Biotic regulation: Density-dependence

Within-species: self-regulation

Intraspecific competition

T-34

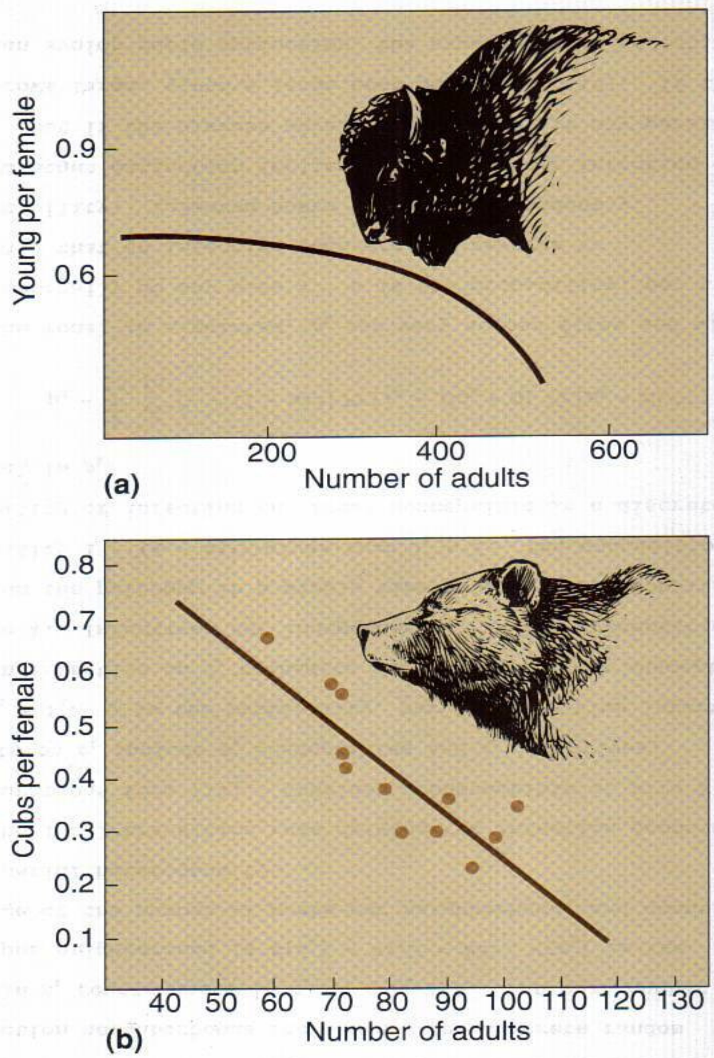
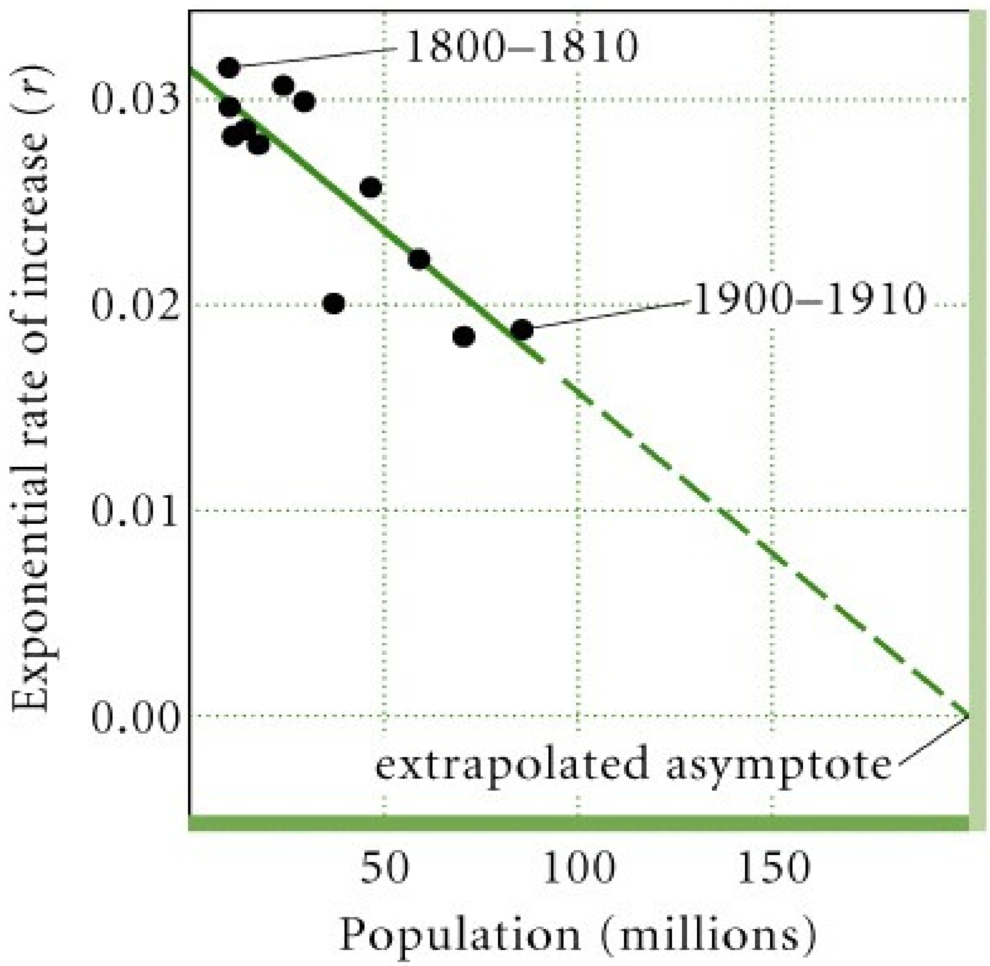


Figure 14.3 Linear and nonlinear density-dependent change in large mammal populations.



Exponential rate of increase (r)
0.03
0.02
0.01
0.00
1800–1810
1900–1910
extrapolated asymptote
50
100
150
Population (millions)

From individual to population

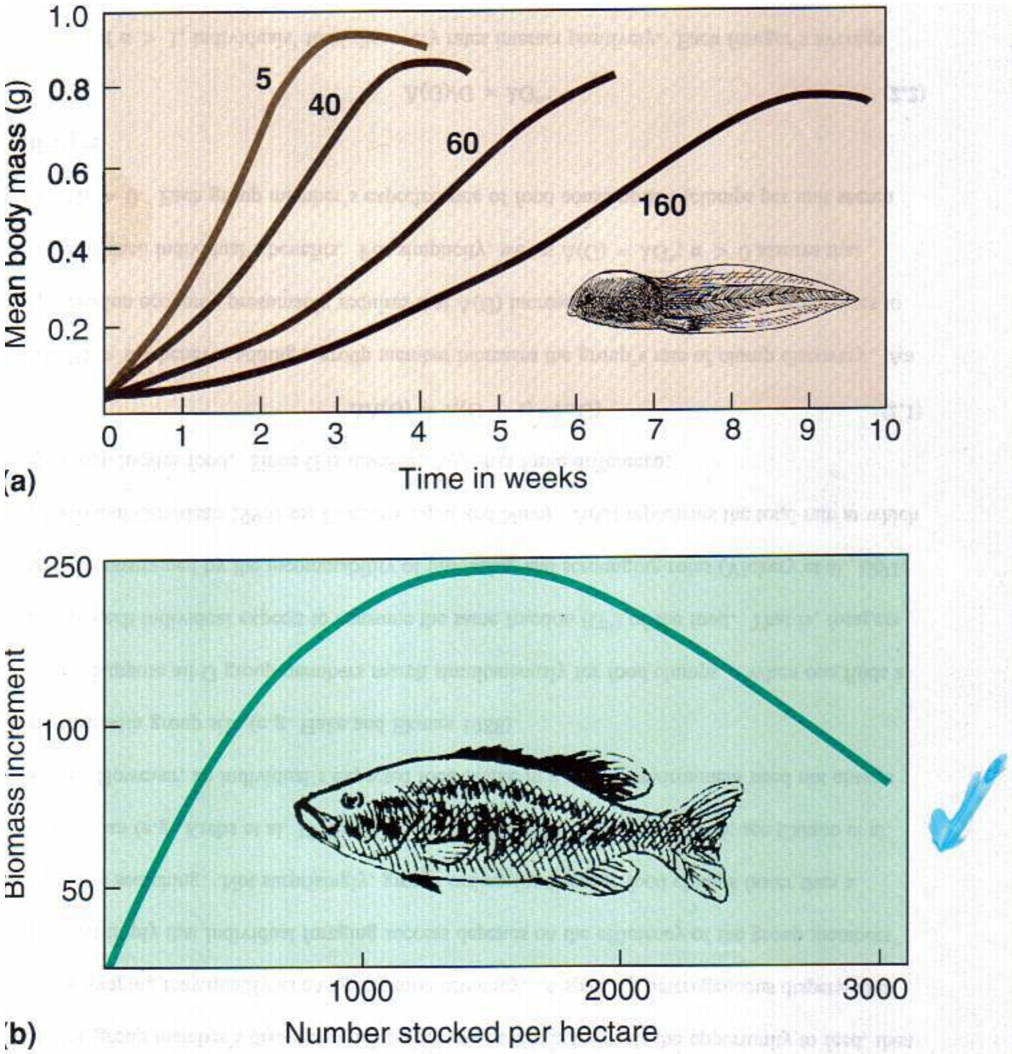


Figure 14.2 Effect of population density on the growth of individuals in scramble species.

Model self-regulation:

Logistic growth

LOGISTIC GROWTH

1. Continuous & Discrete time
2. Identical Individuals, N(t)
3. Self-Regulation =

   Intra-specific Competition

K: Carrying Capacity, Set by

Resource Limitations

Feedback of Increased

Population Size on

Population Growth

Instantaneous

CONTINUOUS TIME

N(t) **Population size, Time t**

r **Intrinsic Rate of Increase**

(Birth - Death)/Indiv/time

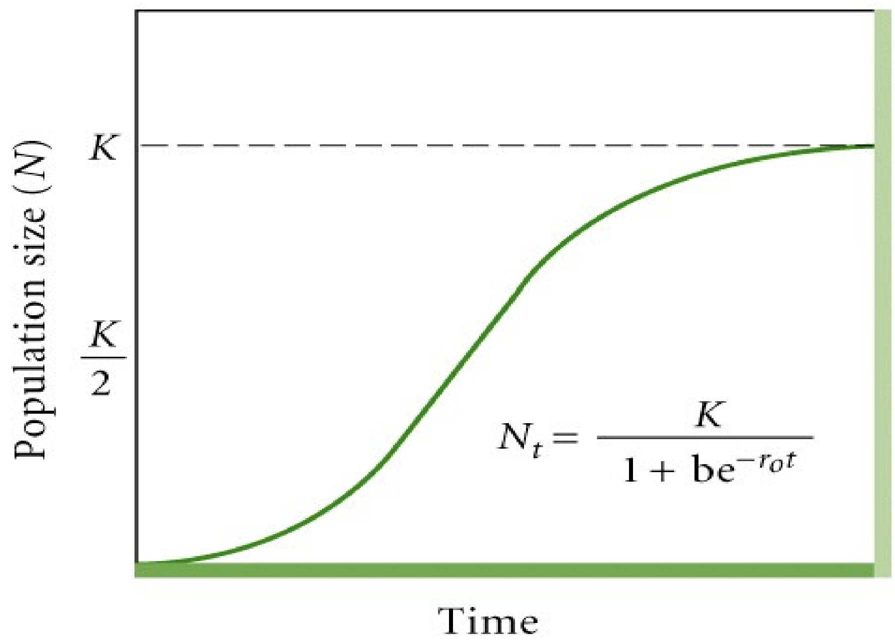
K **Carrying Capacity (Environ)**

$$dN/dt = rN(1 - N/K)$$

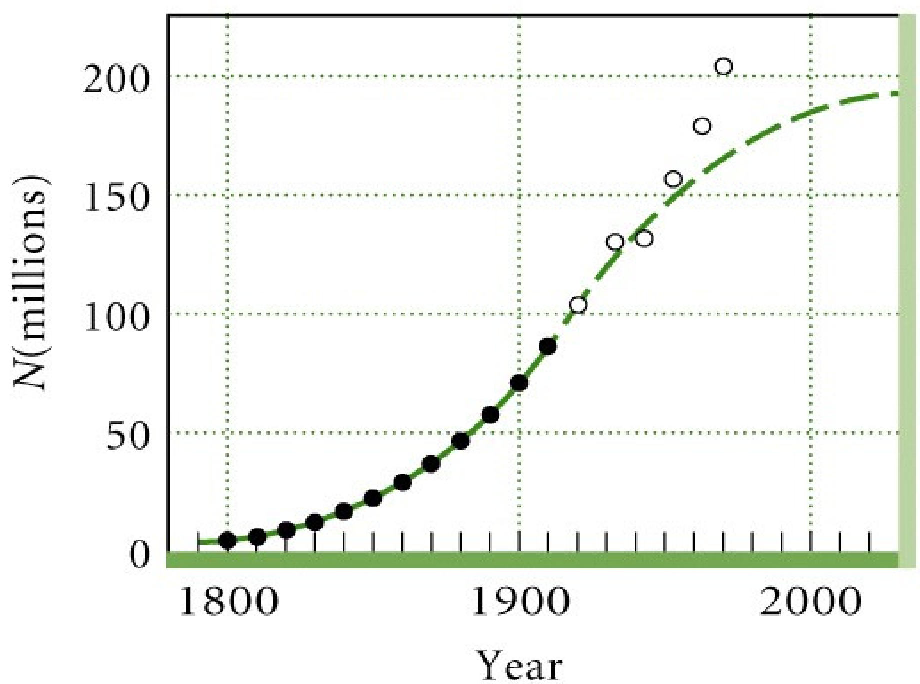
$$= rN\left(\frac{K-N}{K}\right)$$

$$dN/dt = rN - \frac{r}{K}N^2$$

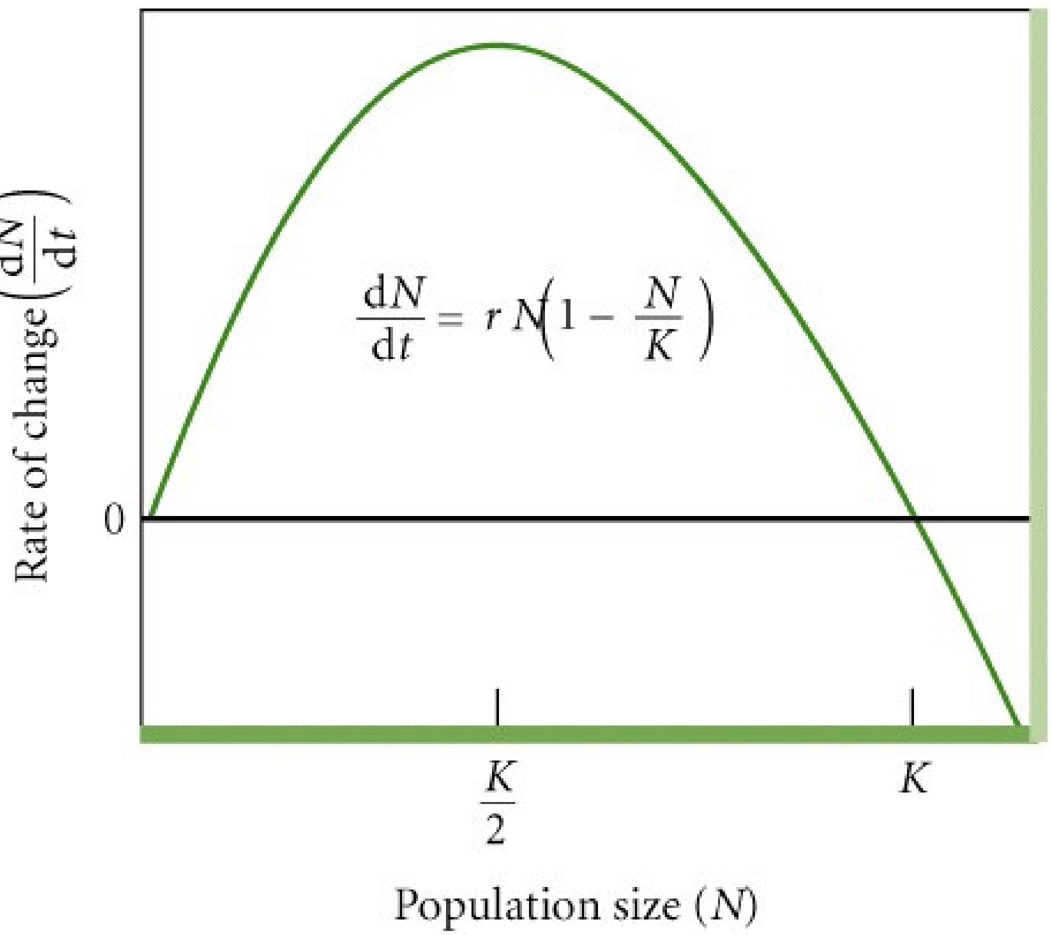
QUADRATIC



Population size (N)
K
K/2
$N_t = \frac{K}{1 + be^{-r_o t}}$
Time



N(millions)
200
150
100
50
0
1800
1900
2000
Year



Rate of change $\left(\frac{dN}{dt}\right)$
$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$
0
$\frac{K}{2}$
K
Population size (N)

GROWTH PER INDIVIDUAL

GROWTH = dN/dt

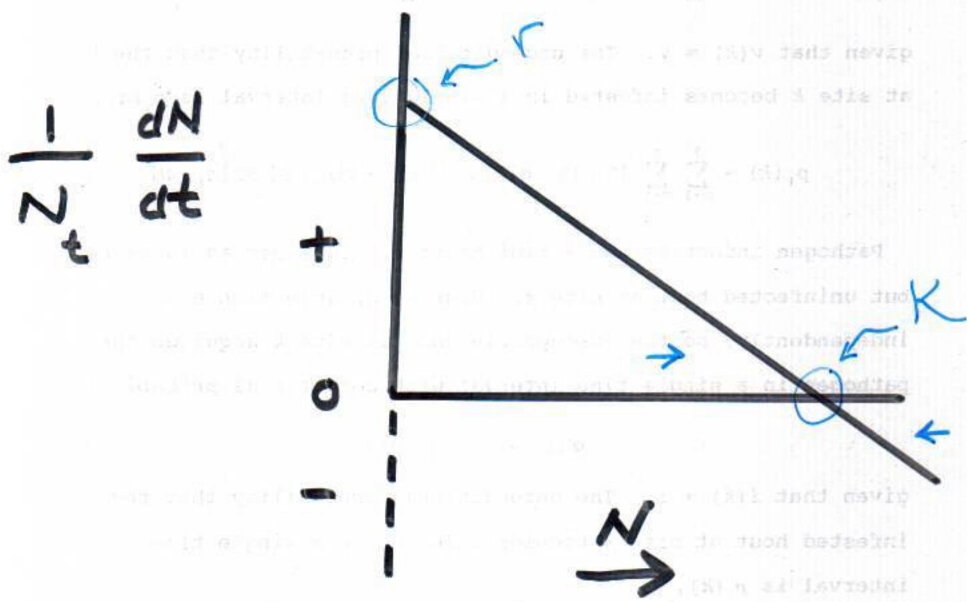
INDIVIDUALS = N_t

$$\frac{1}{N_t}\frac{dN}{dt} = \frac{1}{N_t}\left\{rN_t - \frac{r}{K}N_t^2\right\}$$

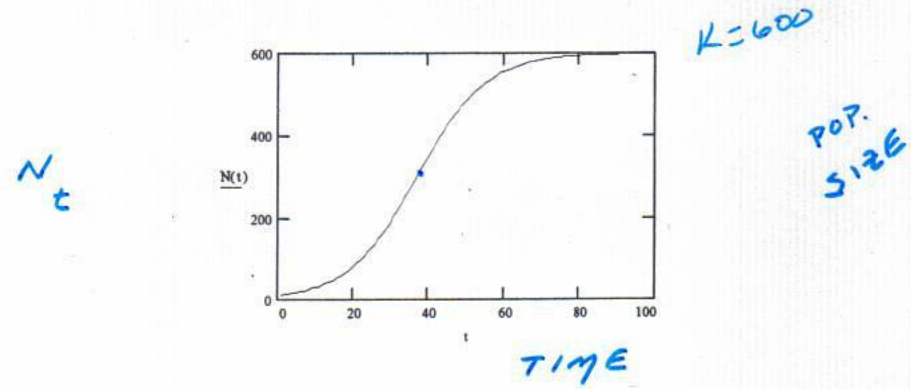
$$\left\{\frac{\mathring{N}}{N_t} = r - (r/K)N_t\right\}$$

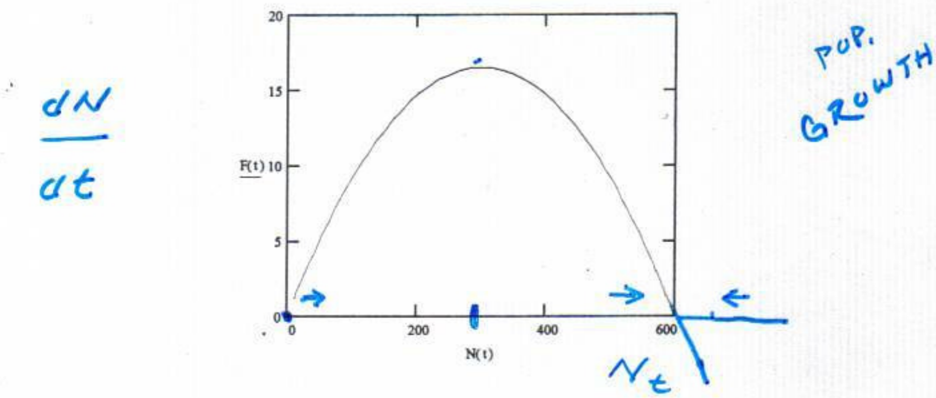
LINEAR:

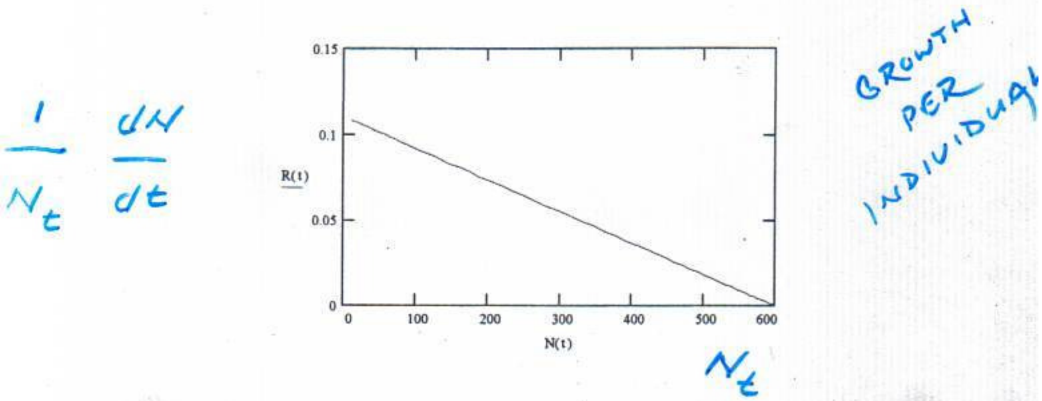
INDIVIDUAL CONTRIBUTION TO POPULATION GROWTH

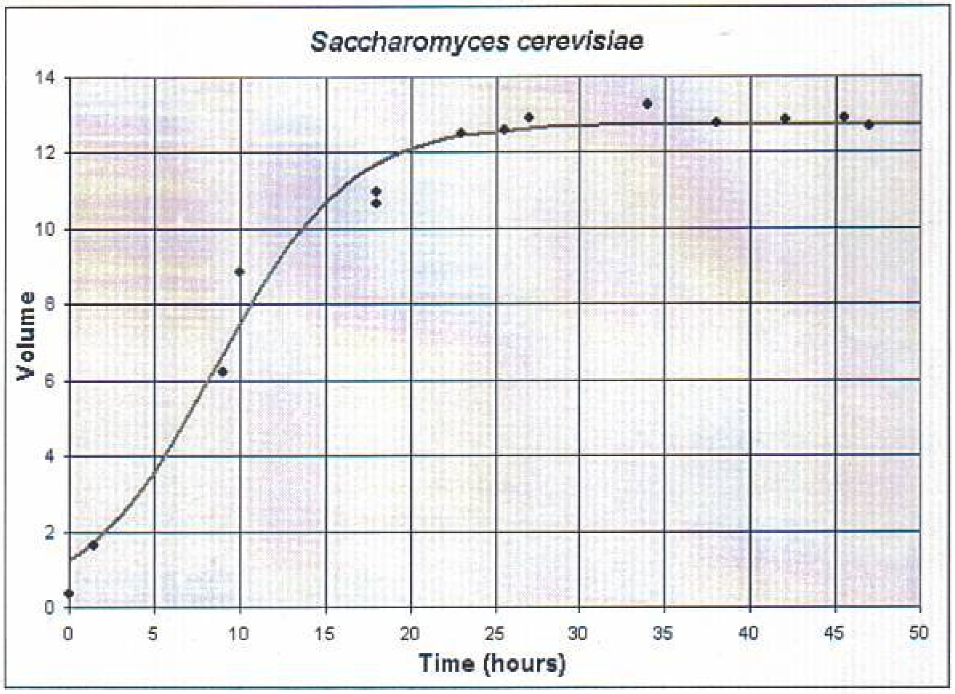


- INTRA-SPECIFIC COMPETITION
- LIMITING RESOURCE(S)
- BIOTIC REGULATION OF POPULATION


K=600
POP. SIZE
N t
N(t)
600
400
200
0
0
20
40
60
80
100
t
TIME

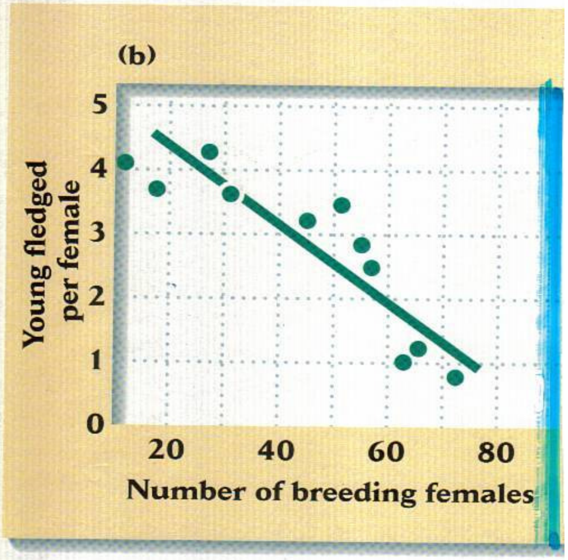

dN
dt
POP. GROWTH
F(t)
20
15
10
5
0
0
200
400
600
N(t)
N t


1
N t
dN
dt
GROWTH PER INDIVIDUA
R(t)
0.15
0.1
0.05
0
0
100
200
300
400
500
600
N(t)
N t


Saccharomyces cerevisiae
Volume
Time (hours)
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
50

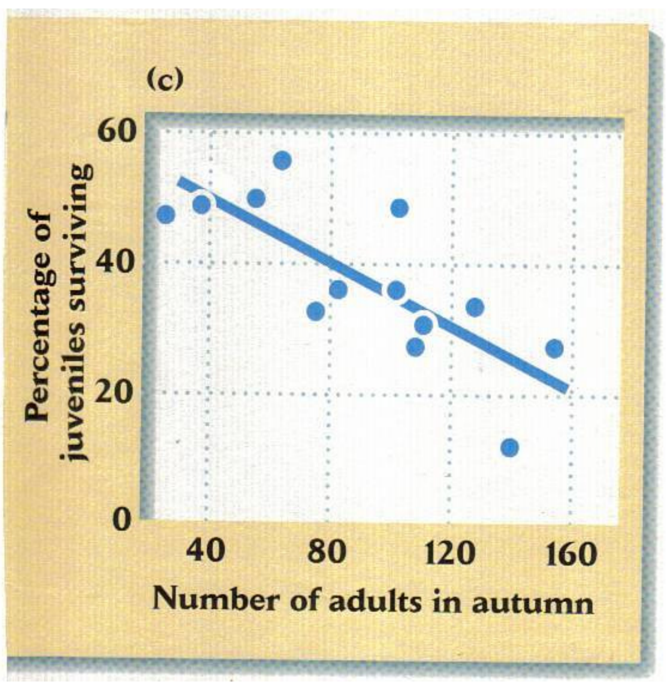
Friday

+4] (((4-M+3)≤0), ((4-M+3)=1),



Ricklefs, THE ECONOMY OF NATURE, Fifth Edition

Figure 14-20b

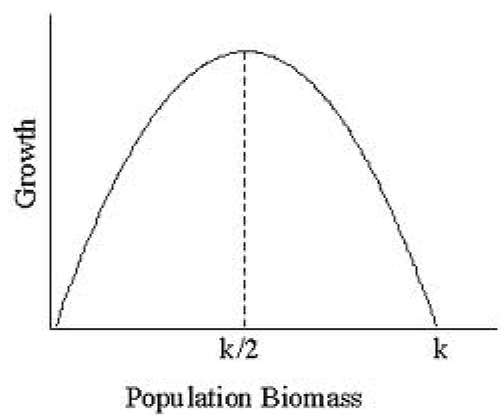


Logistic growth:

$$dN_t / dt = r\, N_t \left(1 - \frac{N_t}{K}\right)$$

r Intrinsic rate of increase

K Carrying capacity (maximal sustainable density)



Population dynamics (*e.g.* logistic growth):

Equilibrium and Stability

Equilibrium: “at rest”

Constancy (equilibrium node)

Repeated pattern (equilibrium cycle)

Stability

System rests at equilibrium

Small (“local”) perturbation away from equilibrium

System **stable**: returns to equilibrium

System **unstable**: does not return to equilibrium

Attractor: System near attractor, moves to attractor

Attractors (stability), “Strange attractors” (chaos)

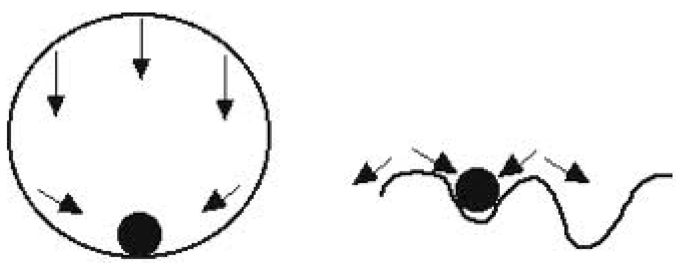
Global stability (a):

One equilibrium node

Local stability (b):

Equilibrium nodes:

Unstable, locally stable (ball), unstable, locally stable ("deeper well")



(a) (b)

Logistic growth: **equilibrium**

"At rest" ⇒ **$dN/dt = 0$**

Births/time = deaths/time; neither growth nor decline

$$dN/dt = rN - \frac{r}{K}N^2 = 0$$

Equilibrium: $N_t = N^*$

$N^* = 0, K$ (Extinction, carrying capacity)

Extinction unstable; K stable

Local stability

$$\left(\frac{\partial}{\partial N}\, dN/dt\right)_{N=N^*} < 0$$ for local stability of N^*

> 0 unstable