

Competition: Neutral Theory vs. the Niche

Reading assignment: Ch. 10, GSF
(especially p. 237-249)
Optional: Clark 2009

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What is competition?

- A reduction in fitness due to shared use of a limited resource
- Can include indirect interactions
- Occurs between and within species
- Affects plants at all life stages and at organizational scales from population to the globe

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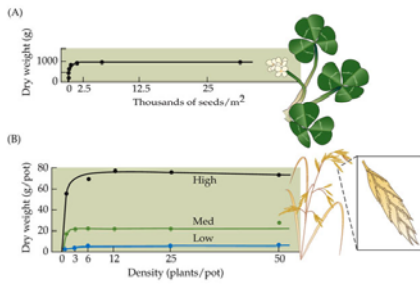
Competition among individuals

- Most seedlings die because only a limited amount of biomass can be supported at a given level of resources
- Among survivors there is a range of different sizes
- Size is a good predictor of seed production and thus fitness

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Increasing seedling density does not lead to greater yield

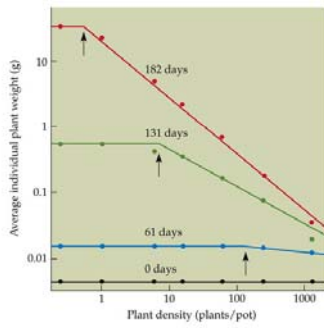


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This can be partly explained by a negative relationship between density and plant size



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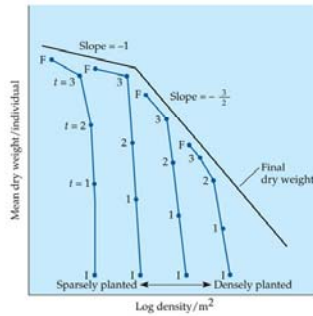
Self-thinning

- Density-dependent mortality in seedling phase
- How predictable is it?
- -3/2 thinning law:
 $w = cN^{-3/2}$
 $w = \text{weight}, c = \text{constant}, N = \text{density}$

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Testing the -3/2 thinning law



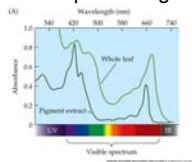
Theoretical basis is that plants' volume is a cubic measure and the ground area they take up is a square measure

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Mechanisms of competition: Defining your niche

- Plants compete for light, water, mineral nutrients, access to mates, pollination, seed dispersal, ...
- Resources are patchy in space and time; plants respond with highly plastic growth patterns

If sunlight is ubiquitous, why do plants have to compete for light?



Competition for Nutrients

- Most limiting nutrients are N, K, Ca, Mg, P, S (macronutrients)
- Also micronutrients (see Table 4.2)
- Is it the concentration of the nutrients that is important?
 - "hot spots"
- Some argue that diffusion through soils is key; plants compete by expanding their zone of resource capture
 - Mycorrhizae, fine roots

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Competition for Water

- What factors regulate water availability?
- How do plants compete for water?
- Is deeper always better?

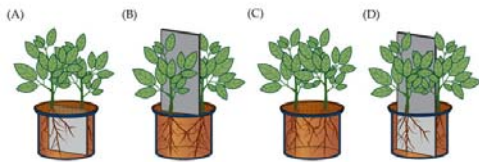


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<http://www.unm.edu/%7Eepockman/index.html>

How do we know competition is occurring?



- Pot studies: easy to conduct, prone to artifacts
- Usually the yield or growth rate is measured with and without competitors
- How can we relate the results to the real world?

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How do we know competition is occurring?

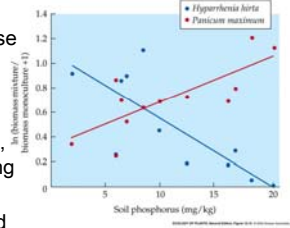
- Do neighbors affect biomass, growth rate, reproduction...
- Field studies manipulate existing plants
 - Plant seeds or seedlings
 - Remove neighbors
- This can be done both above- and belowground
 - Chain saws and shovels may be required

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What strategies lead to better competitiveness?

- It depends
- Grime thinks taller is always better
- Tilman thinks rapid nutrient use is most important
- Westoby suggests several important characteristics: leaf longevity, size, canopy height, seed mass and number among others
- Allocation to roots, shoots and reproductive parts can play a role



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Allelopathy: Chemical warfare

- Plants produce lots of toxic compounds but proving they inhibit other species is difficult
- Many species have bare zones around their bases: evidence for allelopathy?
- Detailed studies of knapweed extracts show toxic effects on N. American range plants but not on closely related European species
- Knapweed is more competitive for P via mycorrhizal symbiosis



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Do competitive hierarchies exist?

- Suggests that some species are always superior, others always subordinate
 - Leads to predictability for community patterns
 - Why would new species evolve?
- Competitive dominance may vary with environmental conditions
 - Community composition determined by
 - dispersal, speciation, extinction (neutral theory)
 - Resource distribution (the niche)

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Competition vs. Inhibition

- Competition: competitors are more evenly matched
- Inhibition: pre-emptive competition, the inhibited plant is so suppressed that it isn't really competing
- Is this really just semantics?

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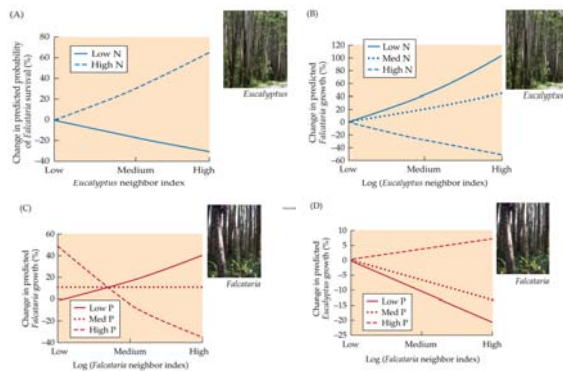
Competition vs. Facilitation

- Negative and positive interactions are likely
 - Can occur simultaneously
 - Can depend on additional factors
- Interactions can and do change with the environment
- Soil nutrients determined the outcome of interactions between *Eucalyptus* and *Falcataria*

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Tree experiments in Hawaii



Common Mycorrhizal Networks

- Mycorrhizae may link plants of different species and transfer nutrients, water and C among them
- Why would this happen?
- This would certainly alter competition, thus succession and biodiversity
 - These linkages may facilitate seedling survival
 - May also result in negative interactions (red maple)
- Really difficult to study in the field

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Modeling competition

- Lotka-Volterra is more useful for animals than for plants
 - L-V treats growth of each population as a fn of densities of two popns in competition
- Equilibrium models look at average differences in niches to predict the outcome of competition
 - How different must niches be to prevent competitive exclusion?
 - MacArthur suggested popn growth should be a fn of resource availability, which depends on supply and use rates
 - Extended by Tilman in resource-ratio model
- Non-equilibrium models focus on stochastic events in space and time
 - Differential response to disturbance plays a large role

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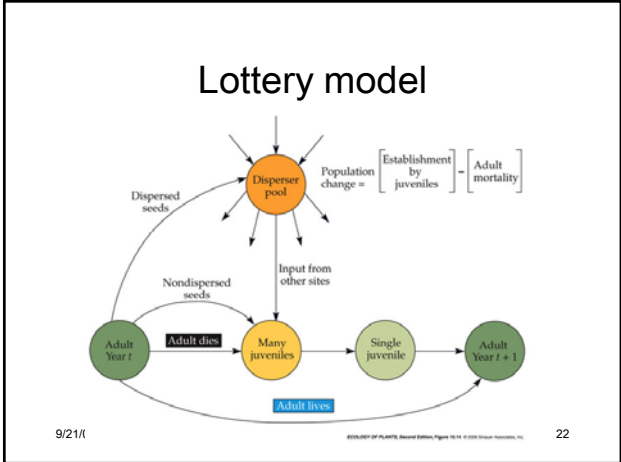
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Nonequilibrium models

- Watt's idea of patch dynamics suggests that predictable patterns are disrupted by chance events, leading to competitive interactions
- Lottery models suggest that species can co-exist without requiring different niches because of nonuniform seed distribution, asymmetric competition, spatial and temporal patchiness

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- ### Neutral model
- Based on theories of genetic drift
 - Assumes:
 - All coexisting species are ecologically equivalent
 - Community composition is thus determined by rates of speciation, extinction, and dispersal
 - Are all species competitively equivalent?
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