Synchrony & Ecological Dynamics

NiMBioS – 11th April 2011

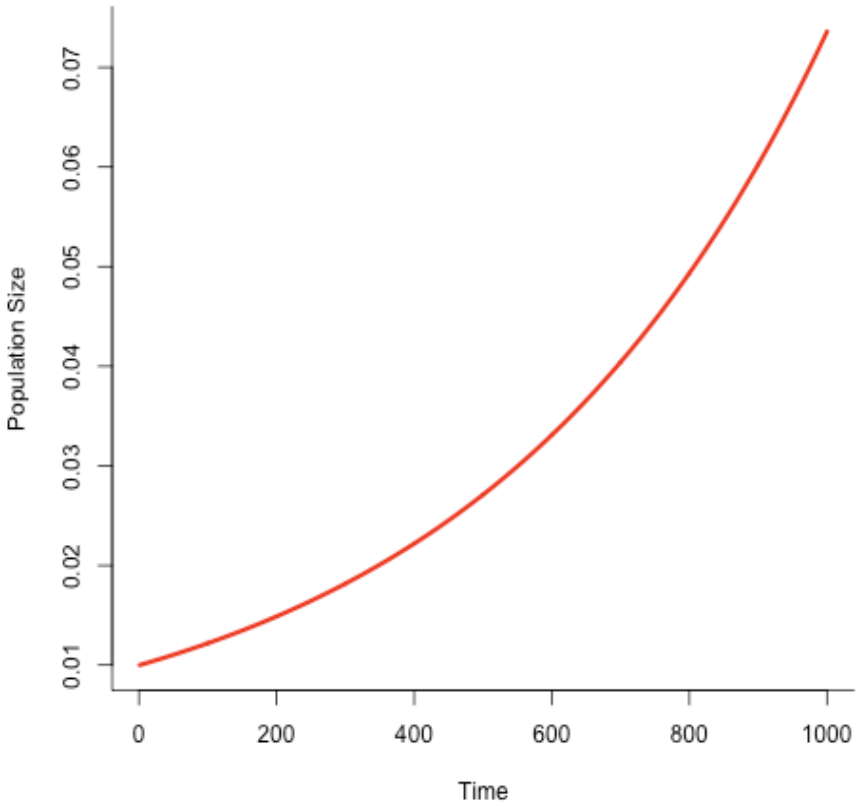
Plan

- overview of ecological dynamics
- ecological processes and synchrony
- noise in ecological systems
- noise and synchrony

Ecological Dynamics

In the absence of limiting processes, ecological systems are expected to show exponential increases or decreases depending on the sign (and magnitude) of the population growth parameter:

$$\frac{dN}{dt} = rN(t)$$



Ecological Dynamics

Negative feedback that alter as density increases can affect dynamics

Increases in deaths or decreases in births lead introduce limitation and regulation into ecological systems: this is **density dependence**

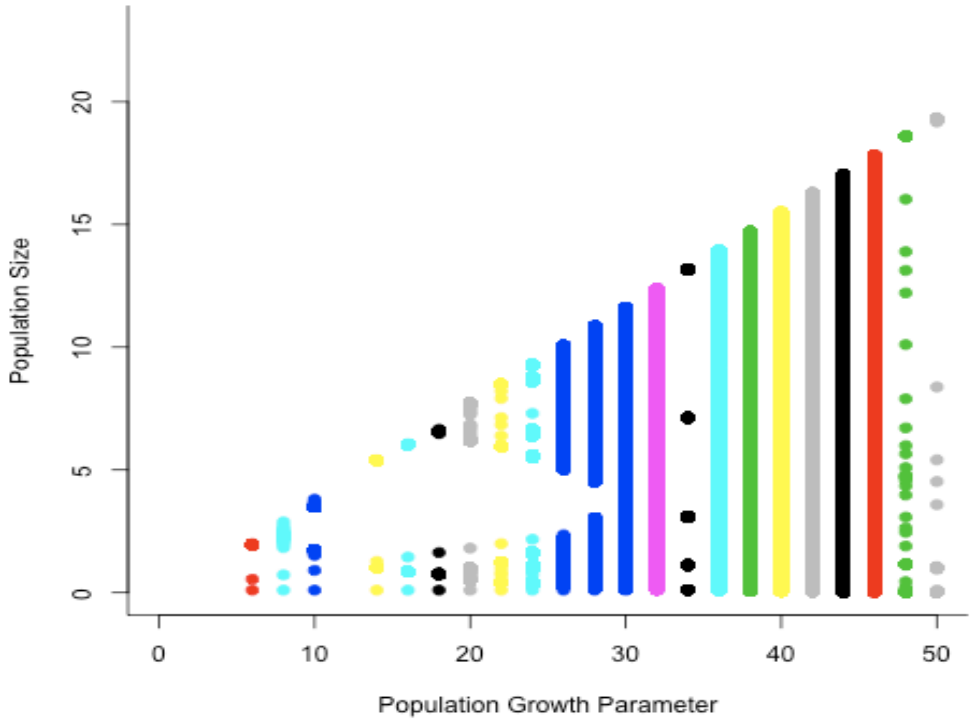
$$\frac{dN}{dt} = rN(t)\,f(N(t))$$

$$\frac{dN}{dt} = rN(t)\left(\frac{K - N(t)}{K}\right)$$

Ecological Dynamics

Non-linear negative feedbacks predicted to lead to oscillatory dynamics:

$$f(N(t)) = (1 + \alpha N)^{-\beta}$$



Synchrony in Ecological Systems

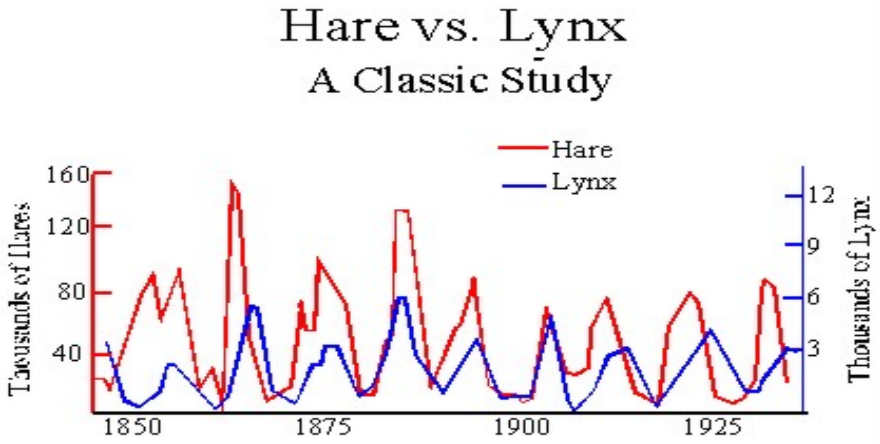
#1 – Non-linear processes must be expected in the ecological system

Ecological Dynamics

Non-linear dynamics common in **trophic ecological systems**

#1 detecting cycles in single species dynamics might be hard

#2 trophic interactions have inherent tendency to oscillate



Delayed density dependence is the phenomenon in which the cycles of two interrelated populations are synchronized, with the predator delayed slightly compared to the prey.

Ecological processes and synchrony

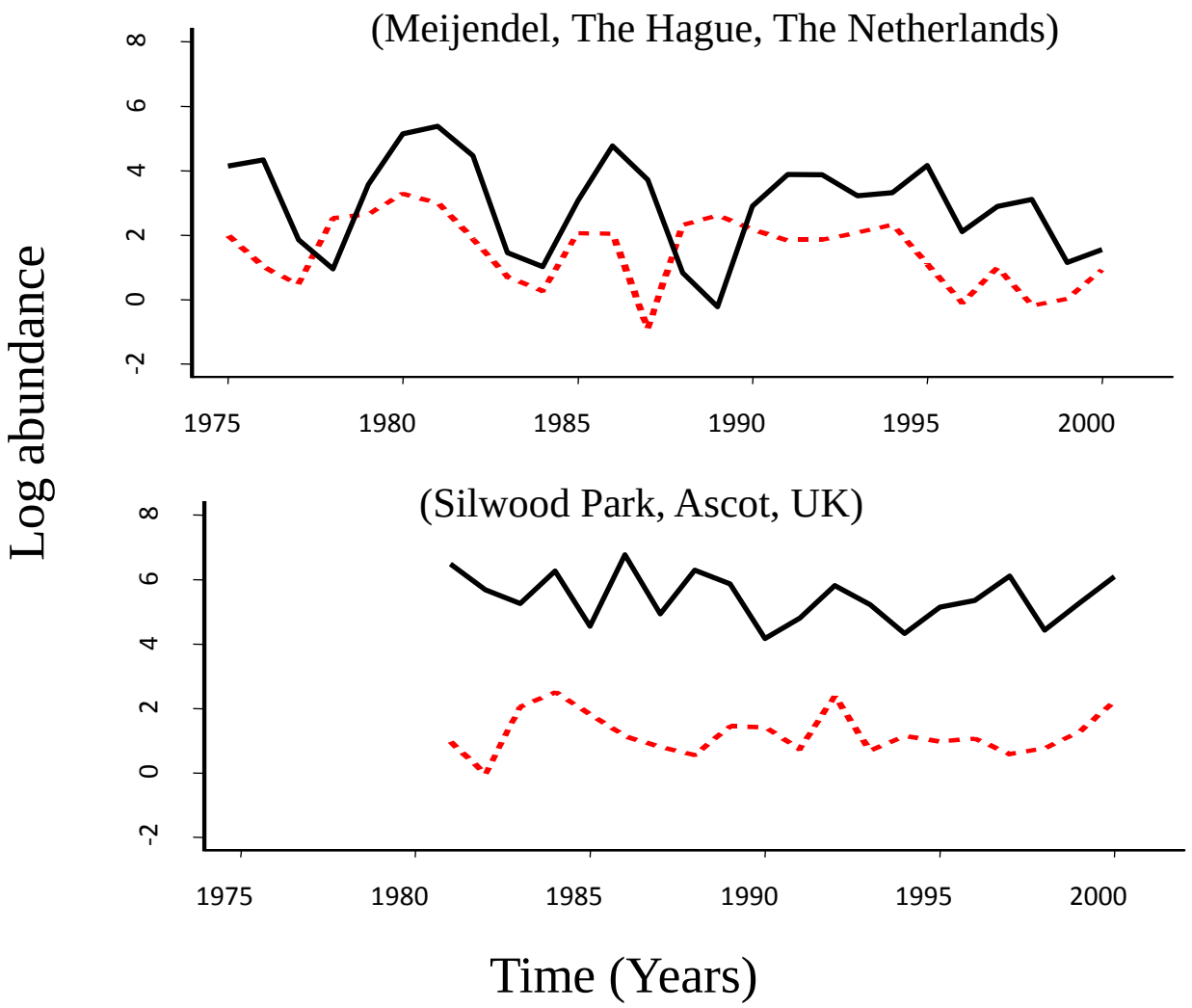
Density–dependence: Moran Effect

If two populations had the same density-dependent structure, then correlated density-independent factors (usually weather-induced) could bring the populations' fluctuations into synchrony

(Moran P.A.P. (1953) **The statistical analysis of the Canadian lynx cycle. II Synchronization and meteorology.** ***Aust. J. Zool., 1:291-29***)

(Grenfell B.T. *et al. (1998)* **Noise and determinism in synchronised sheep dynamics.** ***Nature, 394:674-677)***

Ecological processes and synchrony



Synchrony in Ecological Systems

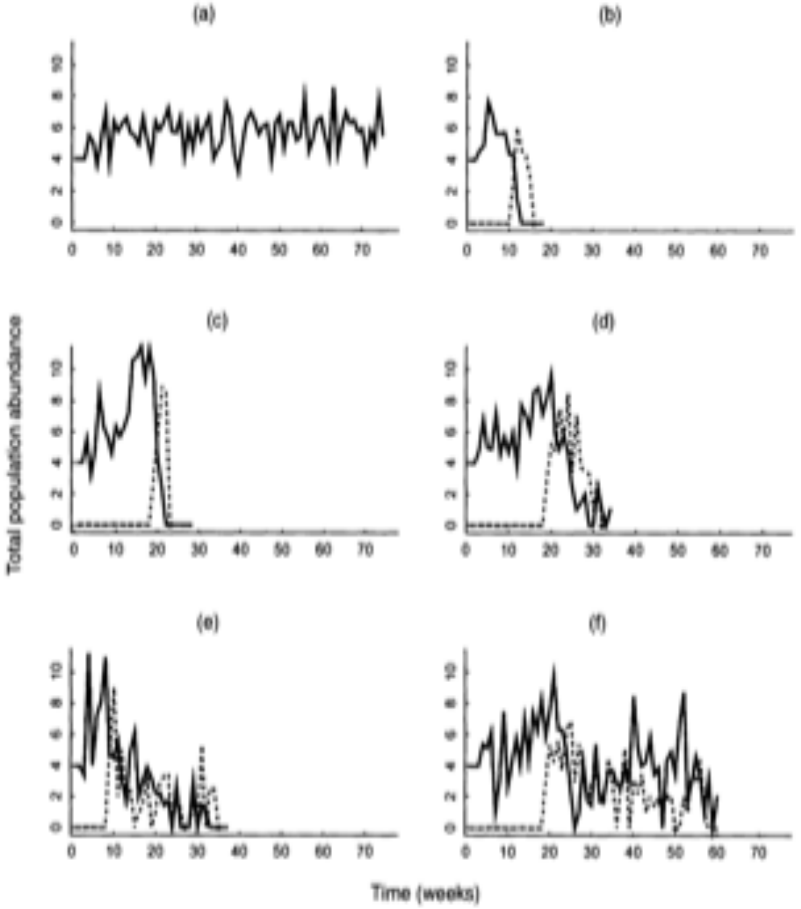
#1 – Non-linear processes must be expected in the ecological system

#2 – Density dependent structures should be the same for synchrony (but by how much?)

Ecological processes and synchrony

Spatial coupling

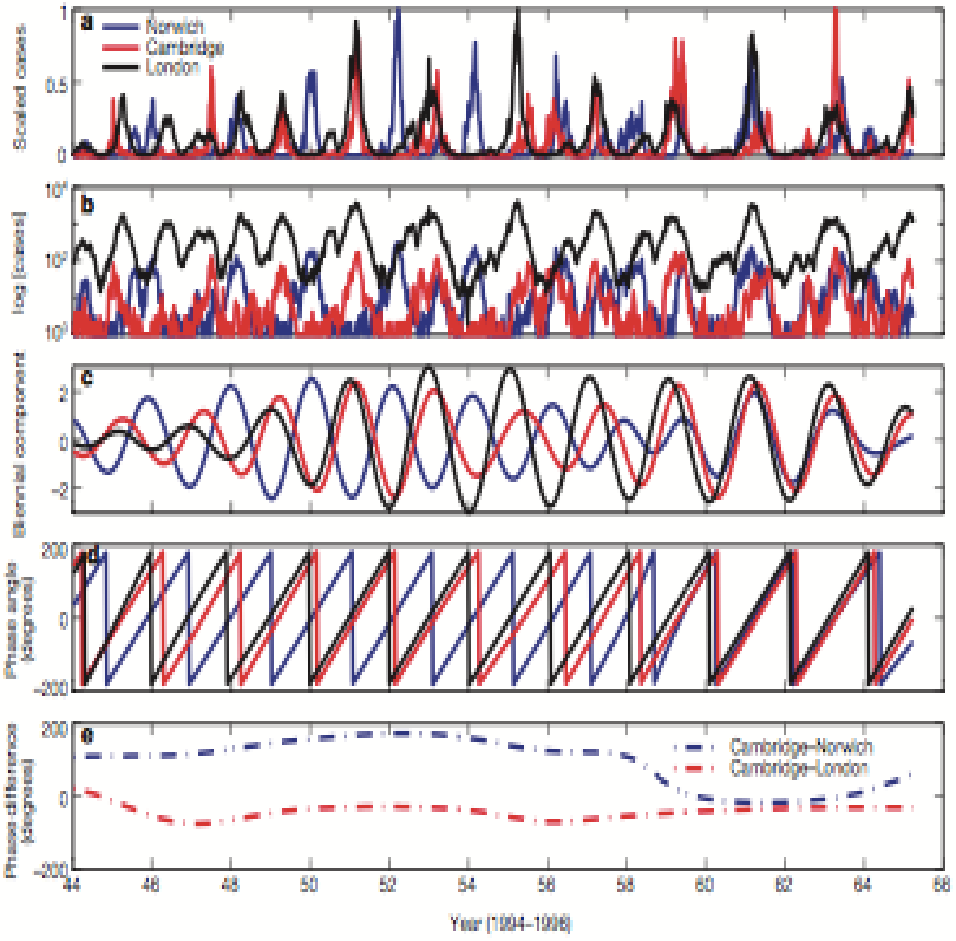
Linking populations through limited dispersal can promote (regional) population persistence



Ecological processes and synchrony

Spatial coupling

Linking populations through limited ecological (epidemiological) processes can influence population synchrony



Synchrony in Ecological Systems

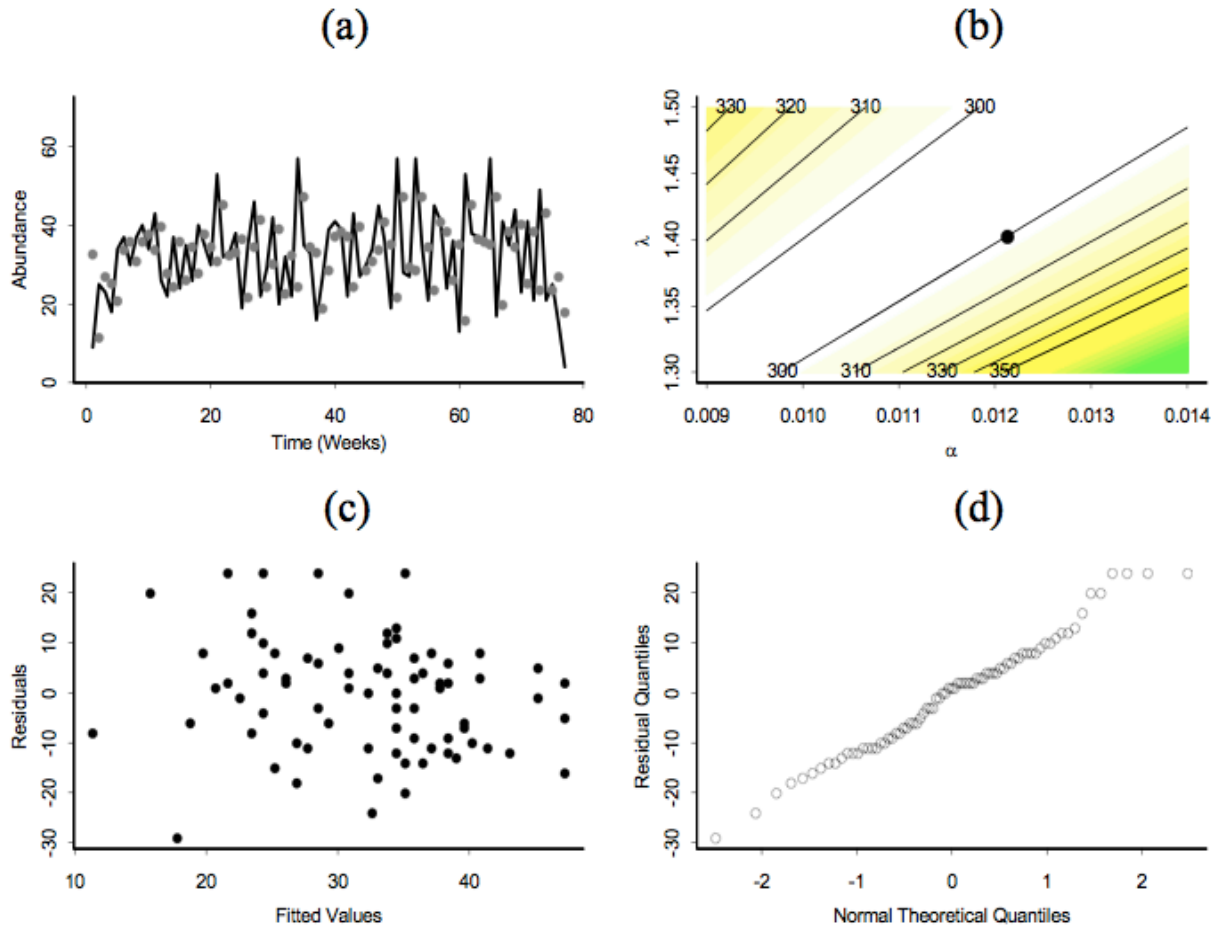
#1 – Non-linear processes must be expected in the ecological system

#2 – Density dependent structures should be the same for synchrony (but by how much?)

#3 – Spatial correlation between populations must be expected (again, by how much?)

Noise and ecological systems

Noise affects deterministic ecological dynamics



Noise and ecological systems

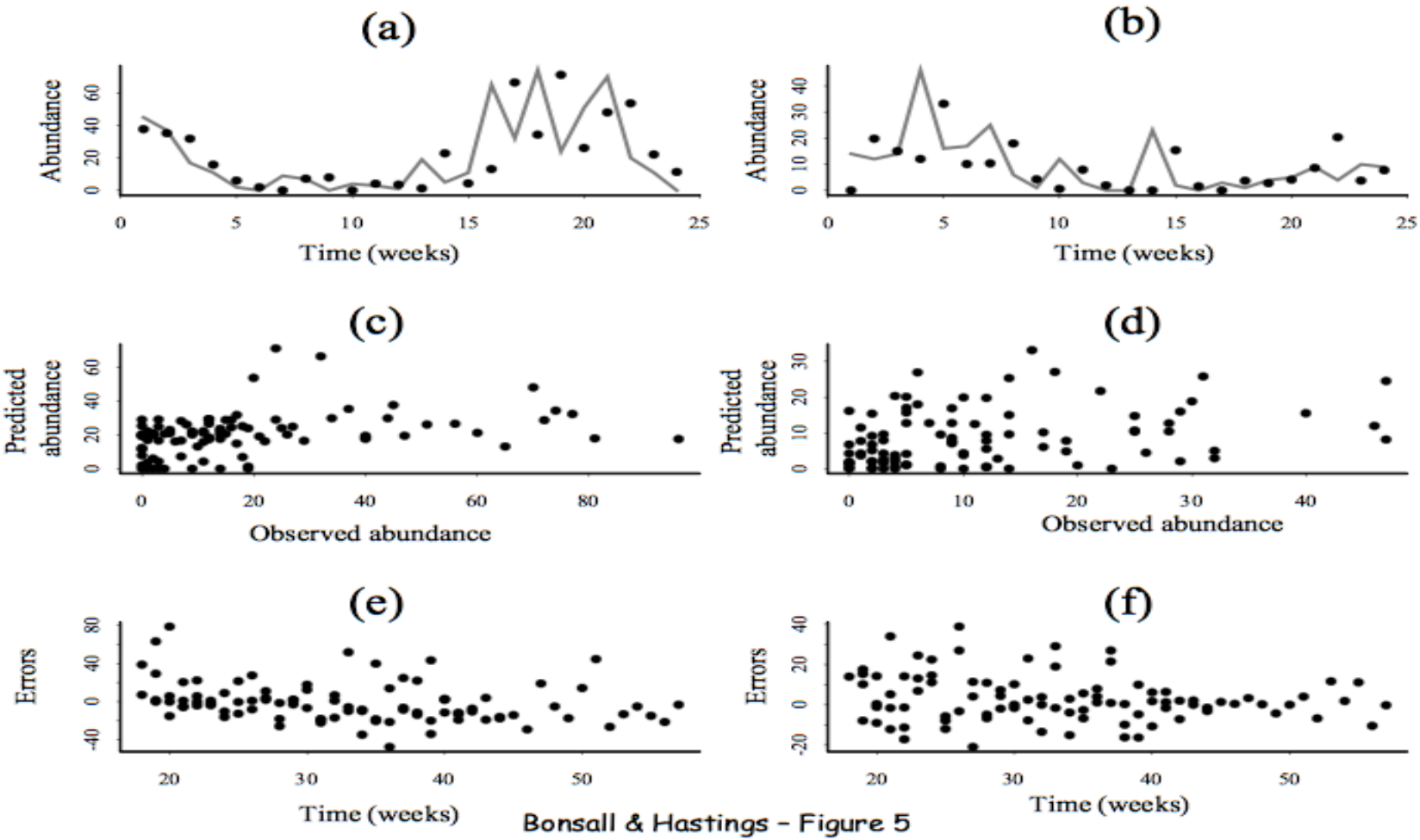
Noise affects deterministic ecological dynamics:

environmental stochastic effects – random processes imposed on a population often manifest through population-level characteristics (population growth/carrying capacity)

demographic stochastic effects – intrinsic uncertainty associated with an individual's reproduction, survival and dispersal

Noise and ecological systems

Noise affects spatial ecological dynamics



Bonsall & Hastings – Figure 5

Synchrony in Ecological Systems

#1 – Non-linear processes must be expected in the ecological system

#2 – Density dependent structures should be the same for synchrony (but by how much?)

#3 – Spatial correlation between populations must be expected (again, by how much?)

#4 – Noise is important in determining ecological dynamics

Noise and synchrony

How important is demographic noise in driving spatial synchrony in ecological systems:

- Predator-prey interactions
- Disease interactions

Approaches might involve coupling multiple oscillatory dynamical systems together with stochastic processes and evaluating macroscopic properties of synchrony (e.g. Kuramoto Index)