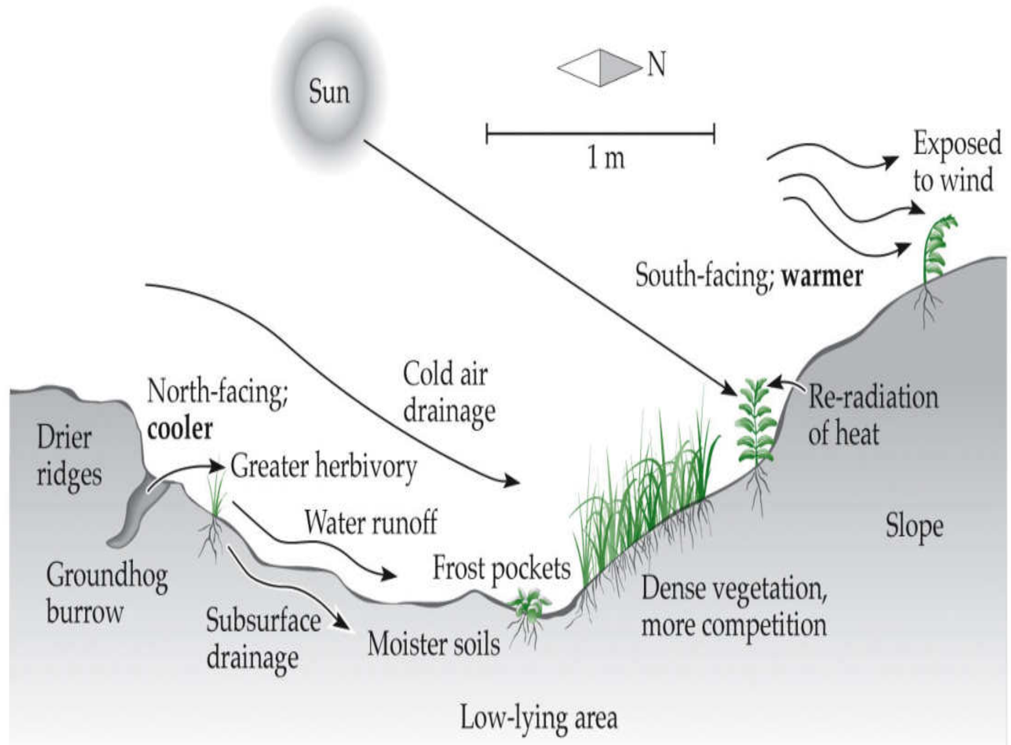
Plant Population Ecology

- Populations
- Measuring Plant density
- Population growth models

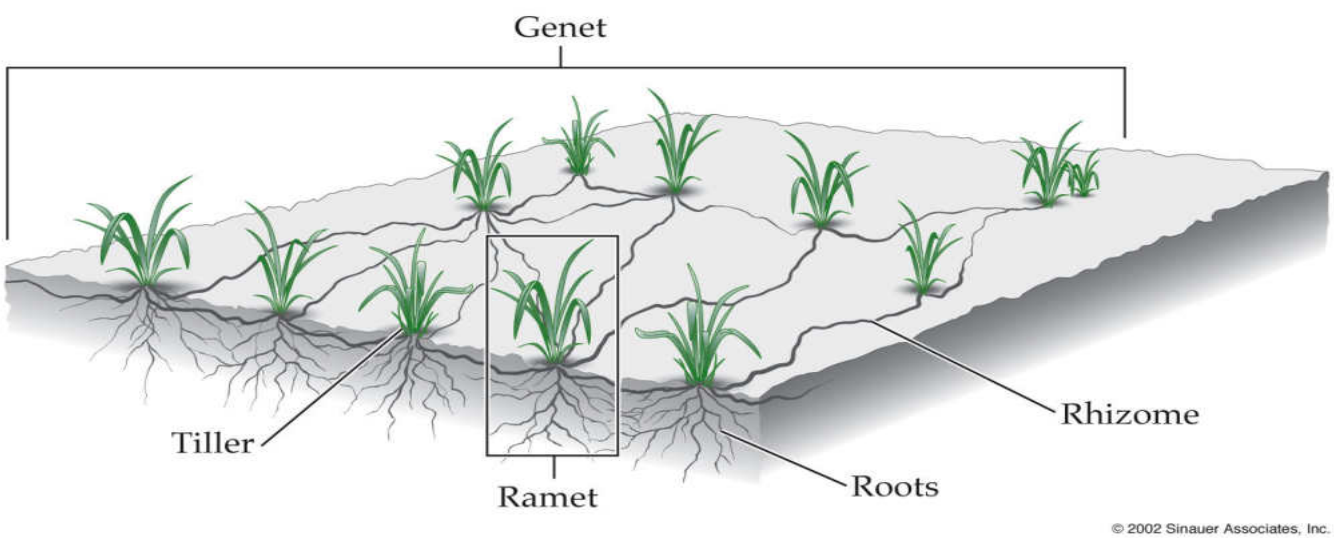


Population

- Population = group of individuals of a species with the potential to interbreed in a defined geographic region

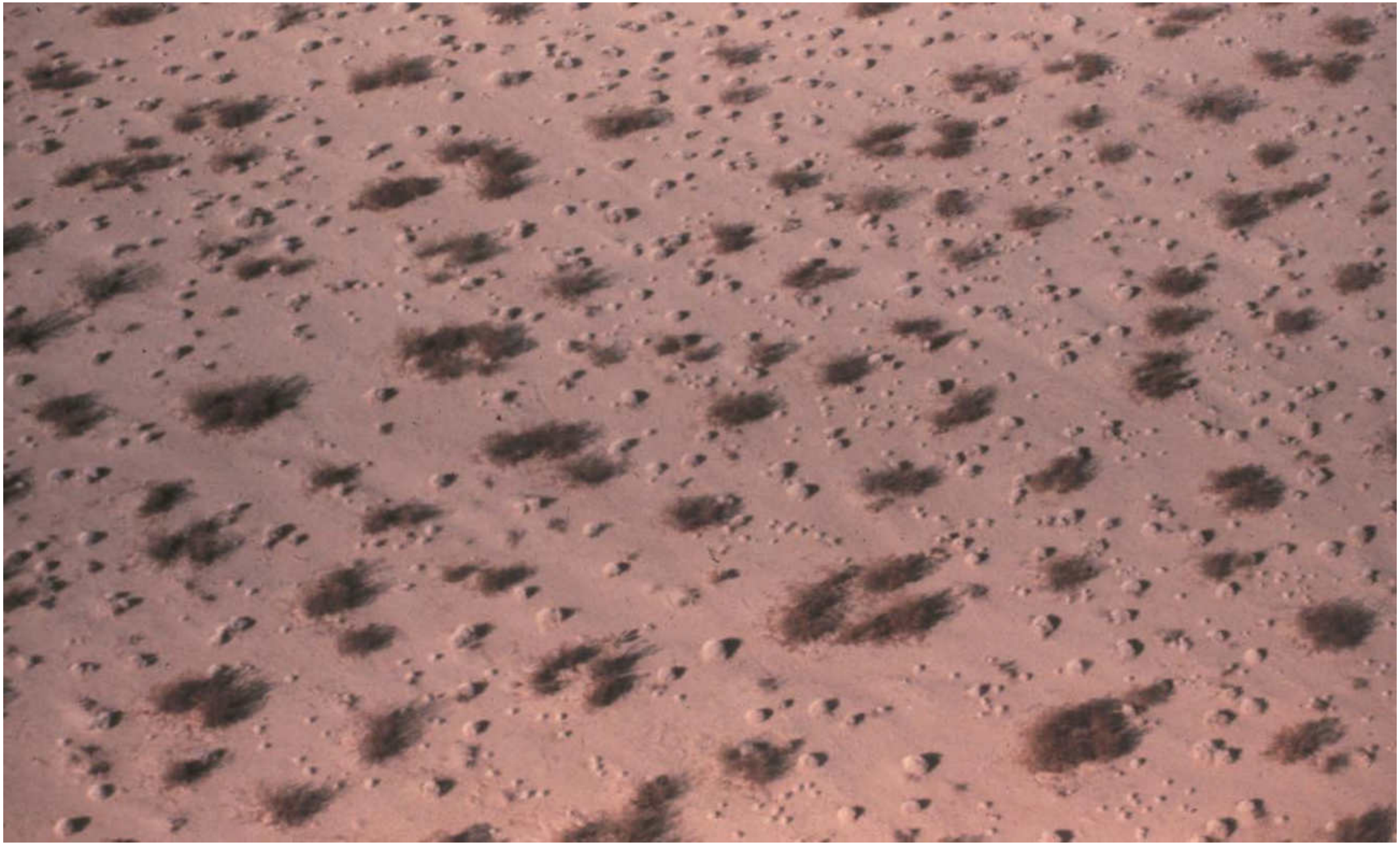
Population

- What is an individual?
- Branches (modular units)
- genets = sexual reproduction, genetically distinct individuals
- ramets = asexual reproduction, tillers , runners; can be physiologically distinct



Opuntia fulgida

- Clonal fragmentation
- ramets



Measuring Plant density

- #'s / unit area, volume, diameter at breast height

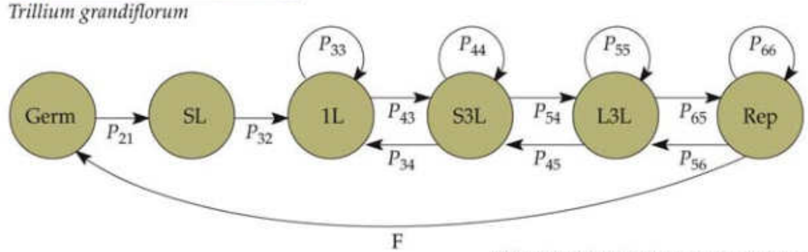
To experience quadrat sampling in plant populations, my ecology classes set out a transect in an upland hardwood forest in southern Indiana. We laid out three lines, each 110 meters long, and counted all trees taller than 25 cm within a swath of 1 meter on either side of the line. Each transect line is, in effect, a very long, thin quadrat with an area of 220 m^2 (0.022 hectare). We obtained the following results:

	No. counted			*Estimated no. per hectare*		
	Line A	**Line B**	**Line C**	**Line A**	**Line B**	**Line C**
Chestnut oak	20	28	18	909	1273	818
Sugar maple	5	4	7	227	182	318
American beech	13	15	16	591	682	727

Plant structure problems

- seed pool
- age structure
- age of reproduction
- population density usually not static

Trillium grandiflorum



Population structure

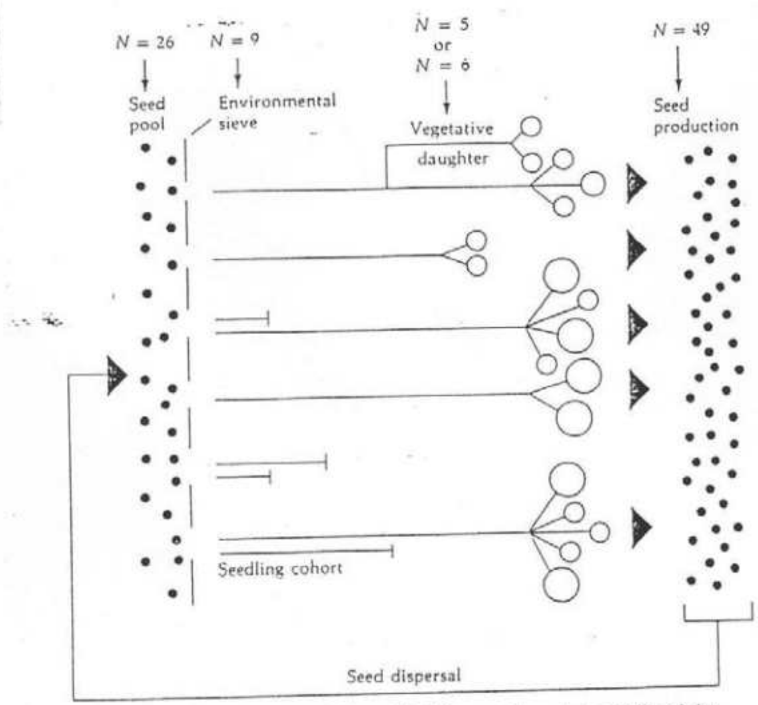
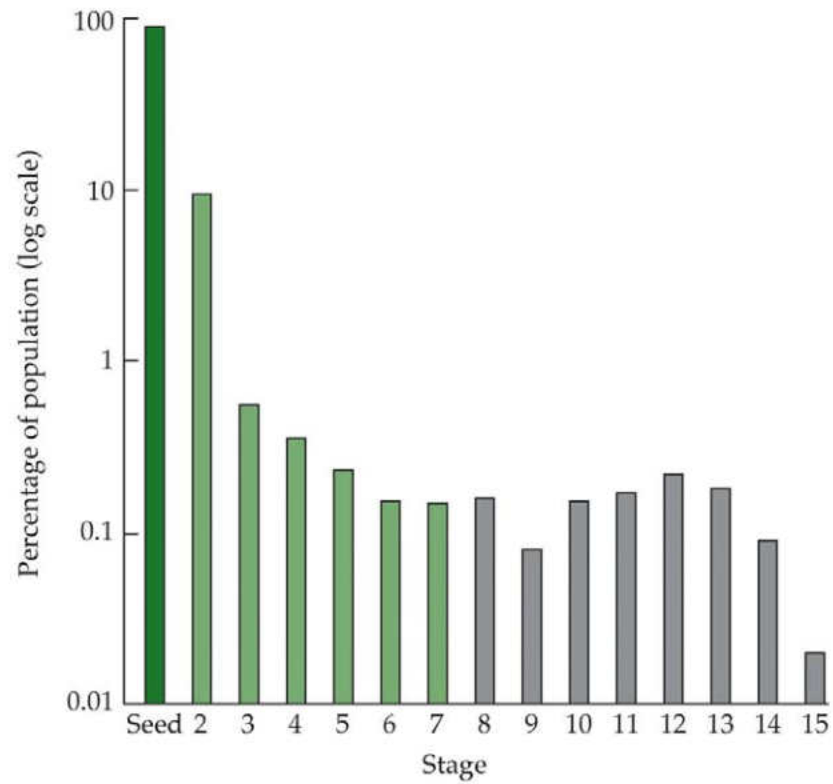
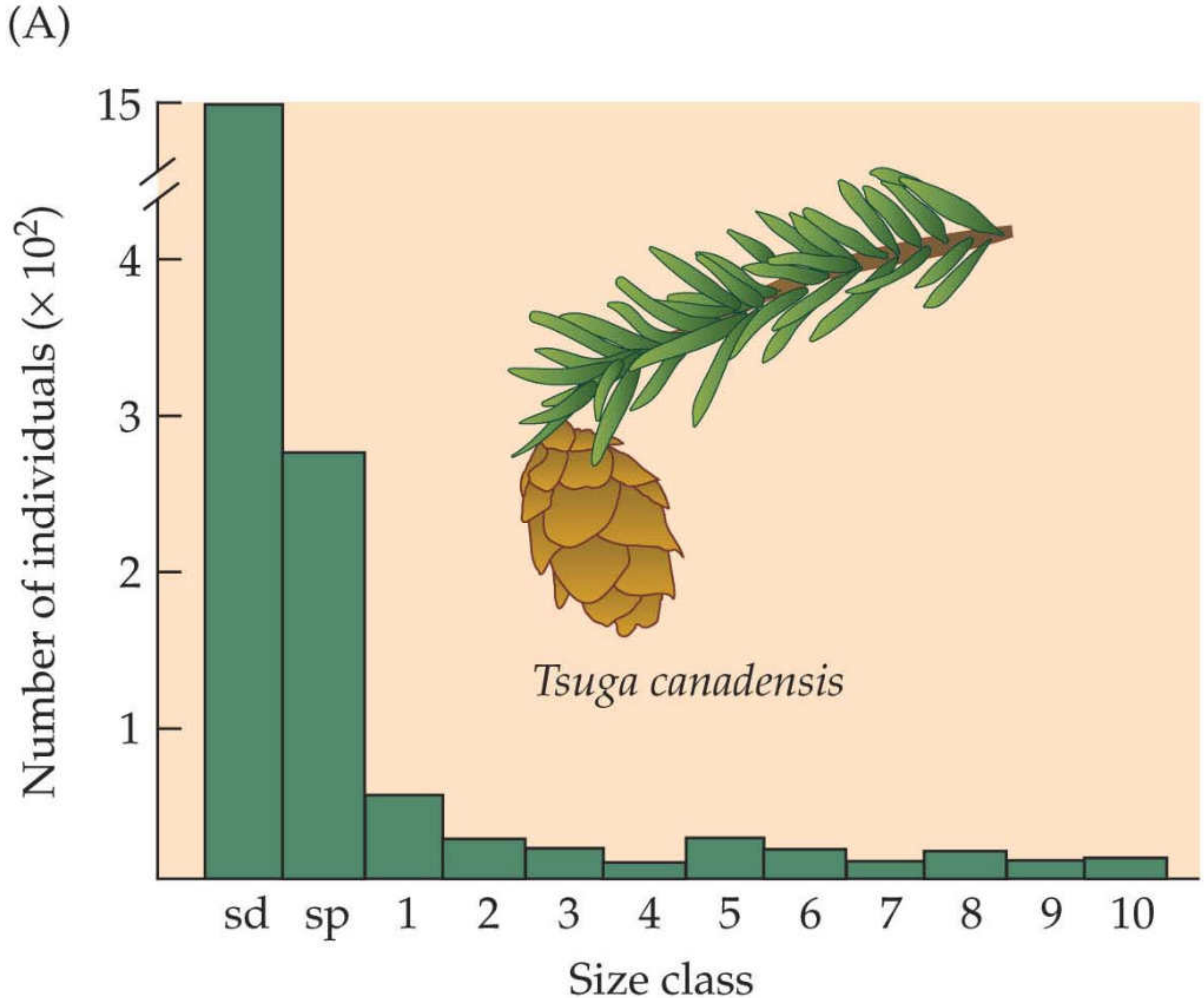


Figure 4-3 An idealized plant life history. Near the middle of the growing period, *N* is 5 or 6, depending on whether the vegetative daughter is considered an individual or part of the parent plant. (Copyright © 1977 by J. L. Harper, *Population Biology of Plants*.)



Age vs stage in plants

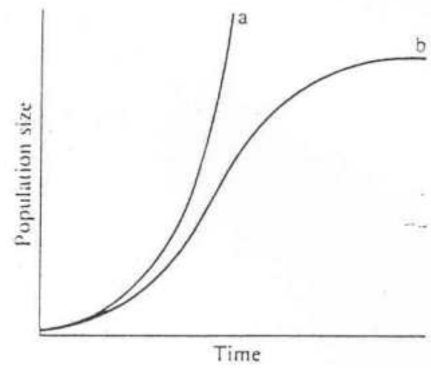


(A)
Number of individuals (× 10²)
15
4
3
2
1
Tsuga canadensis
sd sp 1 2 3 4 5 6 7 8 9 10
Size class

Population growth models

- **Exponential growth model**
- birth and death rates
- immigration/emigratio n
- dN/dt = rN
- assume I and E are 0
- examples of exponential growth

Fig. 1.2 (a) Geometric; and (b) logistic population growth.



Exponential growth

$$\frac{dN}{dt} = rN$$

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

$$R_o = N_{t+1}/N_t$$

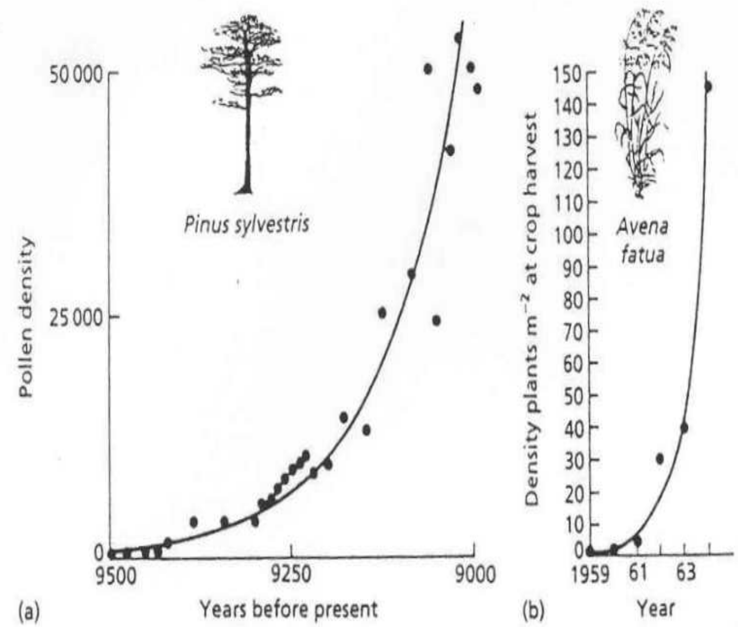


Fig. 5.2 The exponential increase of two species. (a) *Pinus sylvestris* between 9500 and 9000 years ago, when this tree was invading Hockham Mere, Norfolk, England. The abundance of *P. sylvestris* is plotted as the density of pollen grains in peat samples, which it is assumed is correlated with the historical size of the tree population (from Bennett 1983). (b) *Avena fatua* infesting a barley crop at Boxworth Experimental Farm, Cambridge, England (from Selman 1970).

Logistic growth model

- actual populations plateau
- carrying capacity
- dN/dt = rN (K-N/K)
- different types of logistic growth curves
- growth rates differ in different phases
- Overshoot K
- K dependent on resource availability

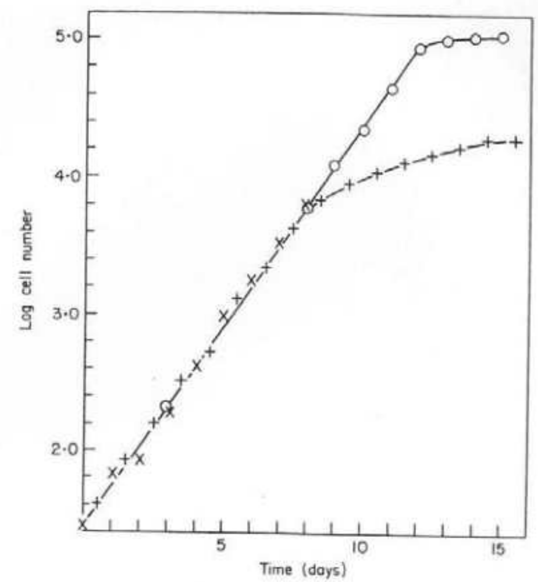


Fig. 1/2. Population growth curve for the alga *Chlorella* in culture. This alga forms clumps and so experiences the effects of density when there are still available resources in the medium. The initially exponential growth rate declines after 8 days but if the clumping is prevented by shaking the exponential rate continues for four more days. (From Pearsall and Bengry, 1940) x and + unshaken, o shaken

Growth rates

Population growth rates of some aquatic plants in culture

Species	Relative growth rate (g/g/day)		Simple growth rate (g/beaker/day)		12 weeks "stable" population (g/beaker)	
	Phase I	(Rank)	Phase II	(Rank)	Phase III	(Rank)
L. minor	0.35	(1)	14.7	(2)	603	(2)
L. gibba	0.25	(3)	9.0	(4)	355	(4)
L. polyrrhiza	0.21	(4)	12.5	(3)	776	(1)
S. natans	0.28	(2)	18.5	(1)	524	(3)

Logistic growth

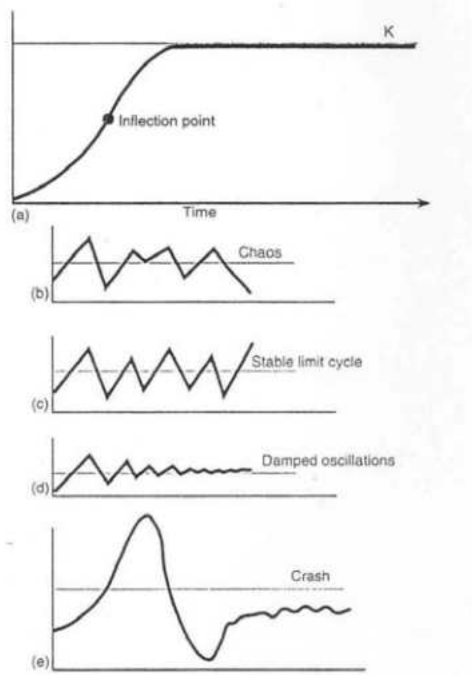
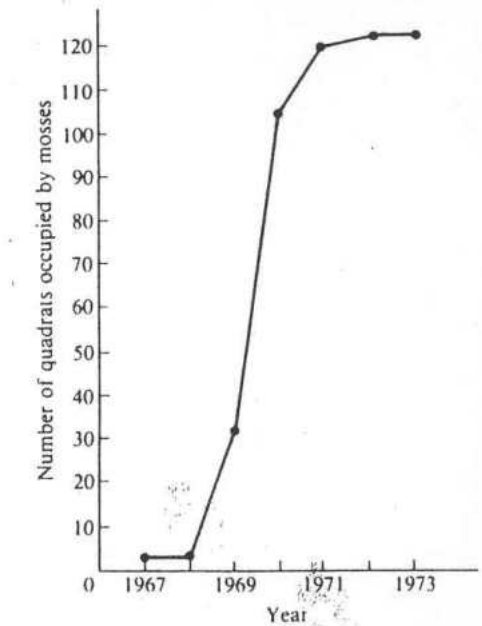


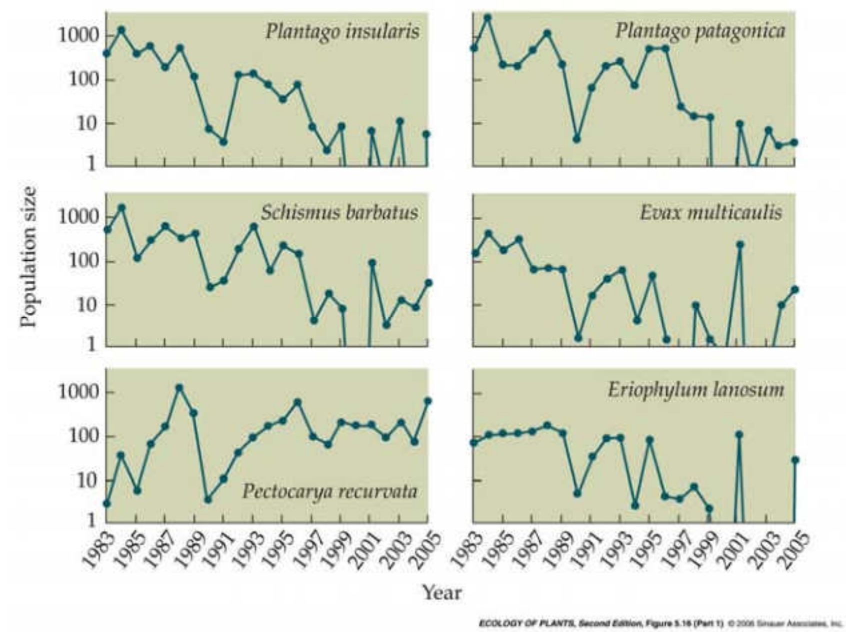
Figure 18.6 (a) A stylized logistic growth curve and (b–e) types of fluctuations that take place when the population overshoots *K*. (b) Chaotic fluctuation. The population fluctuates wildly with no regulation. Such fluctuations can lead to sudden extinction. (c) Stable-limit cycles. The population fluctuates about some equilibrium level, with fluctuations having a certain period and amplitude. (d) Oscillations decrease over time. After overshooting *K*, the population levels off and maintains itself at *K* through compensating birth and death rates. (e) The population strongly overshoots *K* and then crashes. It may drop very low, recover, and return to some lower equilibrium level, or it may go extinct.

Fig. 1.4 Growth of a moss population colonizing ba
Icelandic island of Surtsey. (From Fridrikson 1975)



Random variation in Population growth and decline

- Hurricanes
- Fire
- Pests



Matrix models

- Transition Matrix
- calculation of plant populations
- matrix multiplication

		This census		
		Seed	Rosette	Flower
Next census	Seed	a_{ss}	a_{rs}	a_{fs}
	Rosette	a_{sr}	a_{rr}	a_{fr}
	Flower	a_{sf}	a_{rf}	a_{ff}

Multiplication

Column matrix

$$\begin{bmatrix} N_s \\ N_r \\ N_f \end{bmatrix}$$

$$\underset{\mathbf{A}}{\begin{bmatrix} a_{ss} & 0 & a_{fs} \\ a_{si} & a_{ii} & a_{fi} \\ 0 & a_{if} & a_{ff} \end{bmatrix}} \times \underset{\mathbf{B_1}}{\begin{bmatrix} N_s \\ N_i \\ N_f \end{bmatrix}} = \underset{\mathbf{B_2}}{\begin{bmatrix} (N_s a_{ss}) + 0 + (N_f a_{fs}) \\ (N_s a_{si}) + (N_i a_{ii}) + (N_f a_{fi}) \\ 0 + (N_i a_{if}) + (N_f a_{ff}) \end{bmatrix}} \quad \text{(Matrix 4-3)}$$

- Row X column
- Sum of result
- Gives new column matrix

Site A (northeastern exposure)	Site B (southwestern exposure)	Site C (hilltop) A_{max}
$A_{\text{site A}} = \begin{bmatrix} 0.672 & 0 & 0.561 \\ 0.018 & 0.849 & 0 \\ 0 & 0.138 & 0.969 \end{bmatrix}$	$A_{\text{site B}} = \begin{bmatrix} 0.493 & 0 & 0.561 \\ 0.013 & 0.731 & 0 \\ 0 & 0.234 & 0.985 \end{bmatrix}$	$A_{\text{site C}} = \begin{bmatrix} 0.434 & 0 & 0.560 \\ 0.333 & 0.610 & 0 \\ 0 & 0.304 & 0.956 \end{bmatrix}$

Stable age structure