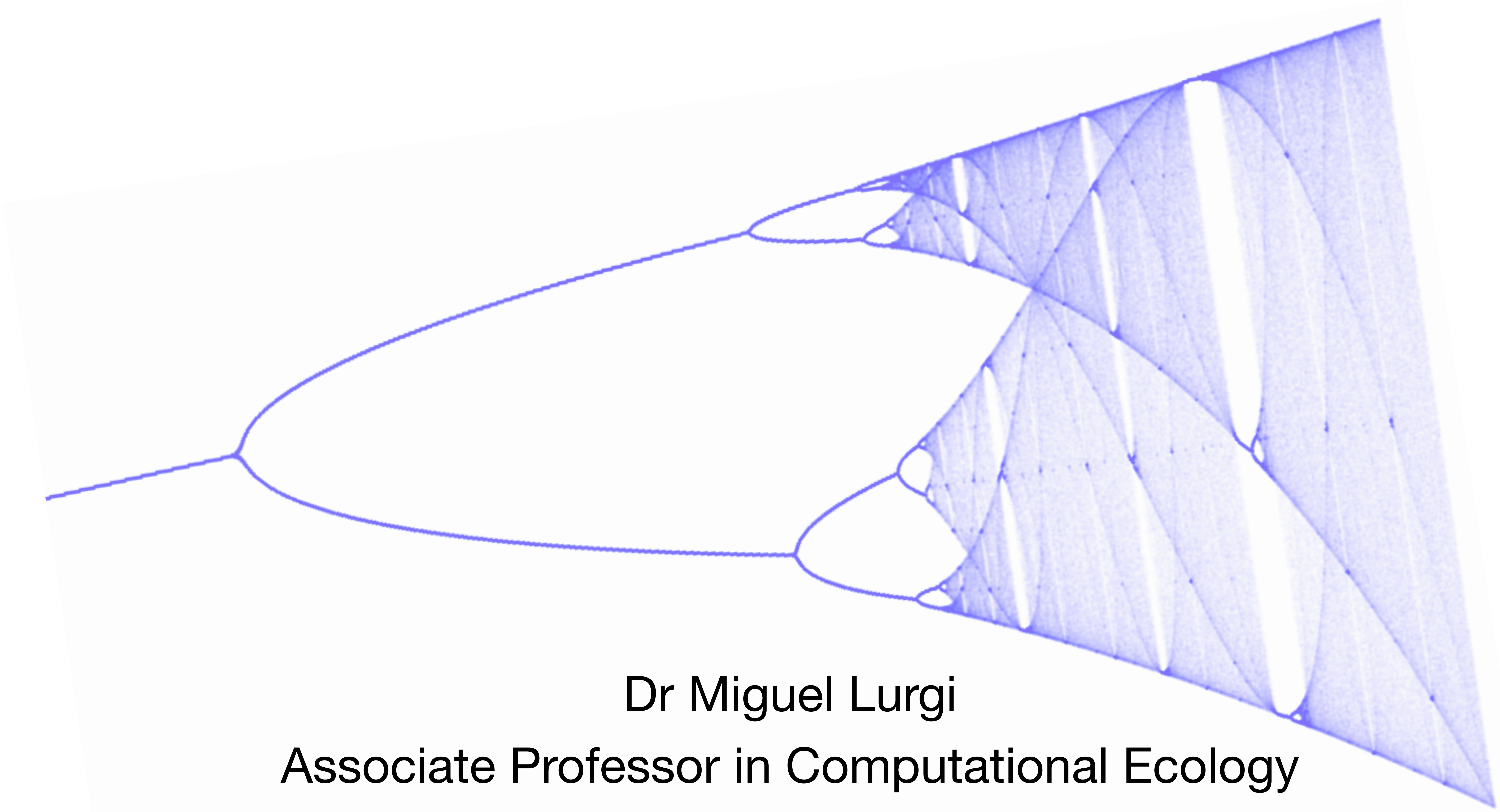
Single species population dynamics



Dr Miguel Lurgi

Associate Professor in Computational Ecology

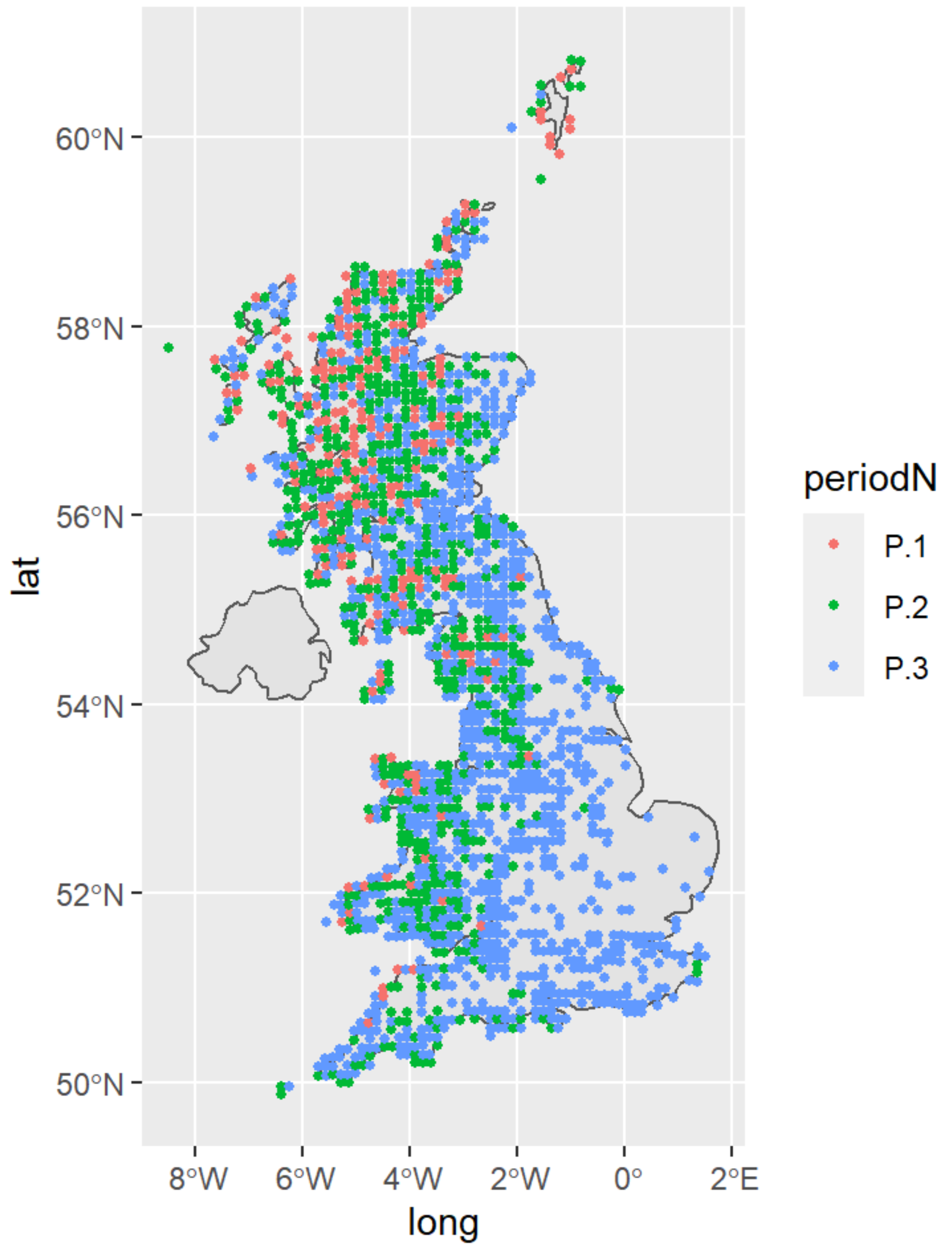
Computational Ecology Lab - https://computational-ecology-lab.github.io/

What we will cover

- Remember what ecology is about: with a focus on populations
- How do populations grow and change over time
- Exponential growth
- Density-dependent growth

Ecology

Describe the patterns of abundance and distribution of species and identify the mechanisms that give rise to these patterns



Population ecology

The study of changes in the size of a population (e.g. number of individuals) of a given species through time (or space) and the factors (mechanisms) that regulate it

Definition - Population: Group of individuals of a single species that occupy the same general area

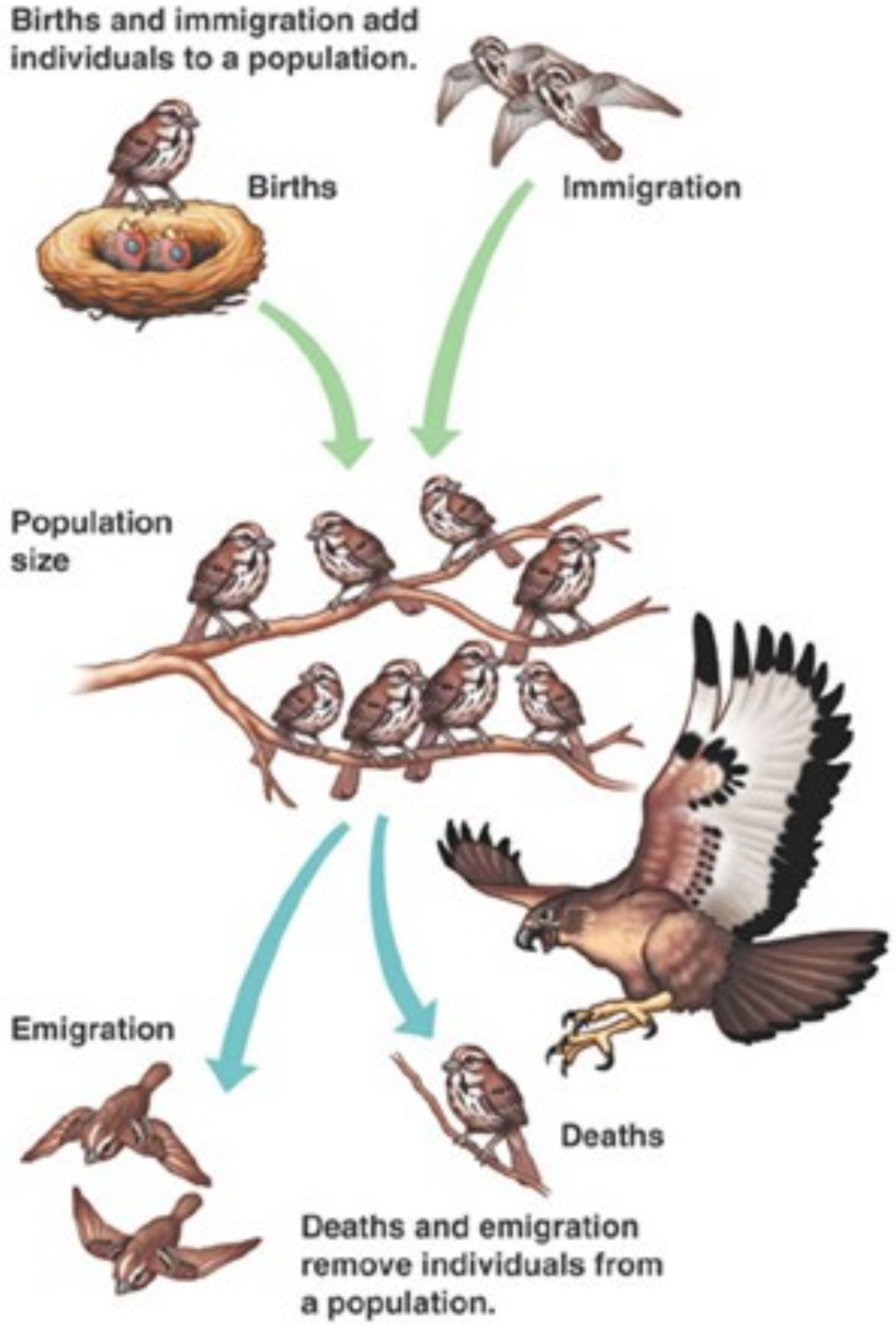
This means that individuals:

- Rely on the same resources
- Are influenced by the same biotic and abiotic factors
- Have a high probability of interacting, e.g. competing, co-operating, breeding with other individuals in the group

Characterising populations

1. How many individuals / density / biomass
2. How fast it grows
3. Limits to its growth

Factors influencing growth



Limits to growth

$$N_{t+1} = \boxed{N_t} + \boxed{B_t + I_t} - \boxed{D_t - E_t}$$

Number of individuals

How fast it grows

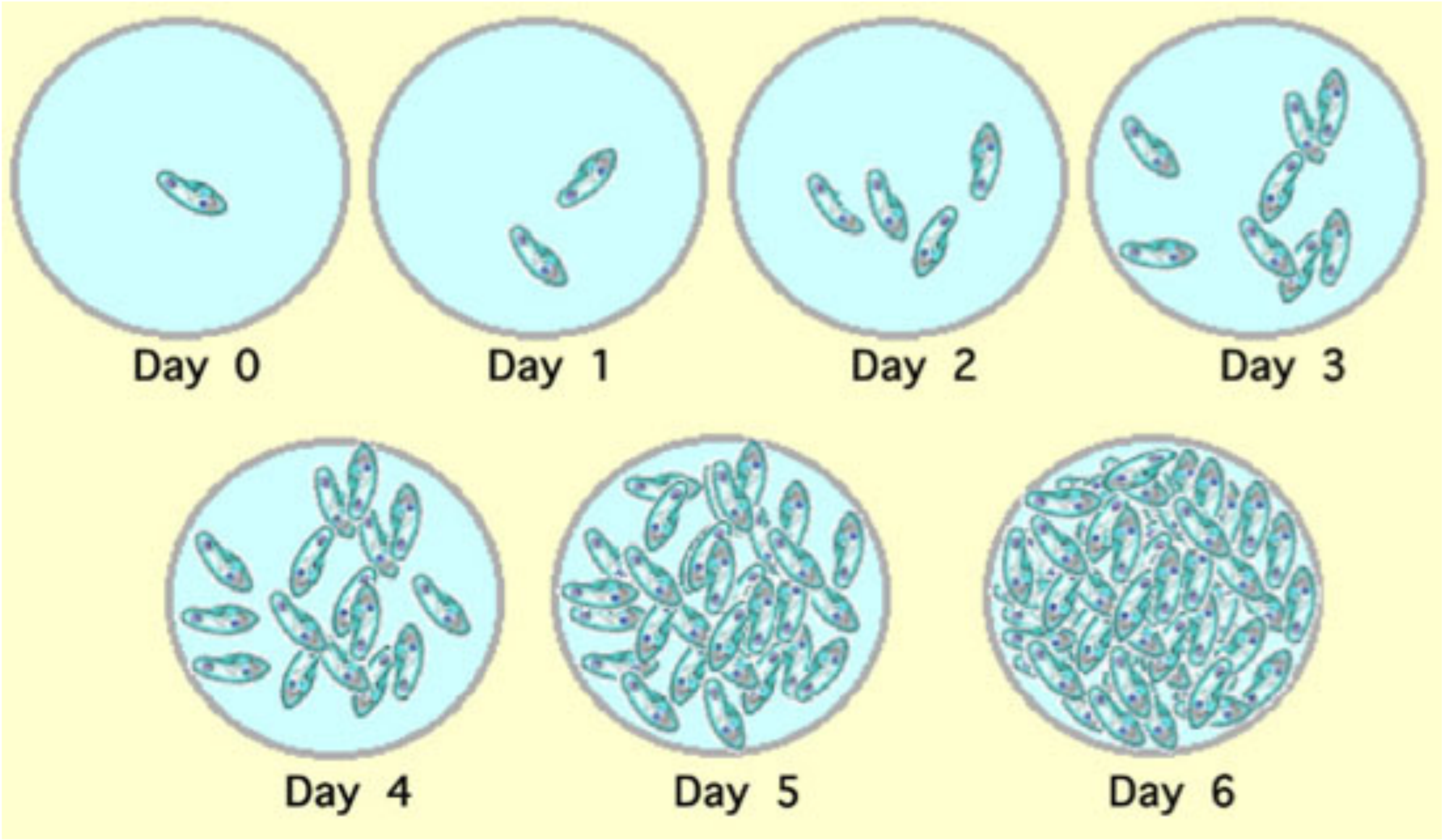
Functional forms

- Density independent growth (e.g. exponential)
- Density dependent growth

Exponential growth

Populations growth exponentially if:

- Birth and death rates are constant
- More births than deaths
- There are no limiting resources



Vandermeer, J. (2010) How Populations Grow: The Exponential and Logistic Equations. Nature Education Knowledge 3(10):15

For local, closed populations

Discrete time equation

$$N_{t+1} = RN_t$$

Finite rate of population increase

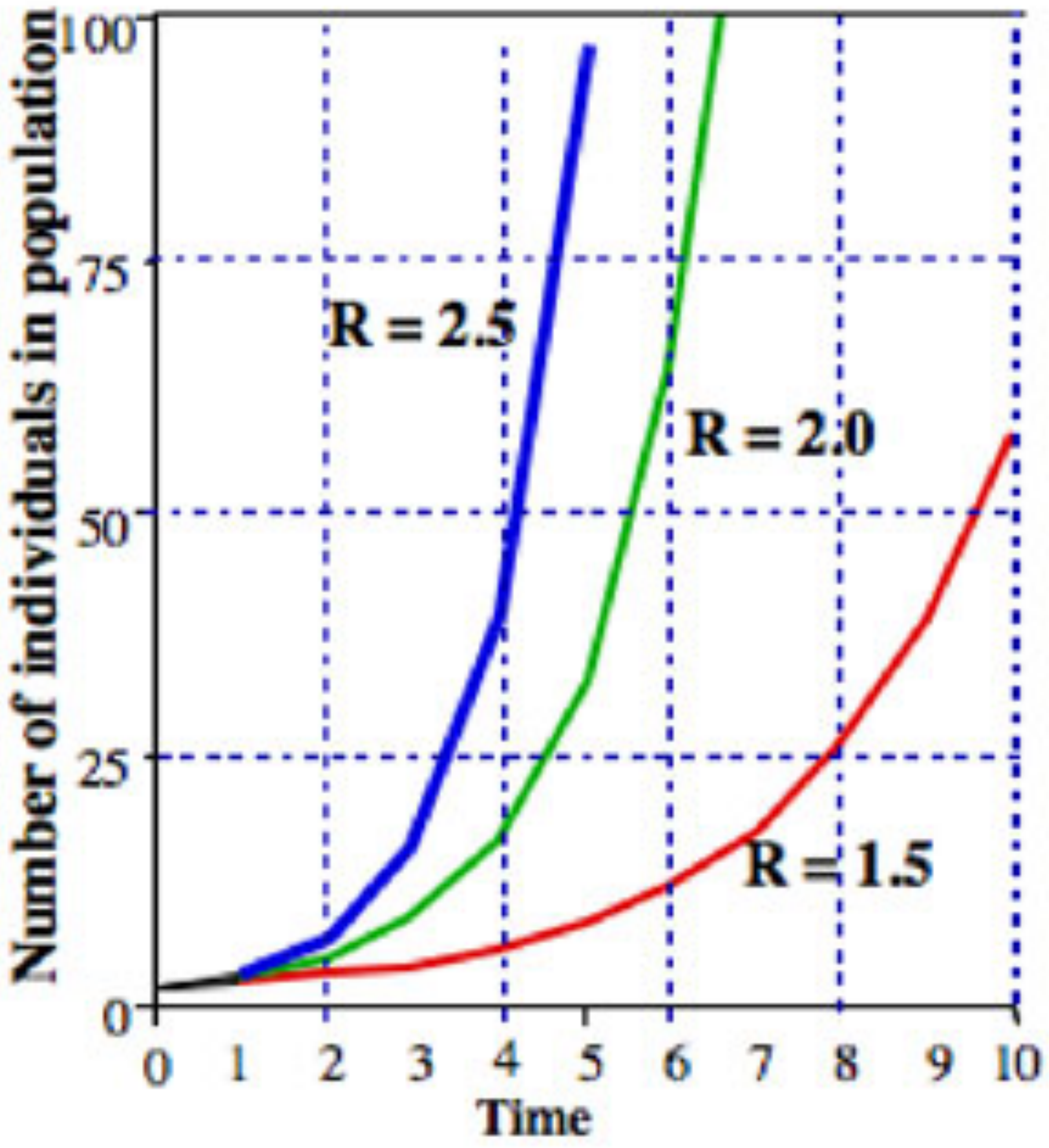
$$N_t = N_0 e^{rt}$$

Intrinsic rate of increase

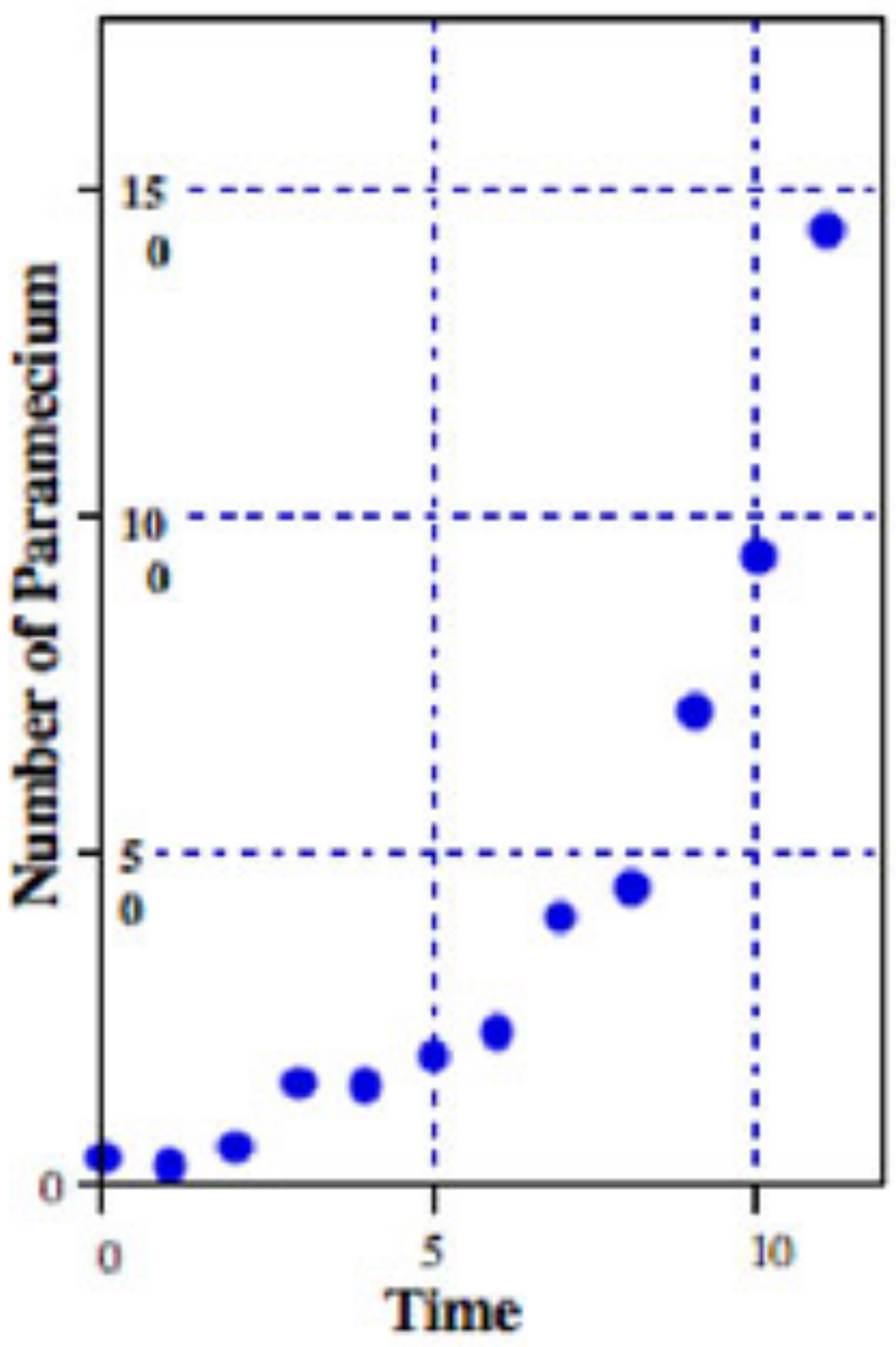
Idealised models help us understand population growth, BUT! they don't exist in Nature

https://www.nature.com/scitable/knowledge/library/how-populations-grow-the-exponential-and-logistic-13240157/

Exponential growth



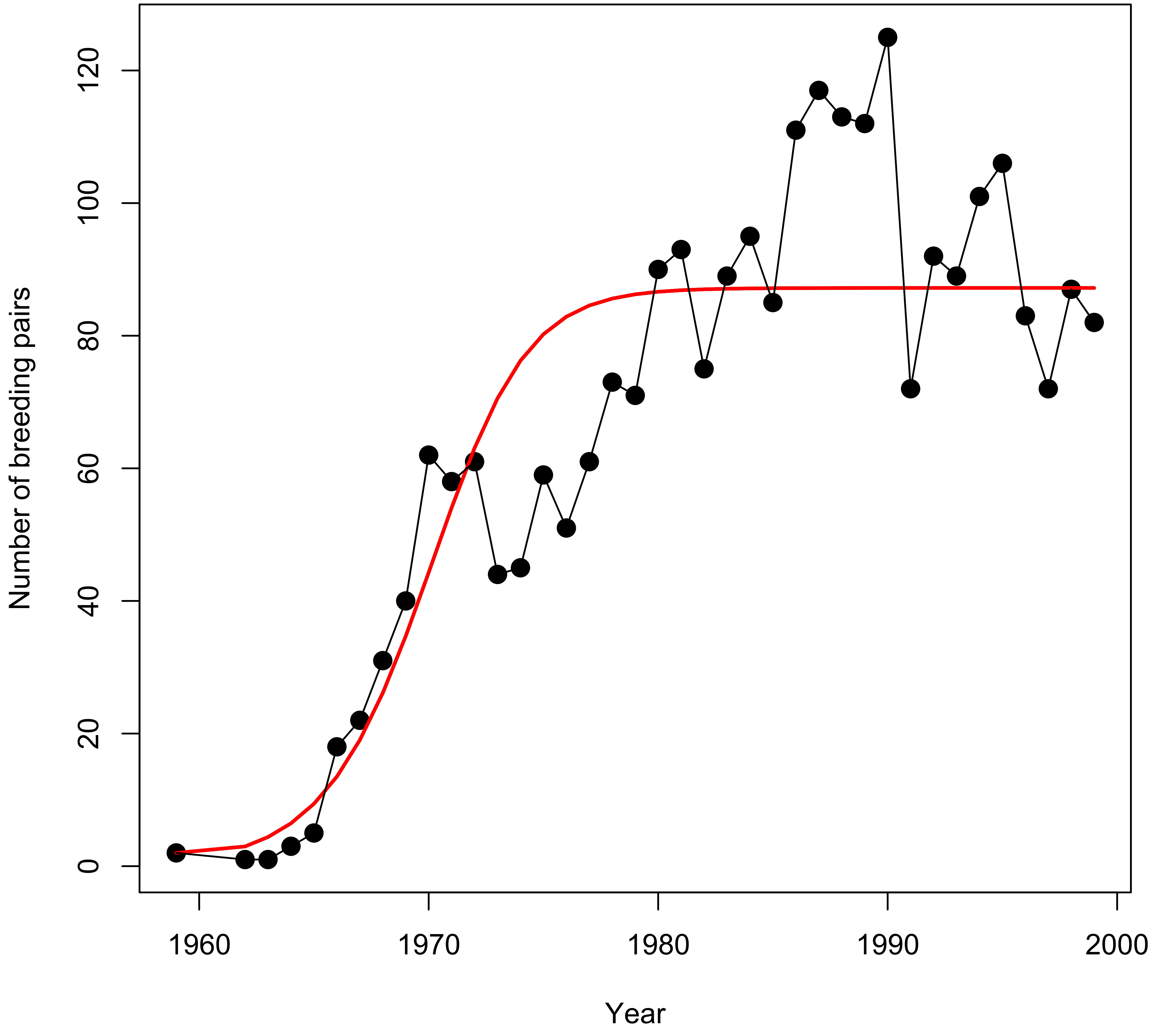
Modeled output



Empirical data

Vandermeer, J. (2010) How Populations Grow: The Exponential and Logistic Equations. Nature Education Knowledge 3(10):15

Density-dependent growth



Density dependence:

- Birth and death rates vary through time and depend on the density of individuals
- There is a least a limiting resource
- This generates competition between individuals

Sæther, B.-E., Engen, S., Lande, R., Both, C. and Visser, M.E. (2002), Density dependence and stochastic variation in a newly established population of a small songbird. Oikos, 99: 331-337.

Density-dependent growth

The Ricker model

Density-dependent growth rate

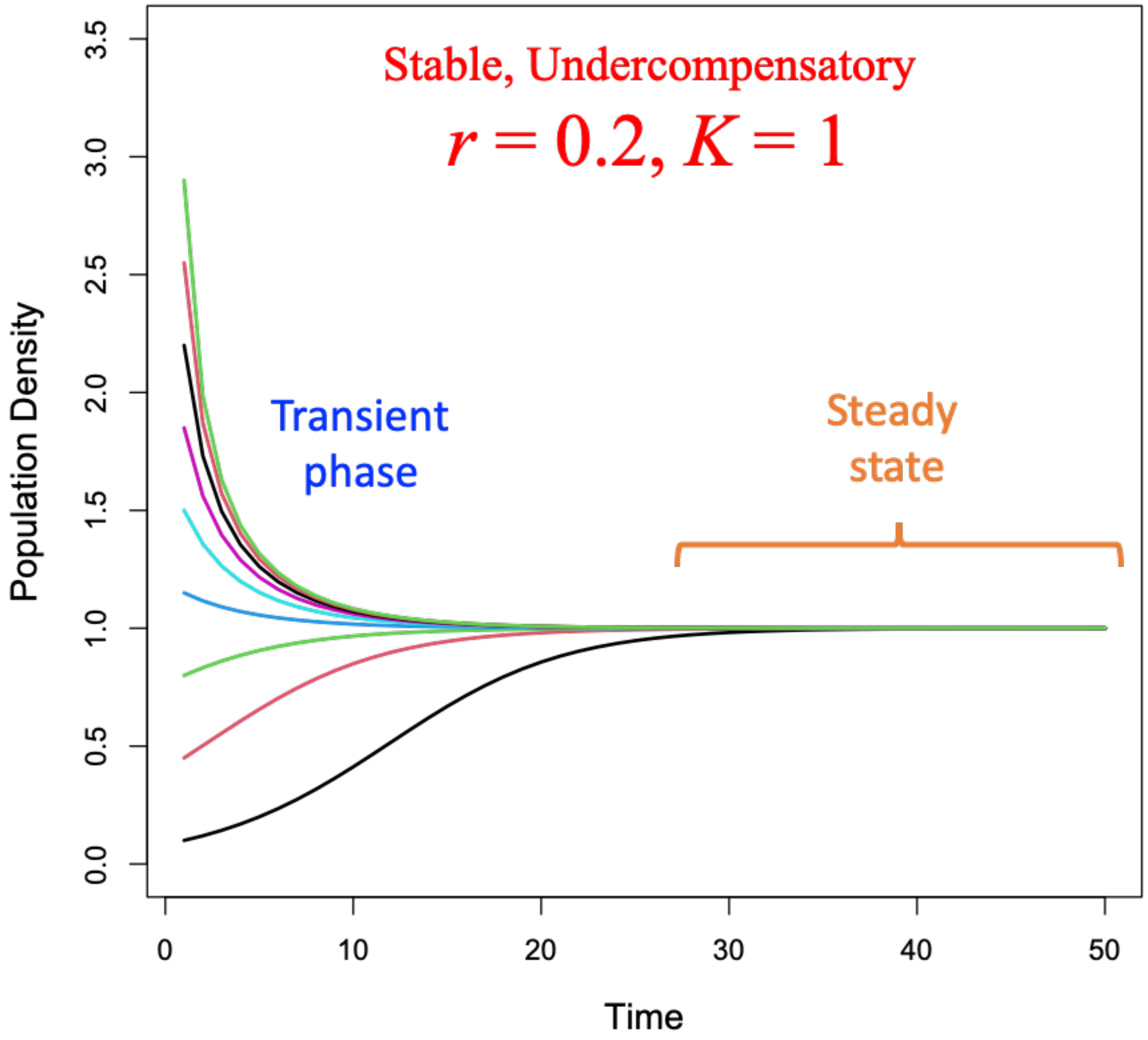
$$N_{t+1} = N_t * e^{\boxed{r\left(1 - \frac{N_t}{K}\right)}}$$

Intrinsic growth rate

Carrying capacity

Ricker (1954) Journal of the Fisheries Research Board of Canada 11: 559–623.

Density-dependent growth



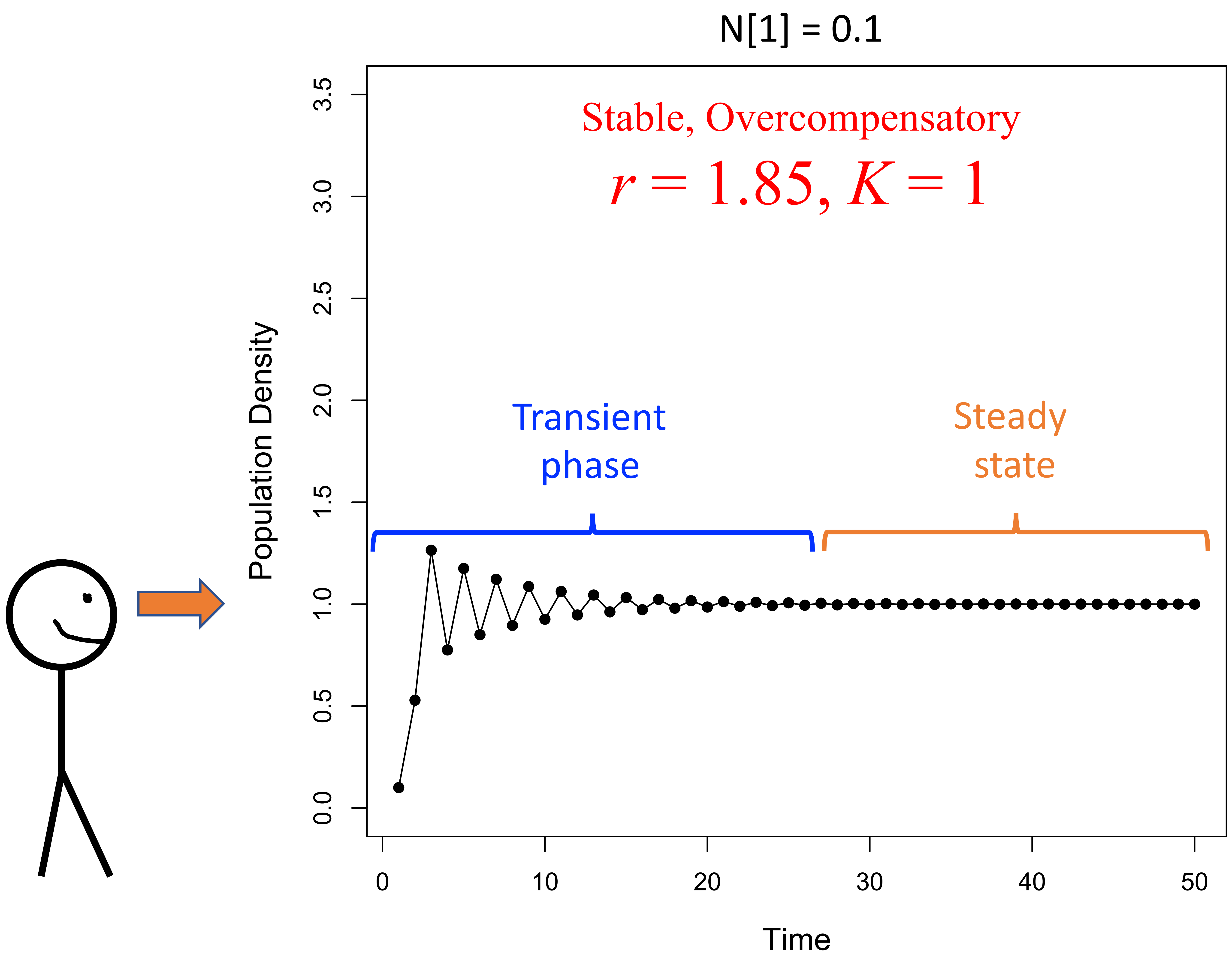
$$N_{t+1} = N_t e^{r\left(1 - \frac{N_t}{K}\right)}$$

Gradual increase if $N_1 < K$)

More rapid decrease if $N_1 > K$)

No obvious change in dynamics

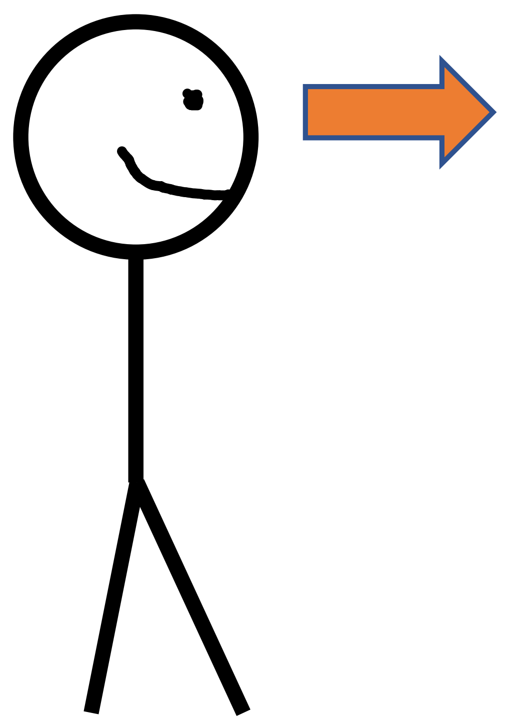
Discrete time dynamics: vary intrinsic growth rate *r*

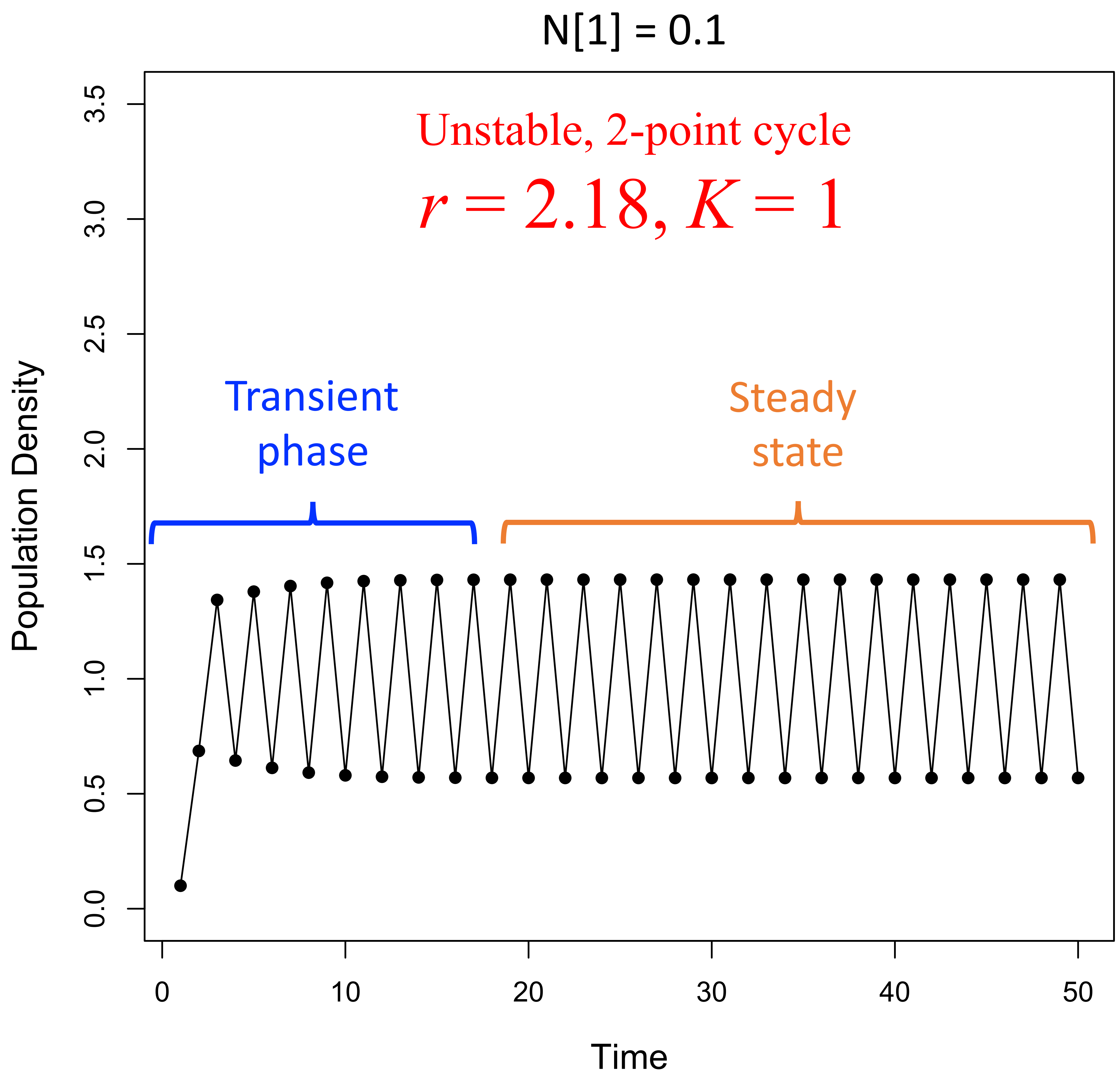


$$N_{t+1} = N_t e^{r\left(1-\frac{N_t}{K}\right)}$$

Damped Oscillations

Discrete time dynamics: vary intrinsic growth rate *r*

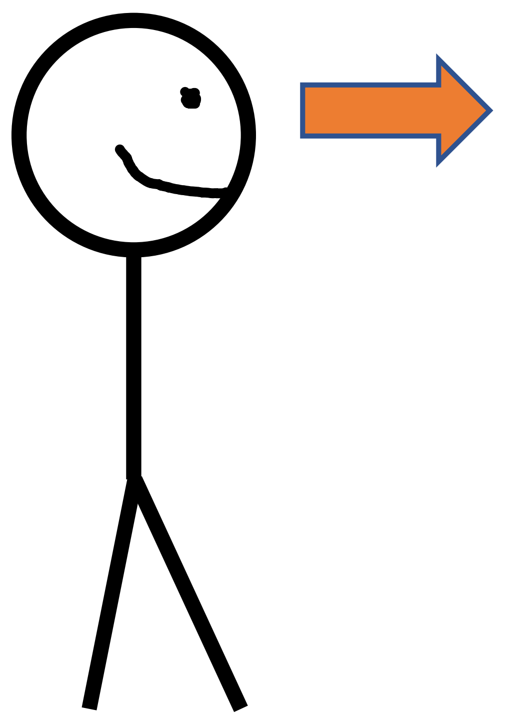


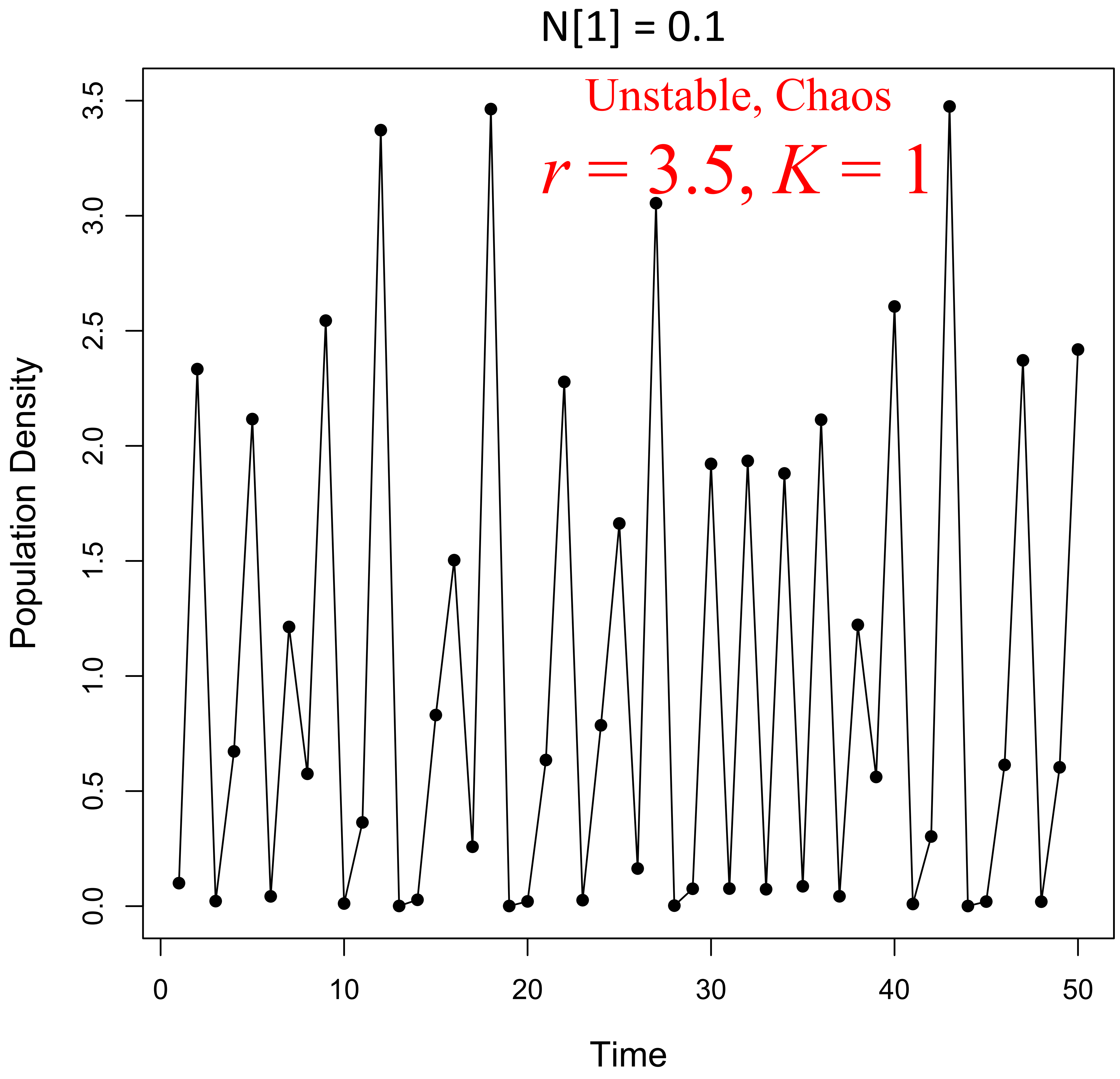


$$N_{t+1} = N_t e^{r\left(1-\frac{N_t}{K}\right)}$$

2-point cycle

Discrete time dynamics: vary intrinsic growth rate *r*





$$N_{t+1} = N_t e^{r\left(1-\frac{N_t}{K}\right)}$$

Chaos!

Bifurcation plot: Period doubling route to chaos

Stability (populations return to this point after disturbance)

vs

Instability (something else… cycles, chaos)