The integrated plant: Ps & growth

I. Intro: Plant responses to elevated CO_2?
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II. Plant growth strategies
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  C. Plant growth strategies
  D. Plant photosynthetic strategies
IV. Summary: Plant responses = ecosystem responses to elevated CO_2?

I. Intro: plant responses to elevated CO_2?

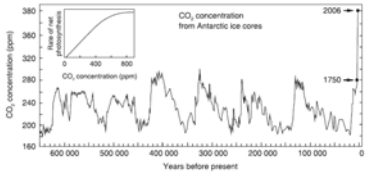


Fig. 1 The two 'icon type' diagrams for plant responses to elevated CO_2: the past 650 000 years' CO_2 concentration as extracted from Antarctic ice cores (combined data from Petit *et al.*, 1999 and Siegenthaler *et al.*, 2005) and the schematic response of leaf net photosynthesis of C_3 plants to rising ambient CO_2 concentrations.

Körner 2006

Variation in plant growth response to elevated CO_2

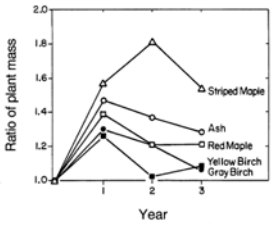


FIG. 6. The time course of growth enhancement caused by elevated CO_2 concentration for several New England tree species. The response ratio is calculated as growth of a given species at 680 μL/L CO_2 divided by its growth at 340 μL/L CO_2. All of the species initially respond positively, but they differ substantially in how long elevated growth rates are maintained. From Bazzaz et al. (1994); reproduced with permission.

Vitousek 1994

Genotypic variation in elevated CO_2 response

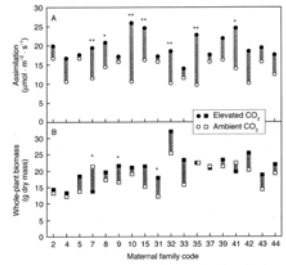


FIG. 21. Genotypic variation in response to different levels of CO_2 concentration. *Plantago lanceolata* was grown in elevated (700 μL/L) and ambient (350 μL/L CO_2) for 120–127 d; $n = 3$–6. Note that (A) photosynthetic responses and (B) biomass responses do not always match. Asterisks indicate statistical significance between data for elevated and ambient CO_2. $^*P < 0.05$, $^{**}P < 0.01$. (Redrawn from Curtis et al. (1996). Fig. 2).

Körner 2000

Space matters: from isolated individuals to communities

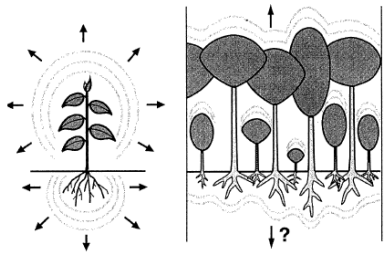


FIG. 8. The problem of expanding vs. steady-state experimenrtal systems. If the experimental system is allowed to freely explore additional ground area (cover) and lateral soil volume, results reflect rates of spatial expansion and thus depend on harvest date (see Fig. 9).

Körner 2000

II. Resource limitations of photosynthesis

Photosynthesis: Light-dependent and light-independent reactions

http://www.digitalfrog.com/resources/archives/leaf.jpg

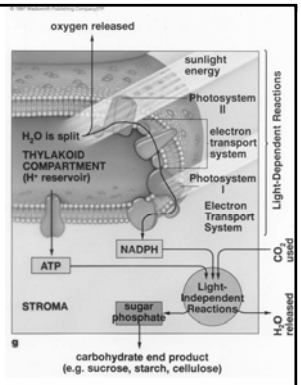
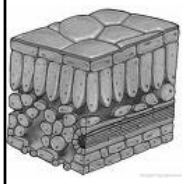
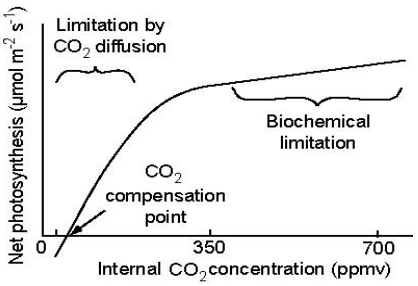


Fig. 5.2g Chloroplast structure and function.

A. CO_2 response curve of photosynthesis

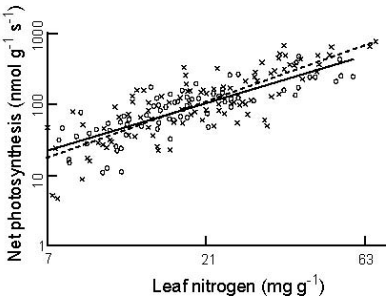




http://www.digitalfrog.com/resources/archives/leaf.jpg

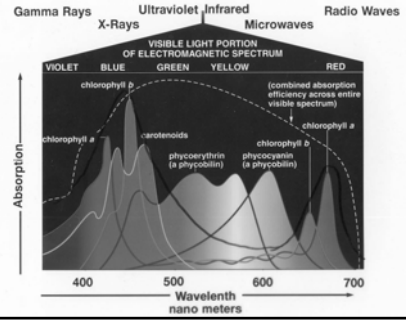
Chapin et al. 2002

B. Nutrient response of photosynthesis



C. Photosynthesis responses to light

1. Photosynthetically active radiation (PAR)



2. Response of Ps to variation in light

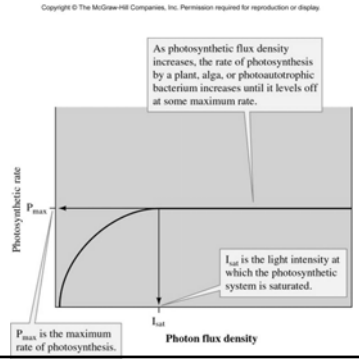
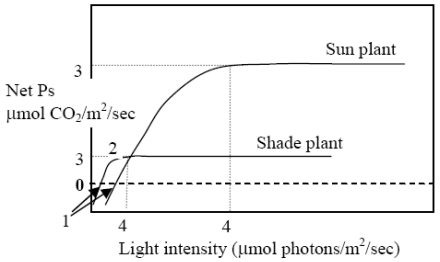


Fig. 6.19

Sun and shade plant adaptations to light



Sun vs. shade plants

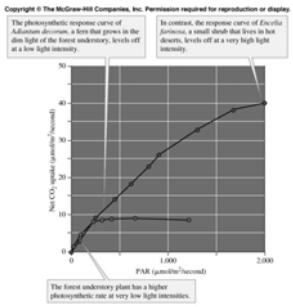


Fig. 7.21

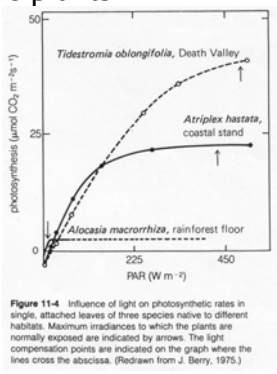


Figure 11-4 Influence of light on photosynthetic rates in single, attached leaves of three species native to different habitats. Maximum irradiances to which the plants are normally exposed are indicated by arrows. The light compensation points are indicated on the graph where the lines cross the abscissa. (Redrawn from J. Berry, 1975.)

III. Plant growth strategies

A. Allocation and exponential growth

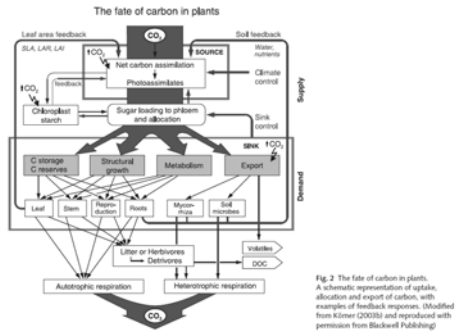
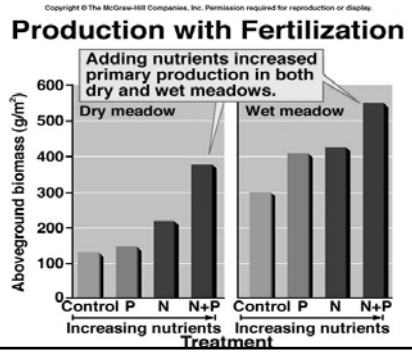


Fig. 2 The fate of carbon in plants. A schematic representation of uptake, allocation and export of carbon, with examples of feedback responses. (Modified from Körner (2003b) and reproduced with permission from Blackwell Publishing)

Körner 2006

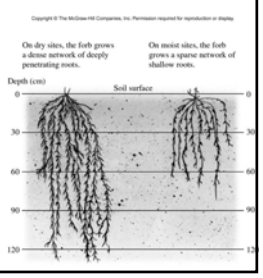
Nutrient response of plant biomass



18.5

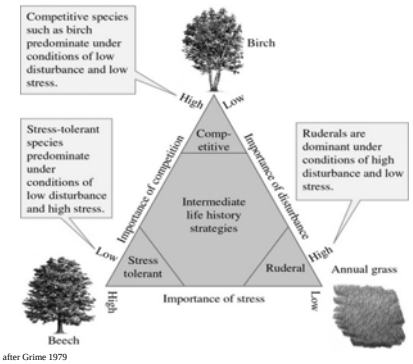
B. Resource limitation and optimal foraging

1. Maximize gain of fixed carbon
2. Need other resources to do that
3. Efficiency of resource use ("cost and revenue")
4. Optimal allocation: co-limitation by multiple resources



Plant life history strategies – Grime's CSR

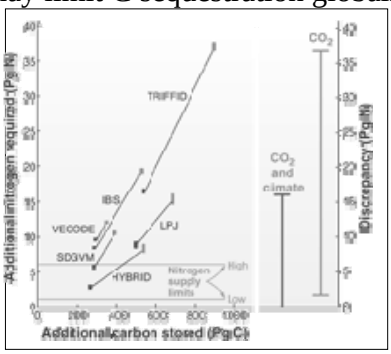
Figure 12.20



12-15

Source: after Grime 1979

N may limit C sequestration globally

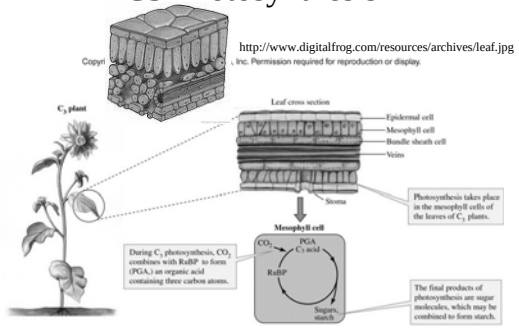


Hungate et al. 2003 Science

D. Plant photosynthetic strategies

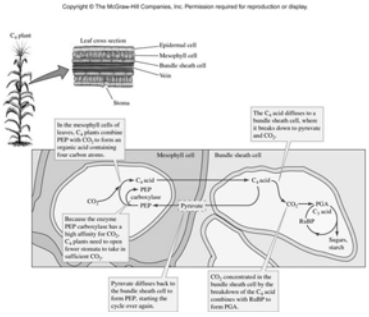
C3, C4, and CAM photosynthesis
READING: pp. 134-139

C3 Photosynthesis

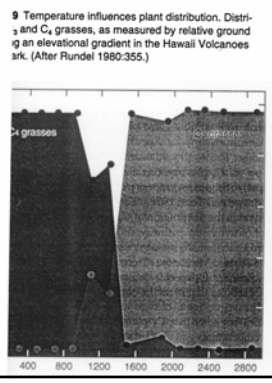


http://www.digitalfrog.com/resources/archives/leaf.jpg

C4 Photosynthesis

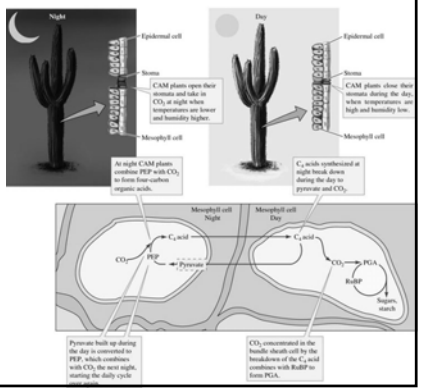


C4 Distribution



7-23
The numbers shown here indicate the percentages of the total number of grass species having the C_4 pathway in each of 32 local floras in North America. The highest percentages are found in those regions with the highest temperatures during the growing season.

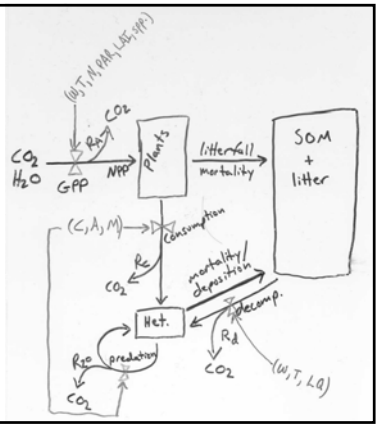
CAM Photosynthesis



Summary: Do plant = ecosystem responses to CO_2?

1. Multiple limitations: New limitations may arise in ecosystem context not seen in individual plant experiments.
2. Allocation: Optimal foraging
3. Different strategies: tradeoffs

Controls on plant uptake of CO_2



End