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 m² (0.022 hectare). We obtained the following results:

<table>
<thead>
<tr>
<th></th>
<th>Line A</th>
<th>Line B</th>
<th>Line C</th>
<th>Estimated no. per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chestnut oak</td>
<td>20</td>
<td>28</td>
<td>18</td>
<td>909 1273 818</td>
</tr>
<tr>
<td>Sugar maple</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>227 182 318</td>
</tr>
<tr>
<td>American beech</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>591 682 727</td>
</tr>
</tbody>
</table>
Plant structure problems

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

Age vs stage in plants
Population growth models

- **Exponential growth model**
- birth and death rates
- immigration/emigration
- \( \frac{dN}{dt} = rN \)
- assume I and E are 0
- examples of exponential growth
Exponential growth

\[ \frac{dN}{dt} = rN \]

\[ N_t = N_0 e^{rt} \]

\[ R_0 = \frac{N_{t+1}}{N_t} \]

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
- \( \frac{dN}{dt} = rN \frac{(K-N)}{K} \)
- 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 Bieygy, 1949) x and + unshaken, o shaken.
## Growth rates

Population growth rates of some aquatic plants in culture

<table>
<thead>
<tr>
<th>Species</th>
<th>Relative growth rate (g/g/day)</th>
<th>Simple growth rate (g/beaker/day)</th>
<th>12 weeks “stable” population (g/beaker)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase I</td>
<td>(Rank)</td>
<td>Phase II</td>
</tr>
<tr>
<td><em>L. minor</em></td>
<td>0.35</td>
<td>(1)</td>
<td>14.7</td>
</tr>
<tr>
<td><em>L. gibba</em></td>
<td>0.25</td>
<td>(3)</td>
<td>9.0</td>
</tr>
<tr>
<td><em>L. polyrrhiza</em></td>
<td>0.21</td>
<td>(4)</td>
<td>12.5</td>
</tr>
<tr>
<td><em>S. natans</em></td>
<td>0.28</td>
<td>(2)</td>
<td>18.5</td>
</tr>
</tbody>
</table>
Logistic growth

Figure 16.6 (a) A stylized logistic growth curve and (b–e) types of fluctuations that take place when the population overshoots K. (b) Chaotic fluctuations. 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 the 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
Multiplication

- Row X column
- Sum of result
- Gives new column matrix
<table>
<thead>
<tr>
<th>Site A (northeastern exposure)</th>
<th>Site B (southwestern exposure)</th>
<th>Site C (hilltop) $A_{\text{max}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{\text{site A}} = \begin{bmatrix} 0.672 &amp; 0 &amp; 0.561 \ 0.018 &amp; 0.849 &amp; 0 \ 0 &amp; 0.138 &amp; 0.969 \end{bmatrix}$</td>
<td>$A_{\text{site B}} = \begin{bmatrix} 0.493 &amp; 0 &amp; 0.561 \ 0.013 &amp; 0.731 &amp; 0 \ 0 &amp; 0.234 &amp; 0.985 \end{bmatrix}$</td>
<td>$A_{\text{site C}} = \begin{bmatrix} 0.434 &amp; 0 &amp; 0.560 \ 0.333 &amp; 0.610 &amp; 0 \ 0 &amp; 0.304 &amp; 0.956 \end{bmatrix}$</td>
</tr>
</tbody>
</table>
Stable age structure

- **Site A**: Predominantly small juveniles, with a smaller presence of large juveniles and adults.
- **Site B**: Similar to Site A, with a high frequency of small juveniles, but with a slightly higher presence of adults.
- **Site C**: Shows a balanced frequency of small juveniles, large juveniles, and adults.

Legend:
- **Green**: Small juveniles
- **Light Green**: Large juveniles
- **Gray**: Adults