster number through time in an ensemble of simulations reveals a substantial amount of information about the transient and asymptotic dynamics of these systems (Fig. 3 and Supplementary Figs 7–11). Increasing randomization of the network dramatically reduces the proportion of solutions with small to moderate numbers of clusters over ecologically relevant timescales.

For systems with heterogeneous dispersal networks, the temporal dynamics of k-cluster solutions suggest that transient dynamics are probably far more important than asymptotic dynamics on ecological timescales (Fig. 3). There are consequences for fluctuation amplitude and extinction risk of predators and prey, as is further revealed by manipulating both the local and the dispersal dynamics of the system. Varying predator efficiency, ϕ, is one way to move the system from low- to high-amplitude fluctuations. Because we are mainly interested in spatial persistence mechanisms, regional amplitude is a reasonable proxy for extinction risk in the context of a deterministic model (see Methods). For relatively low predator efficiencies, the asymptotic dynamics of all patch configurations are globally synchronous (Fig. 4a) and transients are short (Fig. 4b). At higher predator efficiencies, intermediate k-cluster solutions become stable, and asymptotic amplitudes level off near two orders of magnitude. This effect holds even at very high predator efficiencies, where single-patch systems fluctuate over five or more orders of magnitude and local extinction is extremely likely. The transient dynamics of these solutions have even lower median amplitudes, closer to one order of magnitude. Systems with irregular network structures spend much more time on these lower-amplitude transient solutions (Fig. 4b).

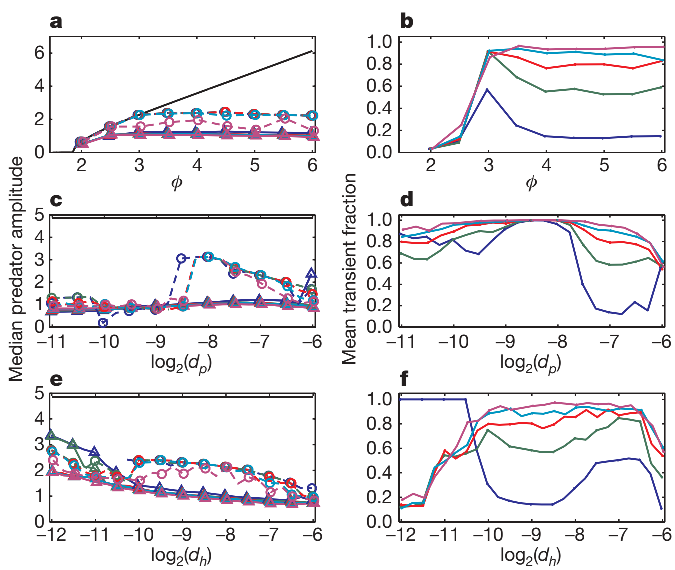

Figure 4 | Predator amplitude and transient duration. **a**, **c**, **e**, Median total predator amplitude during transient (triangles, solid lines) and asymptotic (open circles, dashed lines) solution phases; **b**, **d**, **f**, mean fraction of time spent in transient solutions. The black lines in **a**, **c**, and **e** are amplitudes of globally synchronous solutions for the chosen parameter values: $\theta = 0.3$, $\eta = 1$, $d_h = 2^{-9}$, $d_p = 2^{-7}$ (**a**, **b**); $\phi = 5$, $\theta = 0.3$, $\eta = 1$, $d_h = 2^{-9}$ (**c**, **d**), $\phi = 5$, $\theta = 0.3$, $\eta = 1$, $d_p = 2^{-7}$ (**e**, **f**). Data points are jittered horizontally and alternate markers omitted in **c**–**e** to improve readability. Each case uses at least 150 independent simulations. Dark blue, regular lattice; green, $m = 1$; red, $m = 2$; light blue, $m = 3$; pink, random network.