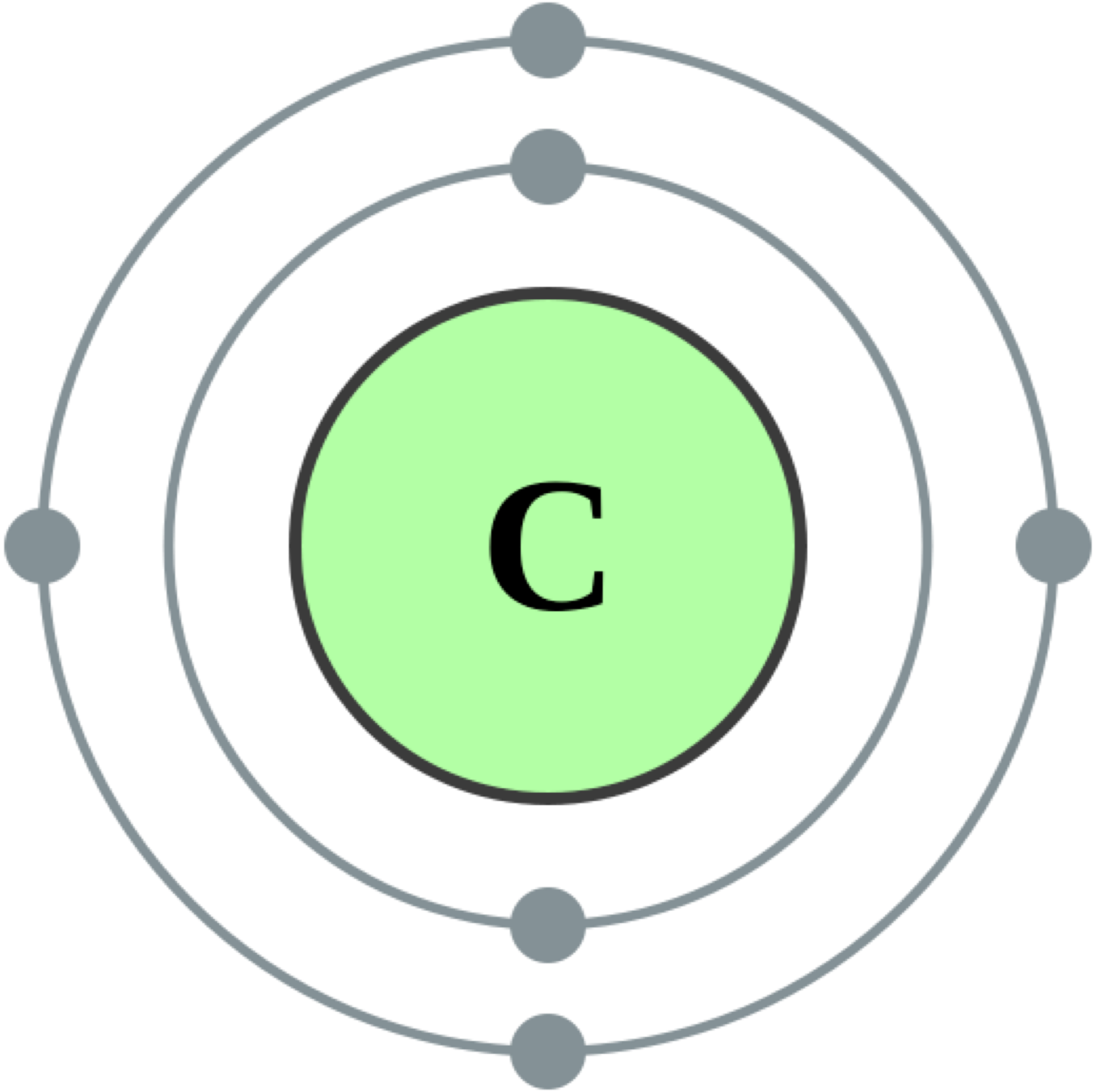
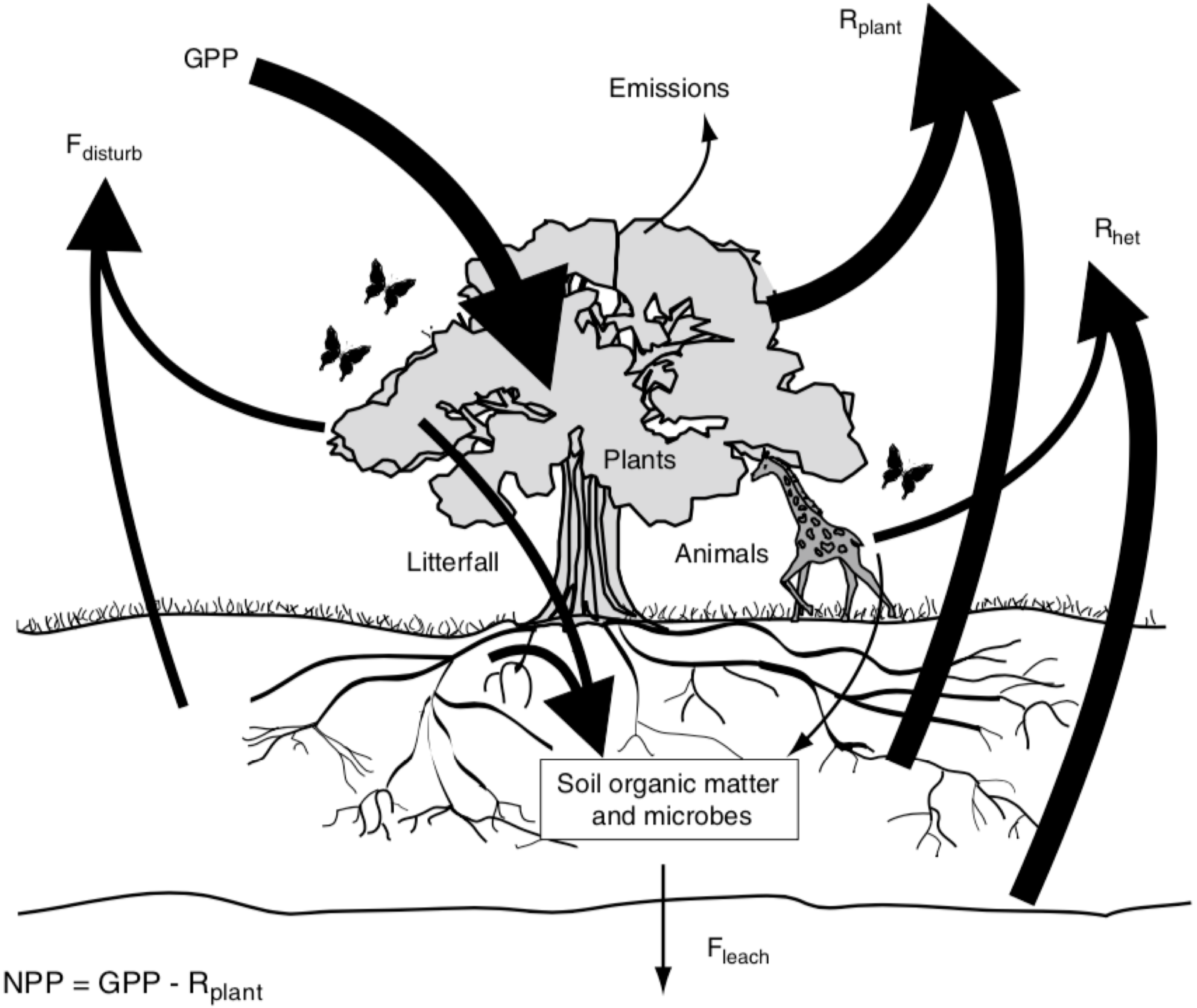


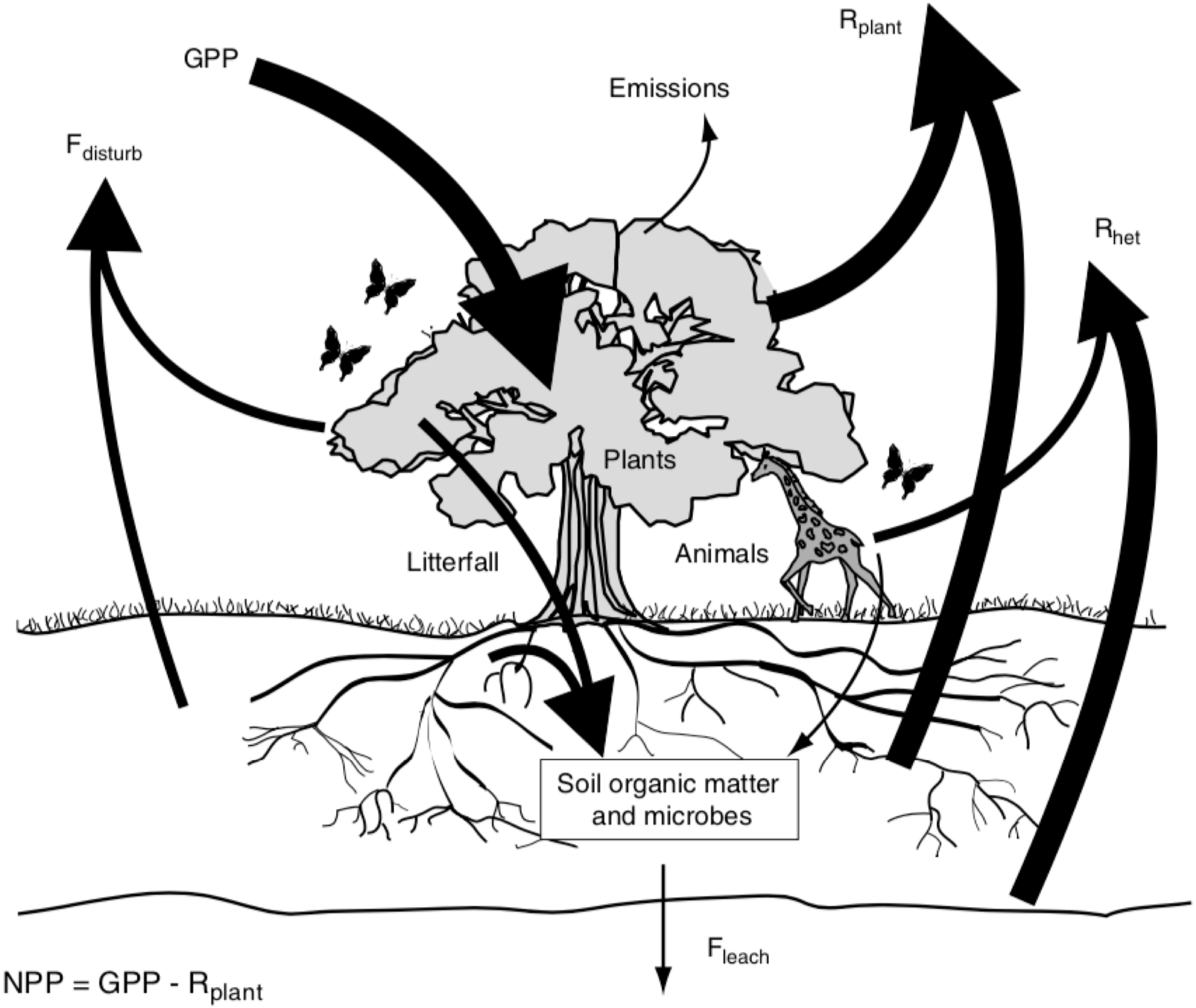
Carbon inputs to terrestrial ecosystems

Terrestrial Ecosystem Carbon Cycle



$NPP = GPP - R_{plant}$

$NEP = GPP - (R_{plant} + R_{het})$



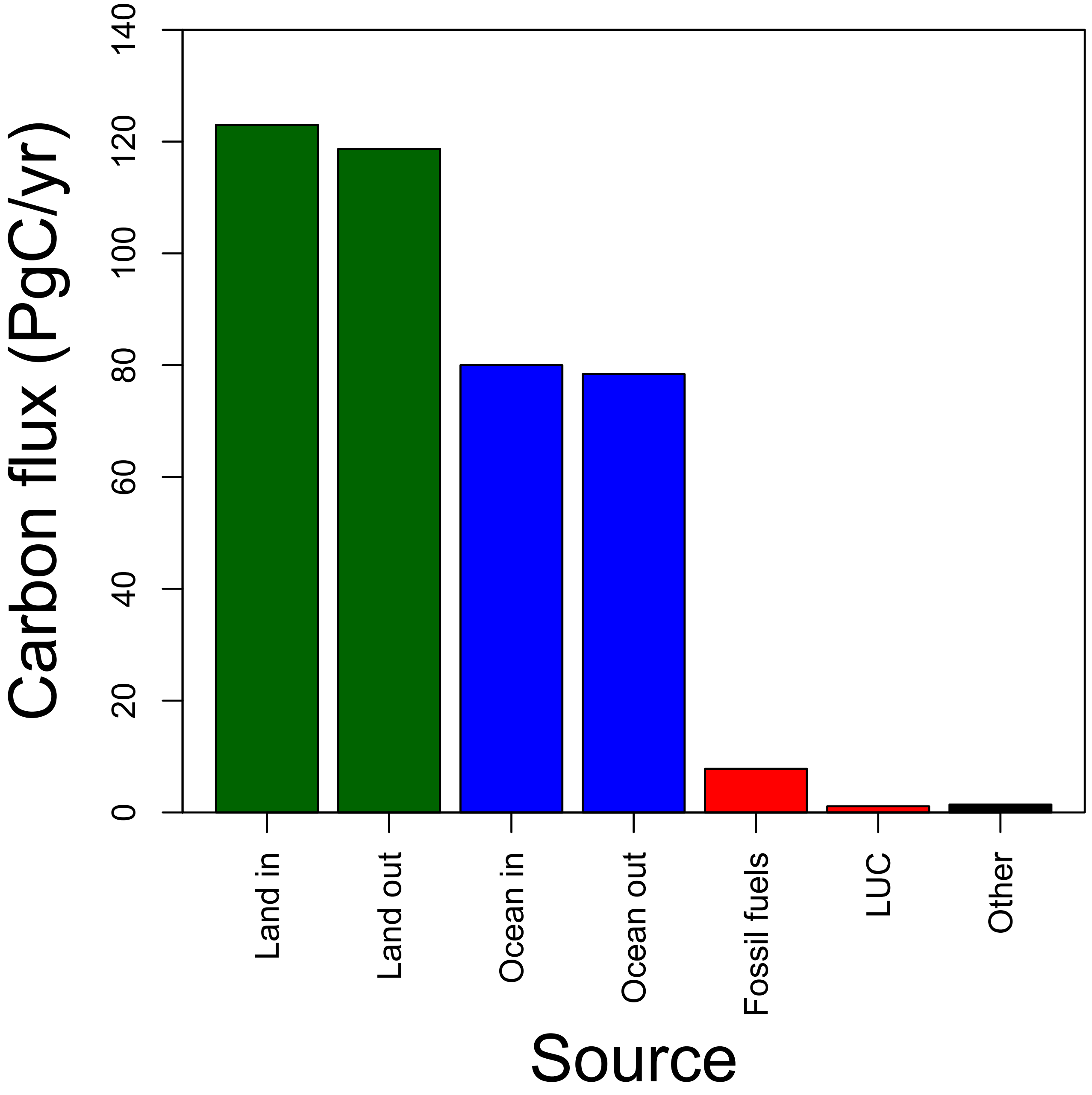
$NPP = GPP - R_{plant}$

$NEP = GPP - (R_{plant} + R_{het})$

Terrestrial Ecosystem Carbon Cycle

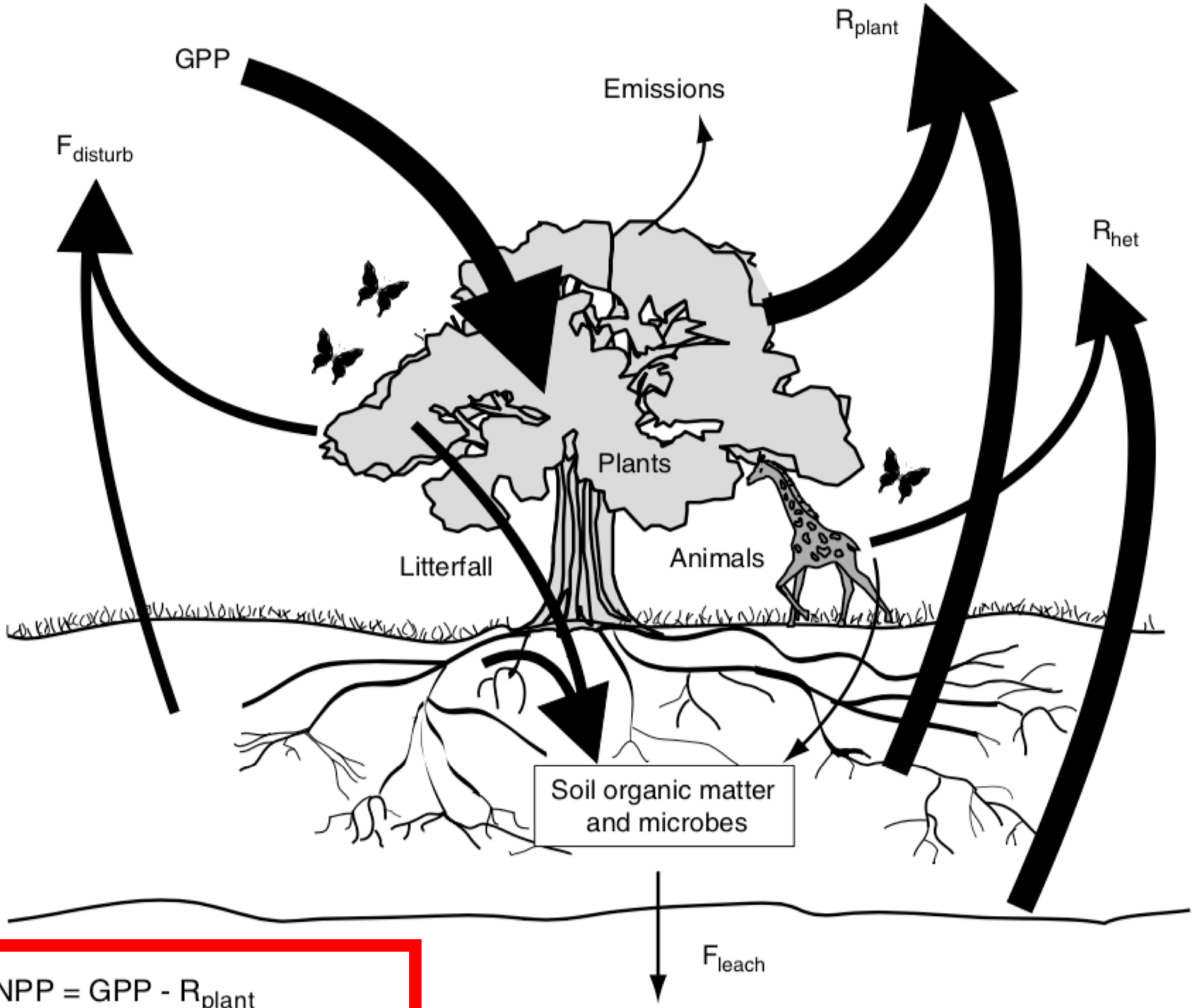
Arrows represent fluxes

How do these compare to anthropogenic carbon fluxes?



Data from IPCC (2013)

1 acre corn plot takes up > 5000 lbs of CO_2 a year



Terrestrial Ecosystem Carbon Cycle

$NPP = GPP - R_{plant}$

$NEP = GPP - (R_{plant} + R_{het})$

$$NPP = GPP - R_{plant}$$

Net Primary Productivity (C into plants – C out of plants; per ground area)

$$\boxed{NPP} = GPP - R_{plant}$$

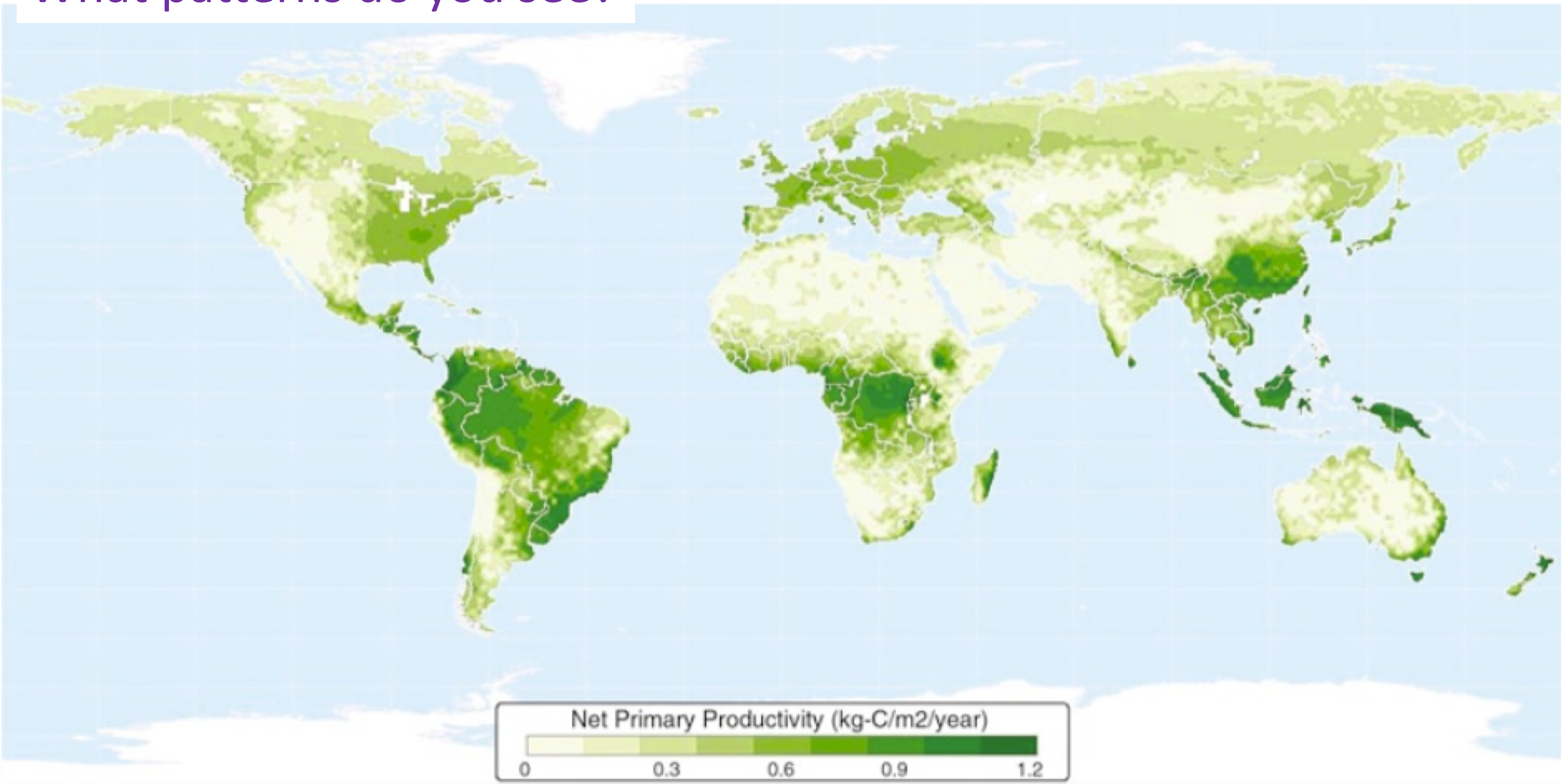
Gross Primary Productivity (total flux of C into plants; per ground area)

$$NPP = \boxed{GPP} - R_{plant}$$

Plant Respiration (total flux of C out of plants ; per ground area)

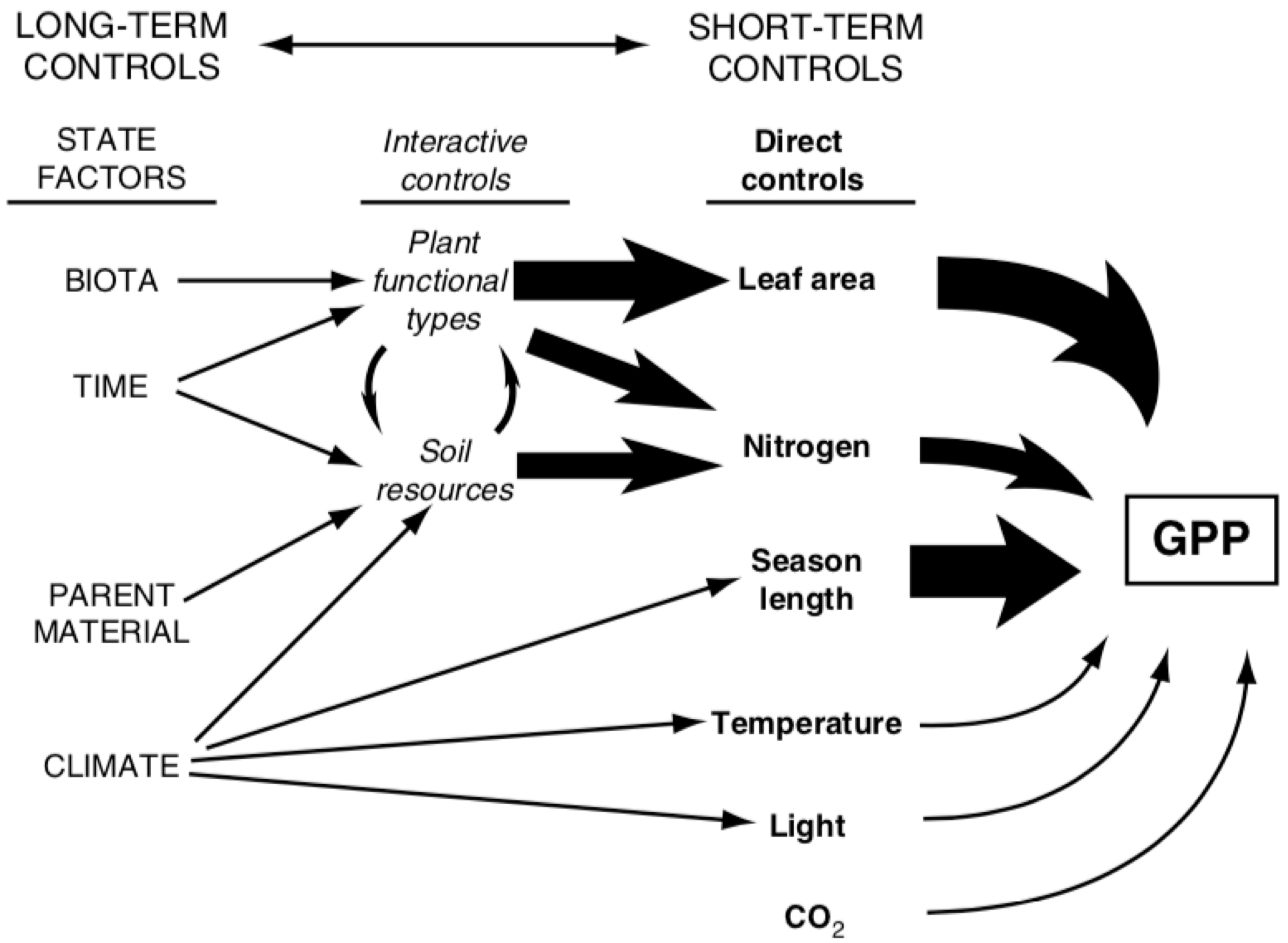
$$NPP = GPP - \boxed{R_{plant}}$$

What patterns do you see?



Gross Primary Productivity (total flux of C into plants; per ground area)

$$NPP = \boxed{GPP} - R_{plant}$$


LONG-TERM CONTROLS
SHORT-TERM CONTROLS
STATE FACTORS
Interactive controls
Direct controls
BIOTA
TIME
PARENT MATERIAL
CLIMATE
Plant functional types
Soil resources
Leaf area
Nitrogen
Season length
Temperature
Light
CO_2
GPP

$$GPP = photosynthesis * LAI$$

Carbon in to leaves (per leaf area)

$$GPP = \boxed{\text{photosynthesis}} * LAI$$

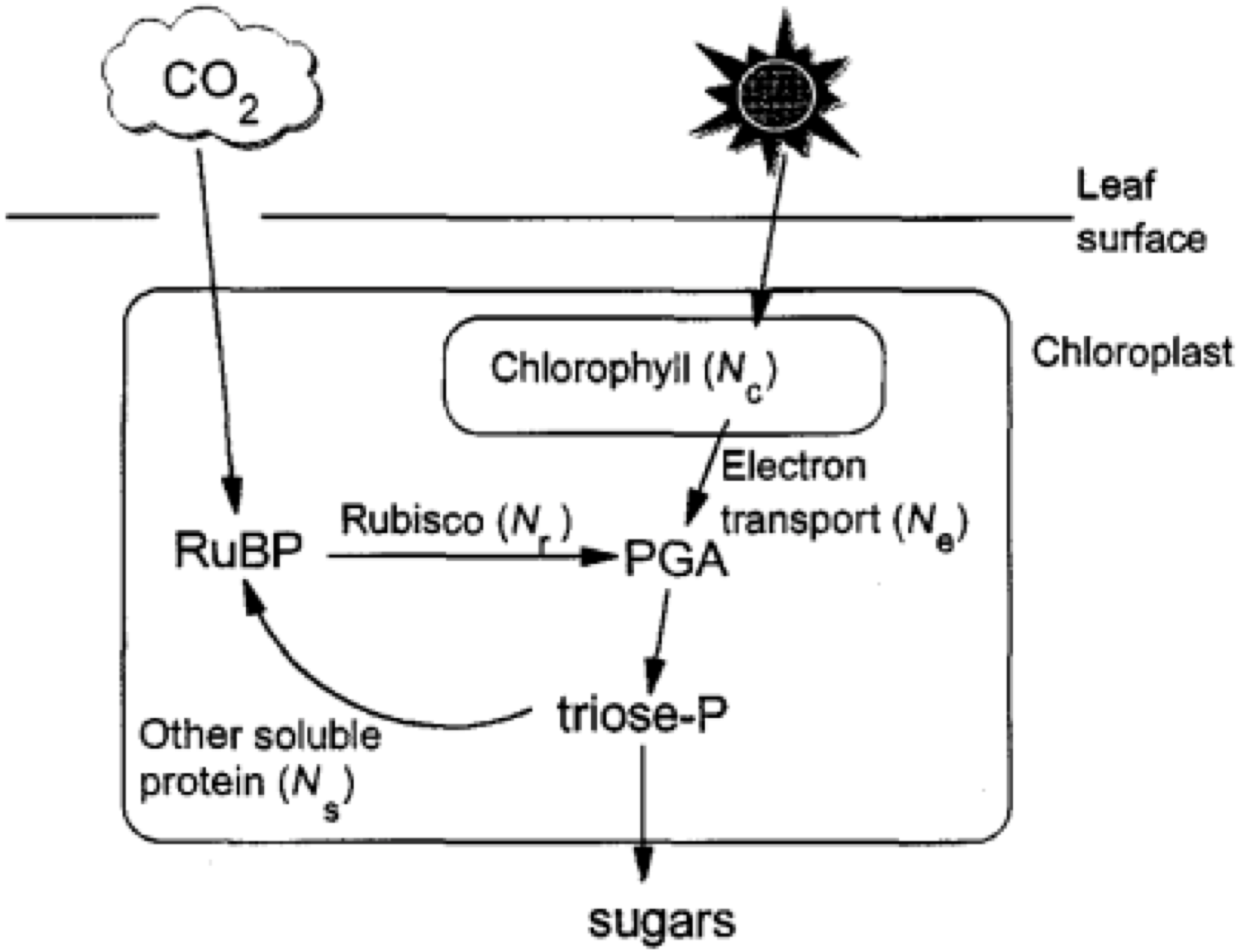
Leaf area index (leaf area per ground area)

$$GPP = photosynthesis * \boxed{LAI}$$

Carbon in to leaves (per leaf area)

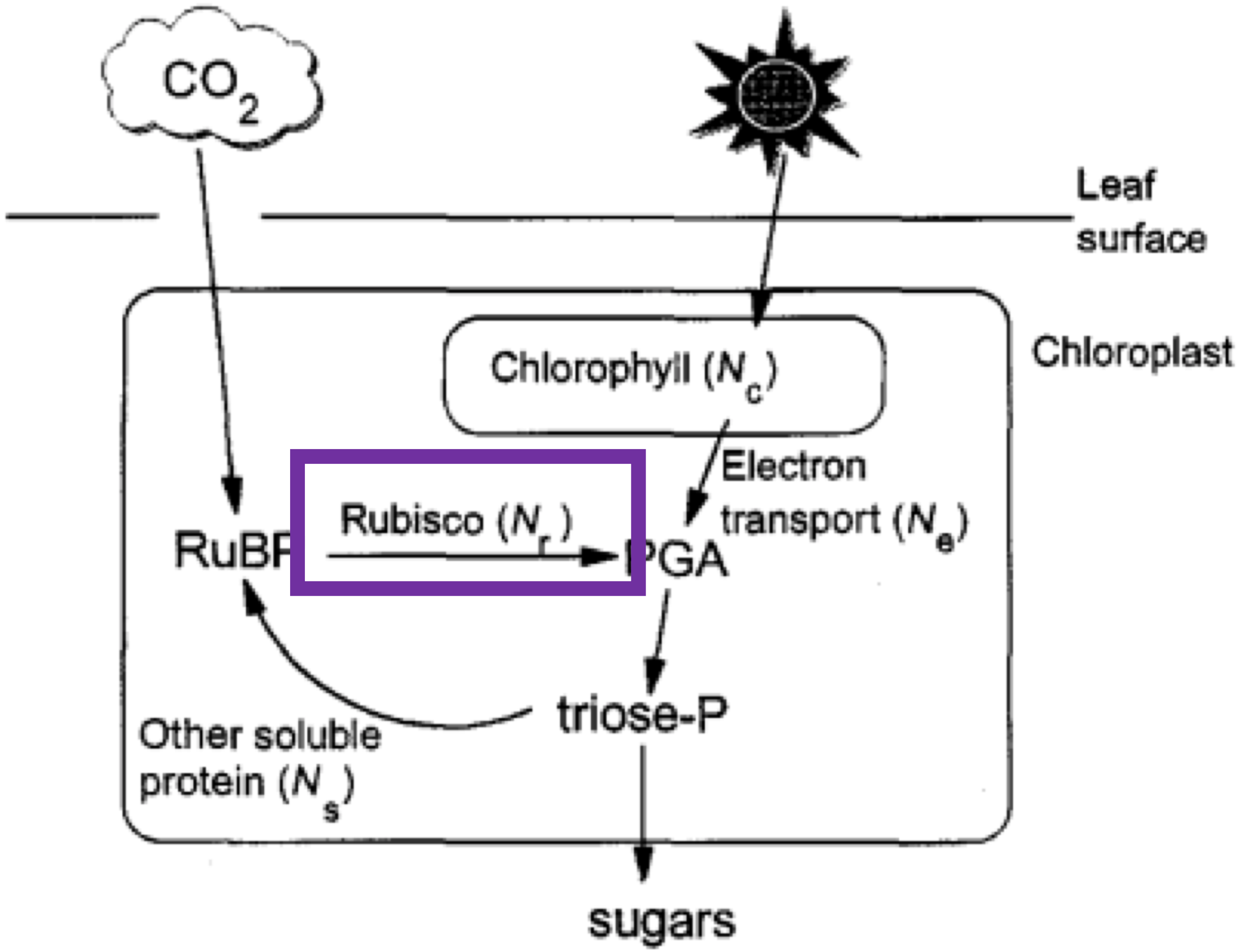
$$GPP = \boxed{\text{photosynthesis}} * LAI$$

Simple recap of photosynthesis



Medlyn 1996

Simple recap of photosynthesis



Medlyn 1996

Photorespiration

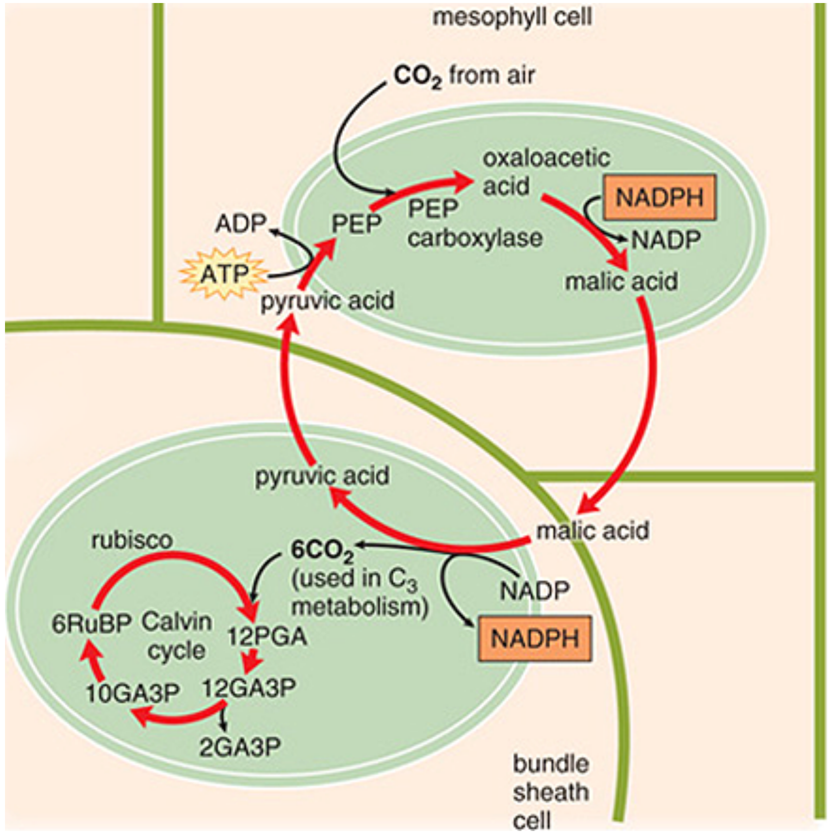
- Rubisco : RibUlose – 1,5 – BISphosphate Carboxylase and Oxygenase
- Catalyzes CO_2 and O_2
- Catalyzing O_2 leads to “wasteful” respiration (loss of CO_2)
- Increases as O_2 increases
- Increases with temperature

3 types of photosynthesis systems

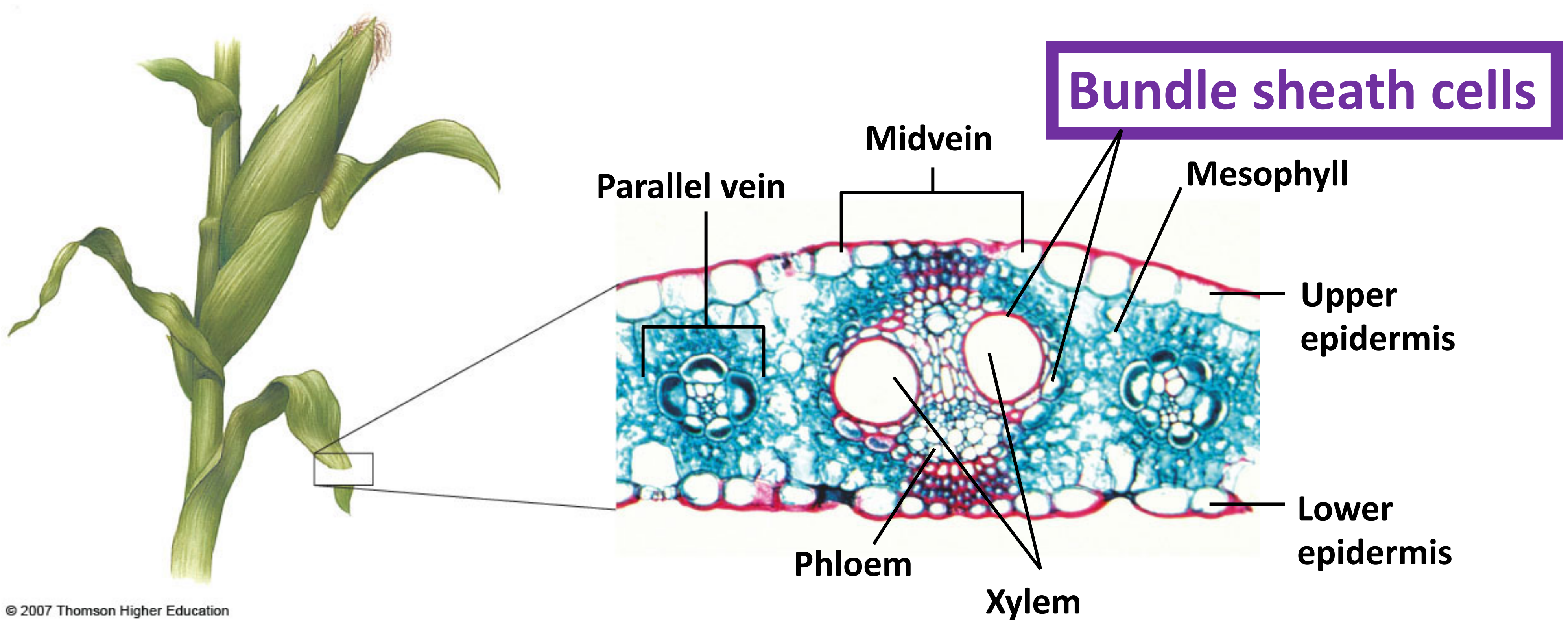
- C_3: what we already covered
  - Most plants
- C_4: Separate carbon acquisition and sugar creation in space
  - Typically grasses
- CAM: Separate carbon acquisition and sugar creation in time
  - E.g., Cacti

C4 photosynthesis

- PEP carboxylase captures CO_2 and creates a 4 carbon sugar in mesophyll
- Moves sugar to bundle sheath, where CO2 is removed
  - Bundle sheath cells surround veins
- Calvin cycle progresses as normal
- “Costs” two extra ATPs



C4 photosynthesis – why the bundle sheath?



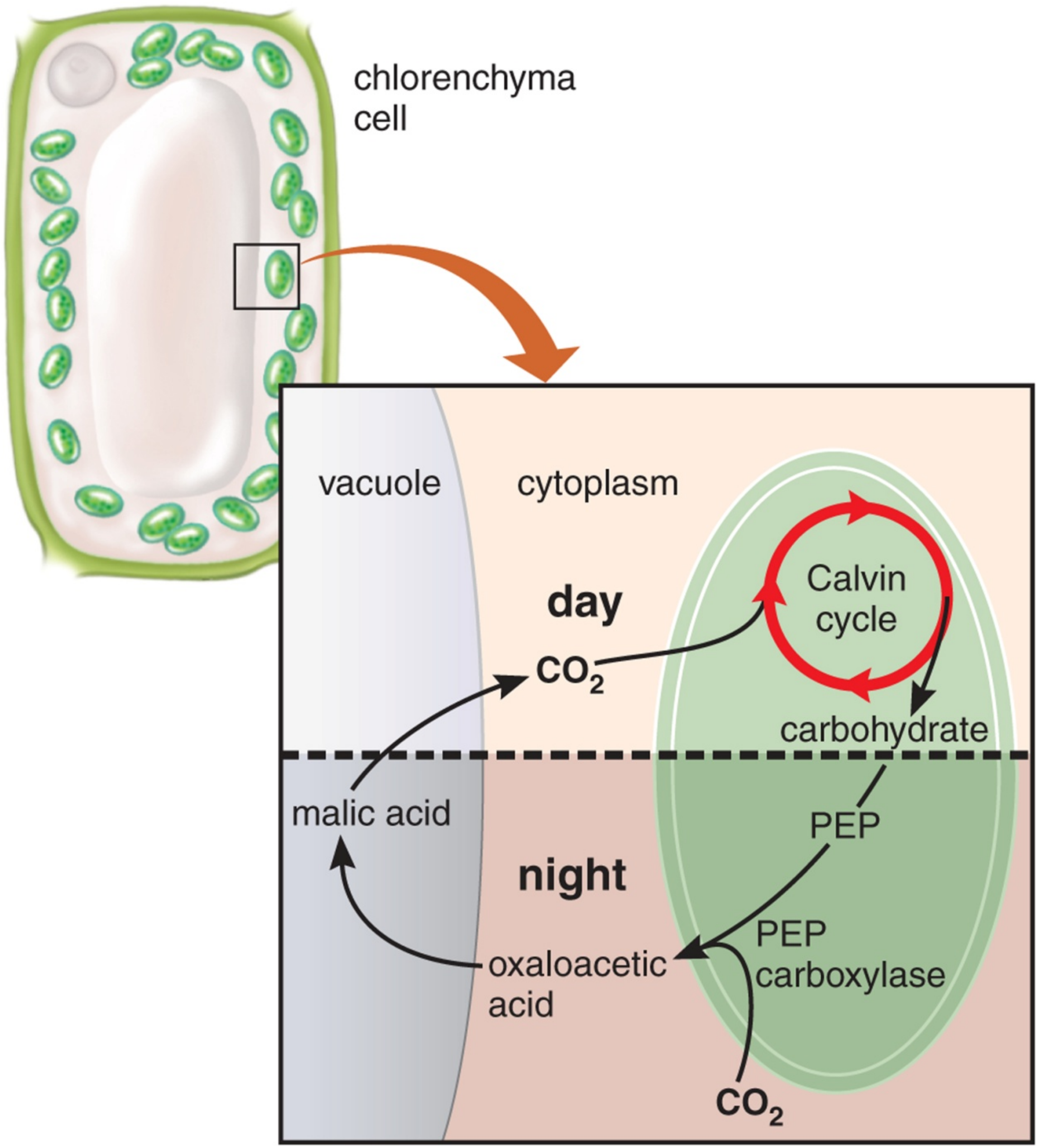
C4 photosynthesis - benefits

PEP carboxylase is not an oxygenase

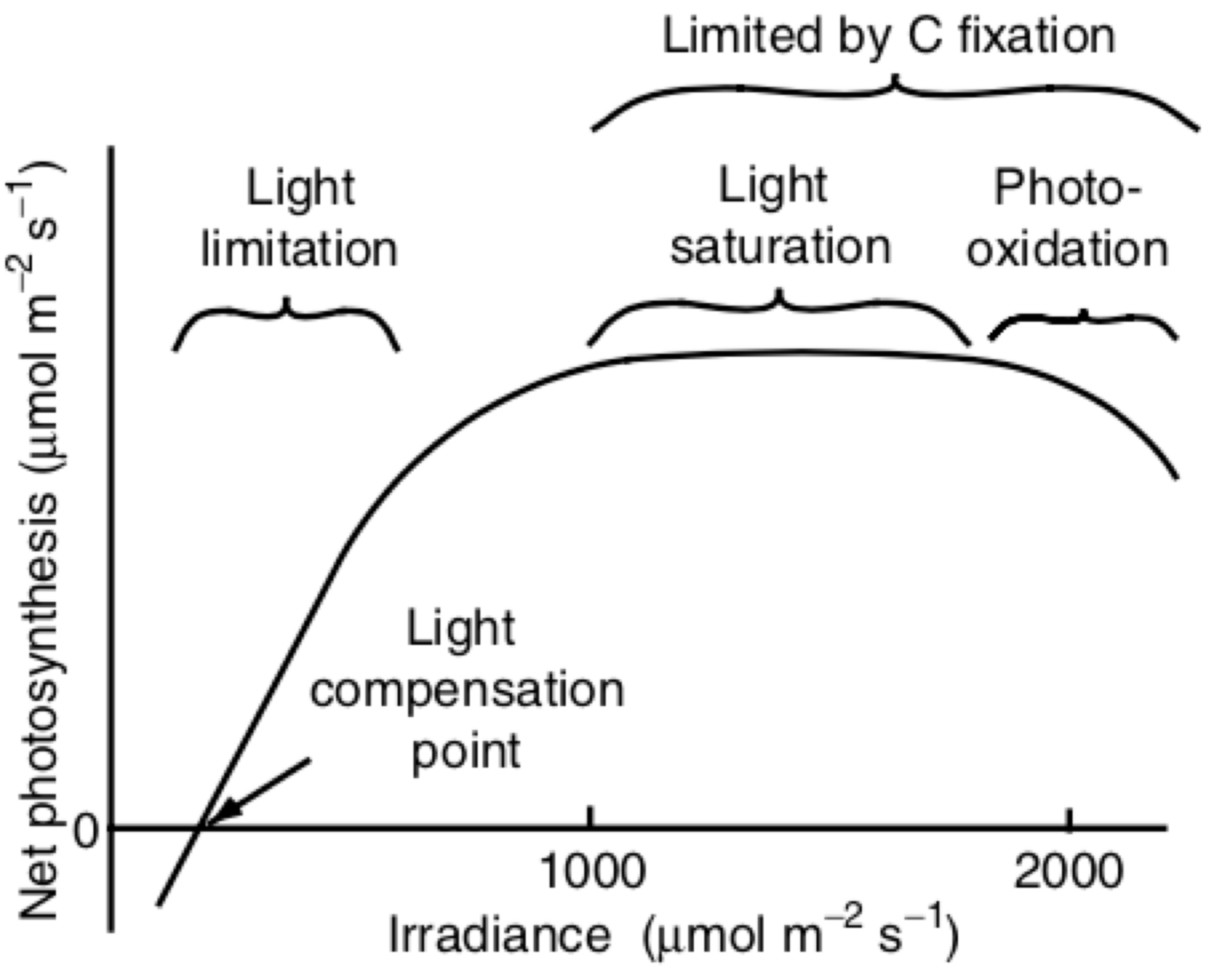
- Good at capturing CO_2
- Good in low CO_2 environments
- Good in hot, dry environments
  - Can close stomata

CAM photosynthesis

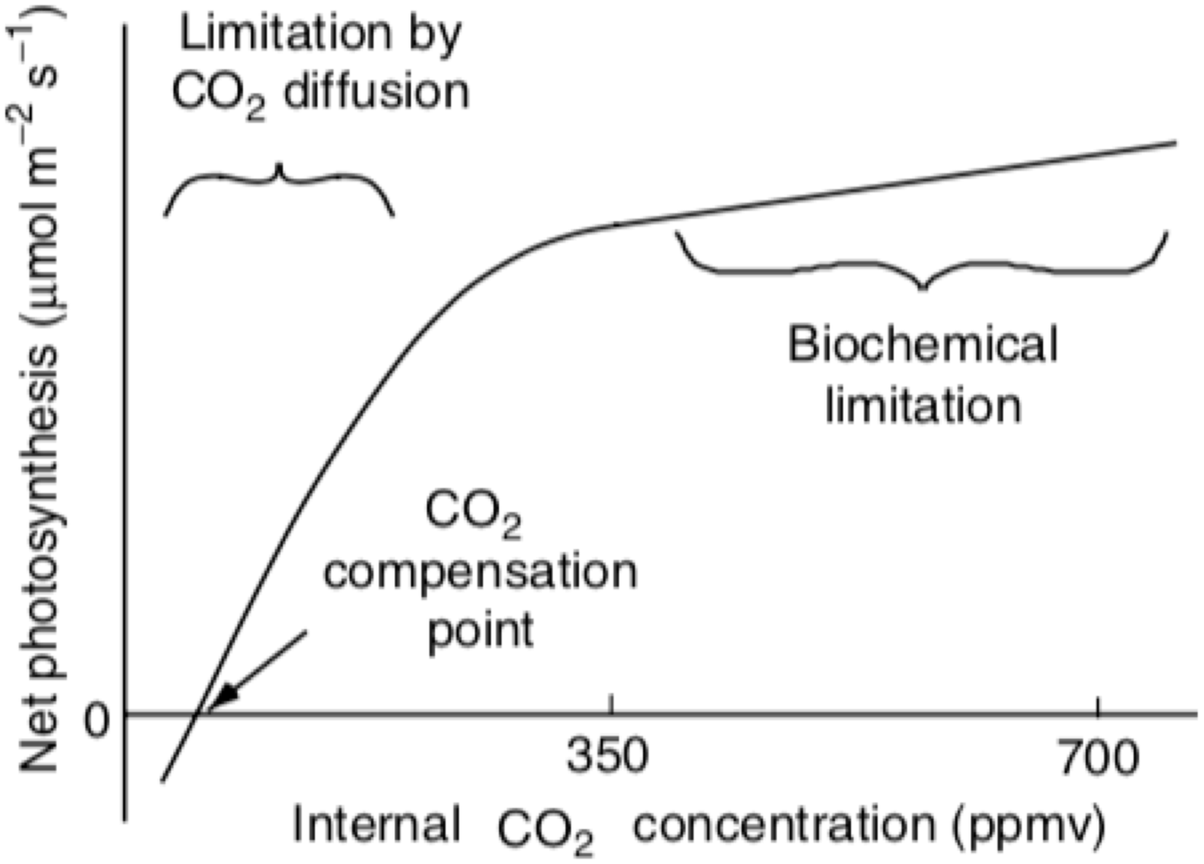
- Opens stomata during the night
  - PEP carboxylase captures CO_2 and creates a 4 carbon sugar
- Closes stomata during the day
  - Calvin cycle



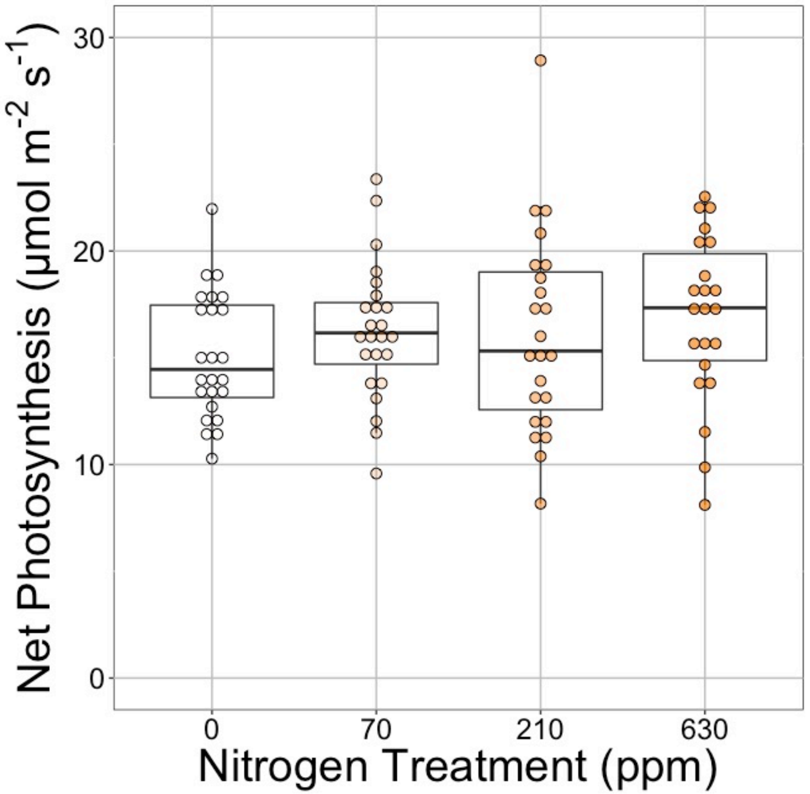
Environmental responses - light



Environmental responses – CO_2

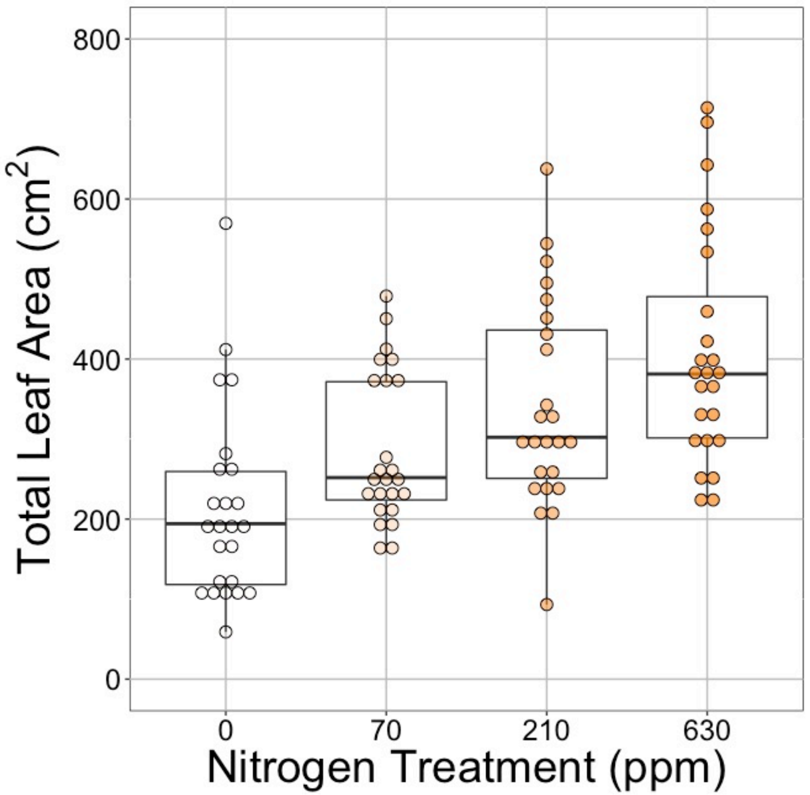


Photosynthesis is less responsive to soil resources (water and nutrients). Why?



Waring et al. (2023)

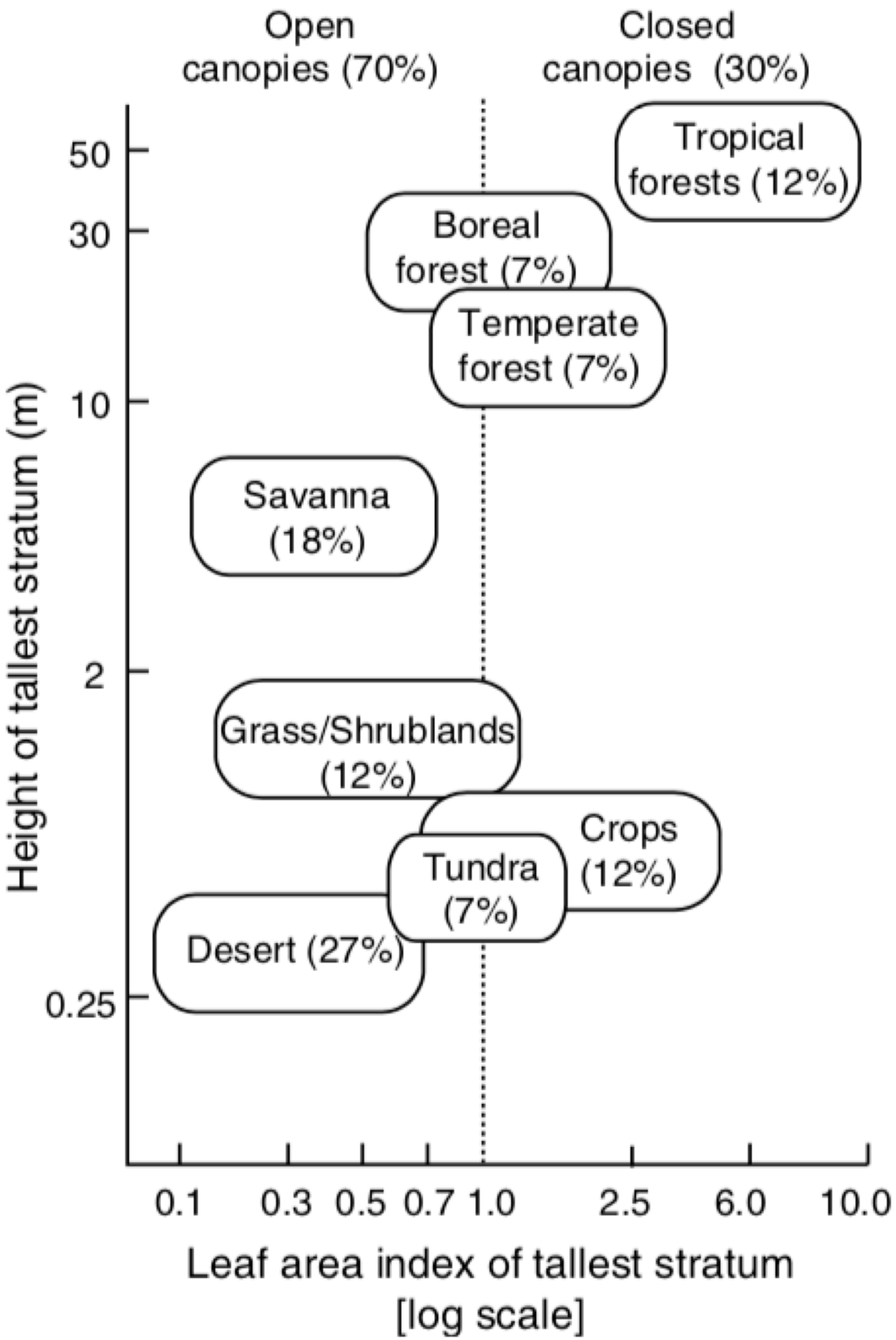
Photosynthesis is less responsive to soil resources (water and nutrients). Why?



Waring et al. (2023)

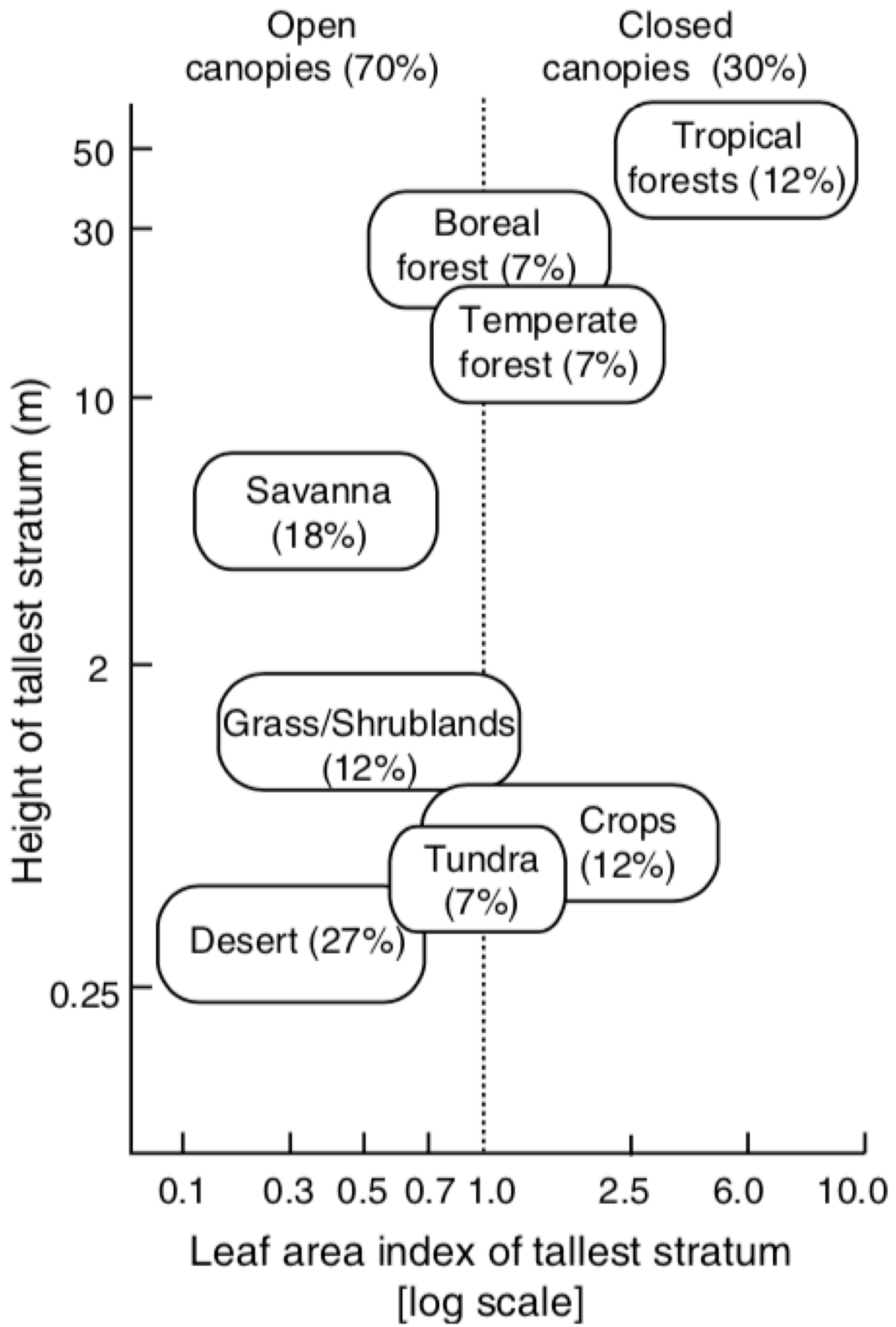
Leaf area index (leaf area per ground area)

$$GPP = \text{photosynthesis} * \boxed{LAI}$$



What's driving the x-axis distribution?

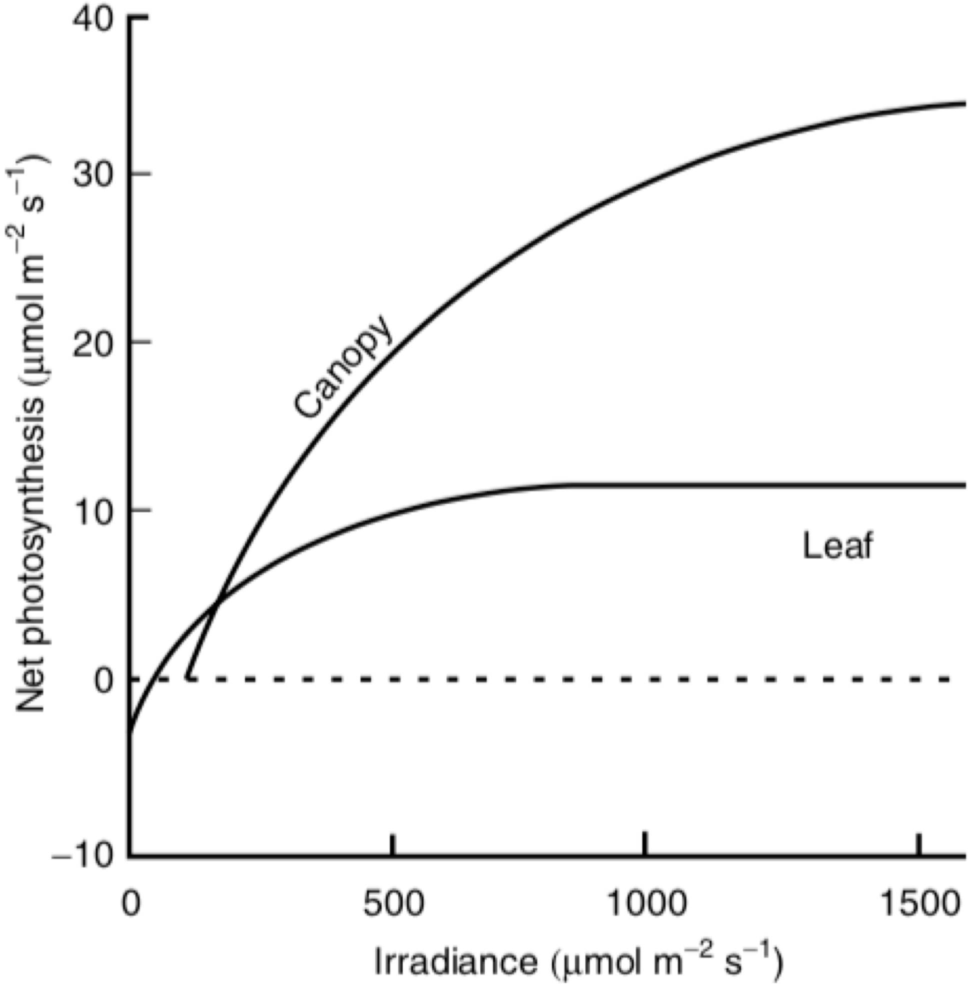
Figure 5.20 from book



What’s driving the y-axis distribution?

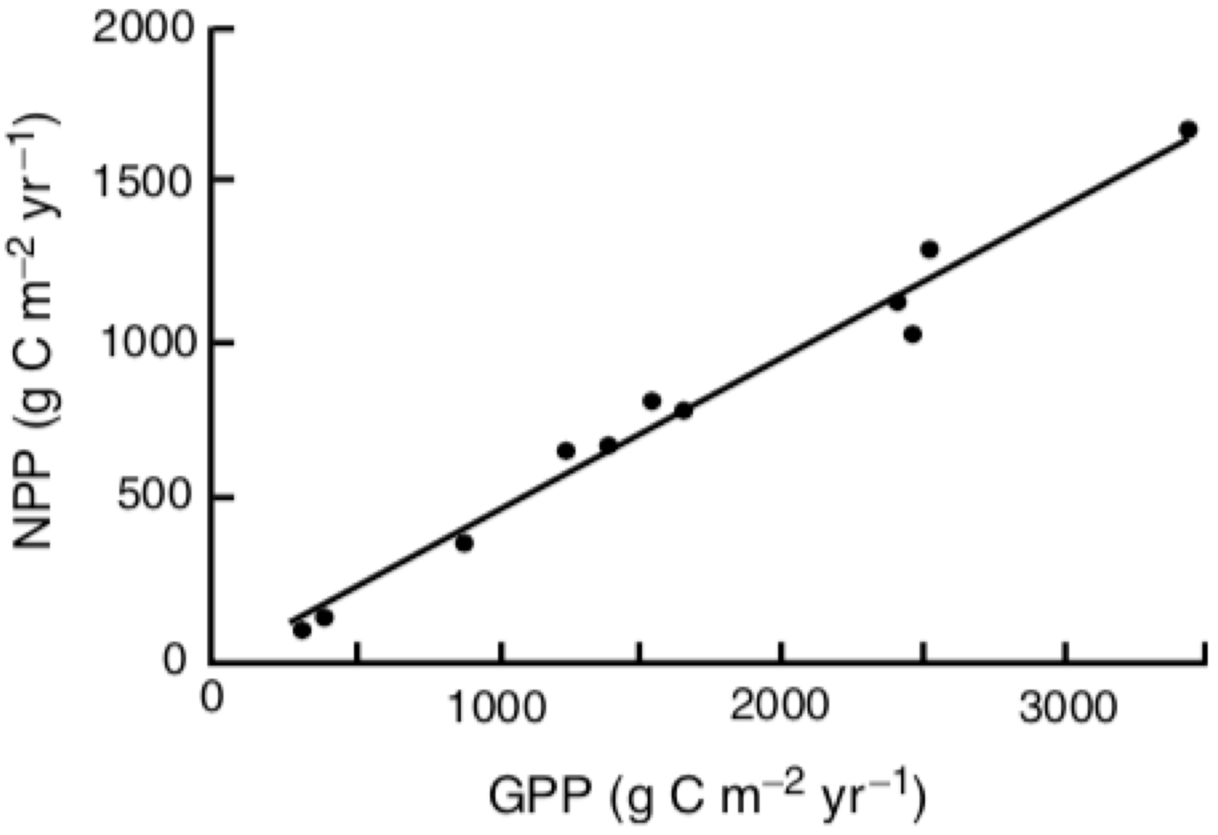
Figure 5.20 from book

Canopies tend to have higher light use efficiency than leaves



Plant Respiration (total flux of C out of plants ; per ground area)

$$NPP = GPP - \boxed{R_{plant}}$$



NPP = GPP – 0.47*GPP

Originally proposed by Waring (1998)

JOURNAL ARTICLE

Is NPP proportional to GPP? Waring's hypothesis 20 years on

A Collalti, I C Prentice

Tree Physiology, Volume 39, Issue 8, August 2019, Pages 1473–1483,
https://doi.org/10.1093/treephys/tpz034
Published: 17 May 2019 **Article history** ▾

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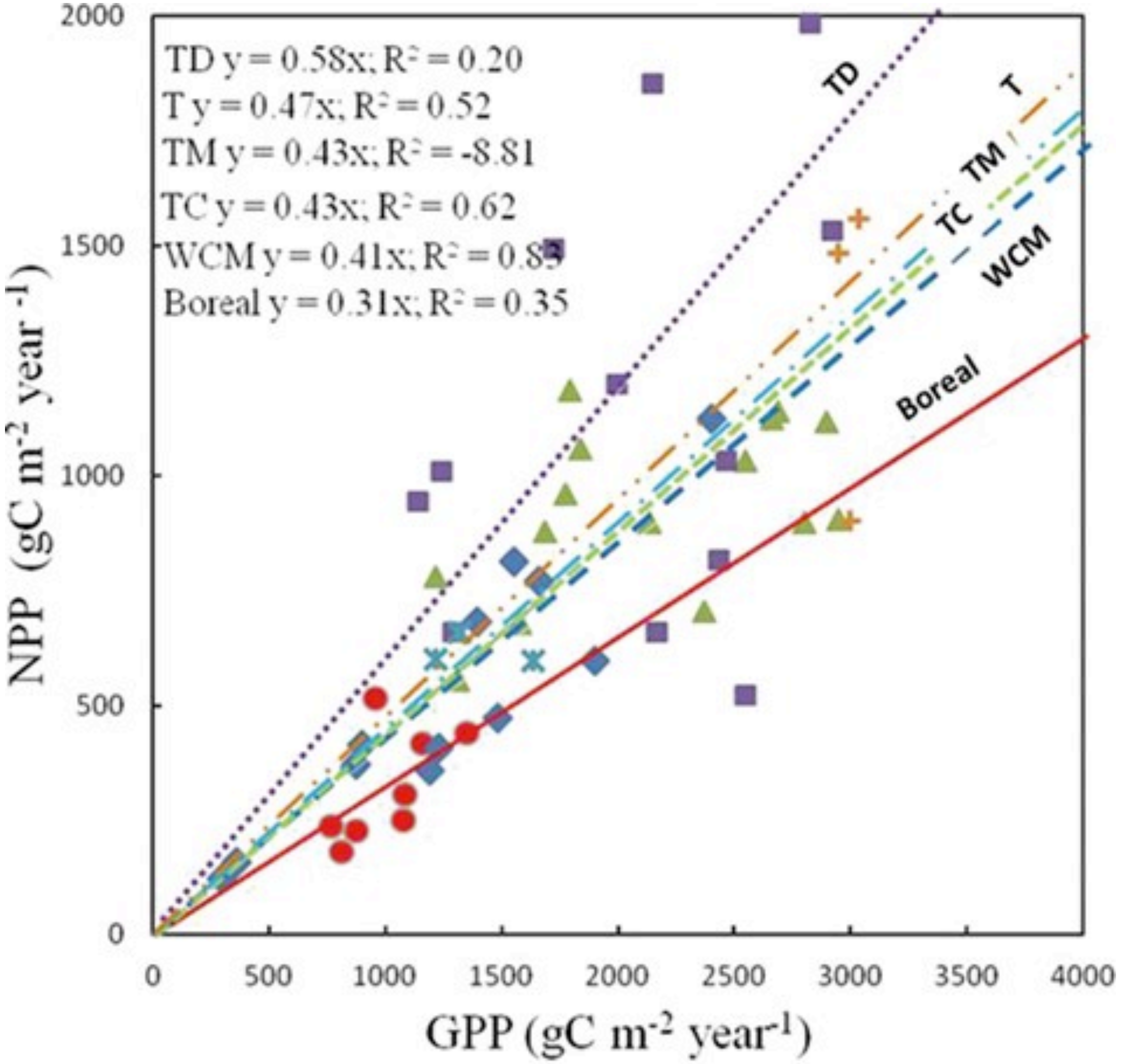
Abstract

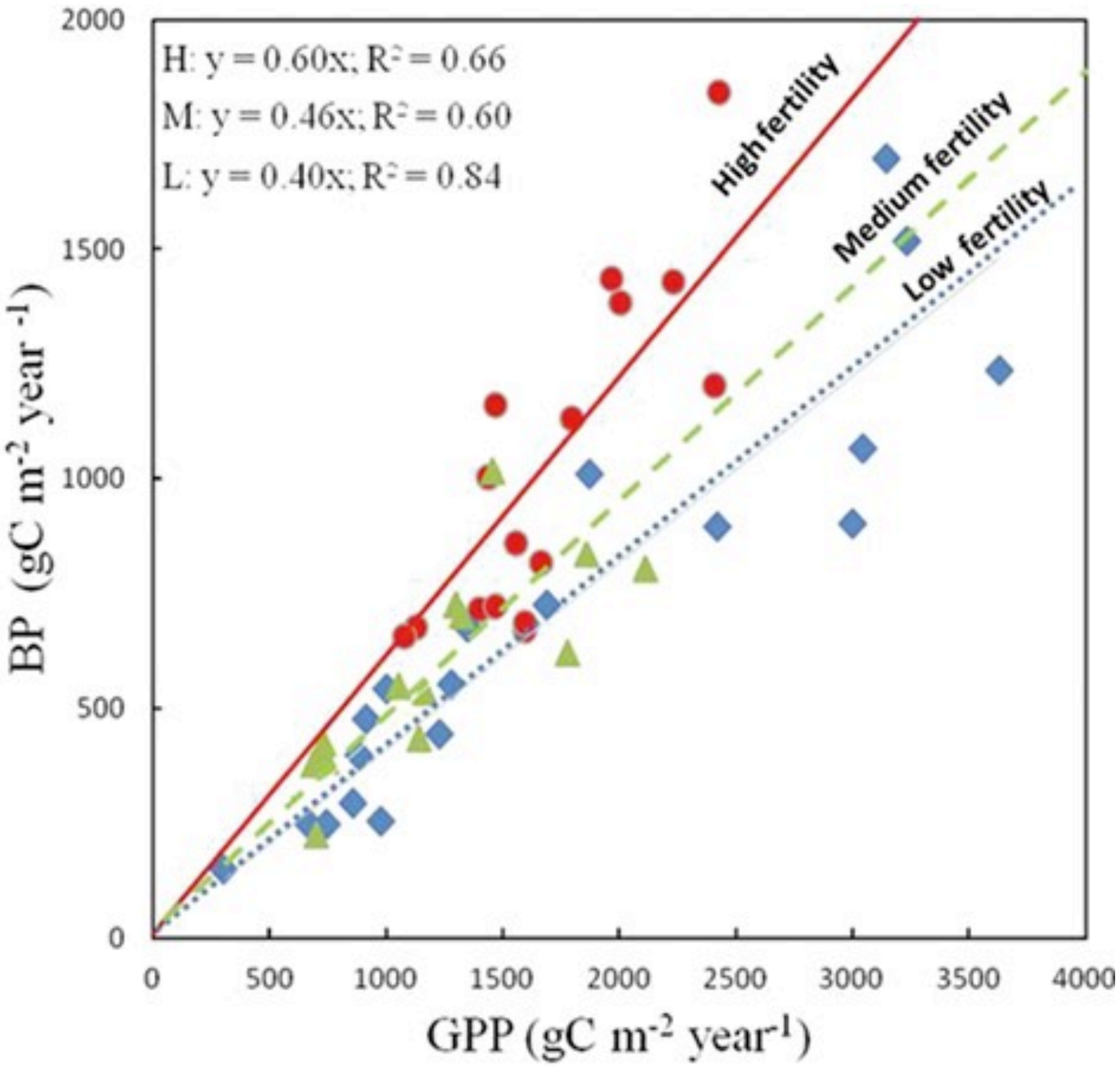
Gross primary production (GPP) is partitioned to autotrophic respiration (R_a) and net primary production (NPP), the latter being used to build plant tissues and synthesize non-structural and secondary compounds. Waring et al. (1998; Net primary production of forests: a constant fraction of gross primary production? *Tree Physiol* 18:129–134) suggested that a NPP:GPP ratio of 0.47 ± 0.04 (SD) is universal across biomes, tree species and stand ages. Representing NPP in models as a fixed fraction of GPP, they argued, would be both simpler and more accurate than trying to simulate R_a mechanistically. This paper reviews progress in understanding the NPP:GPP ratio in forests during the 20 years since the Waring et al. paper. Research has confirmed the existence of pervasive acclimation mechanisms that tend to stabilize the NPP:GPP ratio and indicates that R_a should not be modelled independently of GPP. Nonetheless, studies indicate that the value of this ratio is influenced by environmental factors, stand age and management. The average NPP:GPP ratio in over 200 studies, representing different biomes, species and forest stand ages, was found to be 0.46, consistent with the central value that Waring et al. proposed but with a much larger standard deviation (±0.12) and a total range (0.22–0.79) that is too large to be disregarded.

NPP – GPP relationship varies slightly by biome



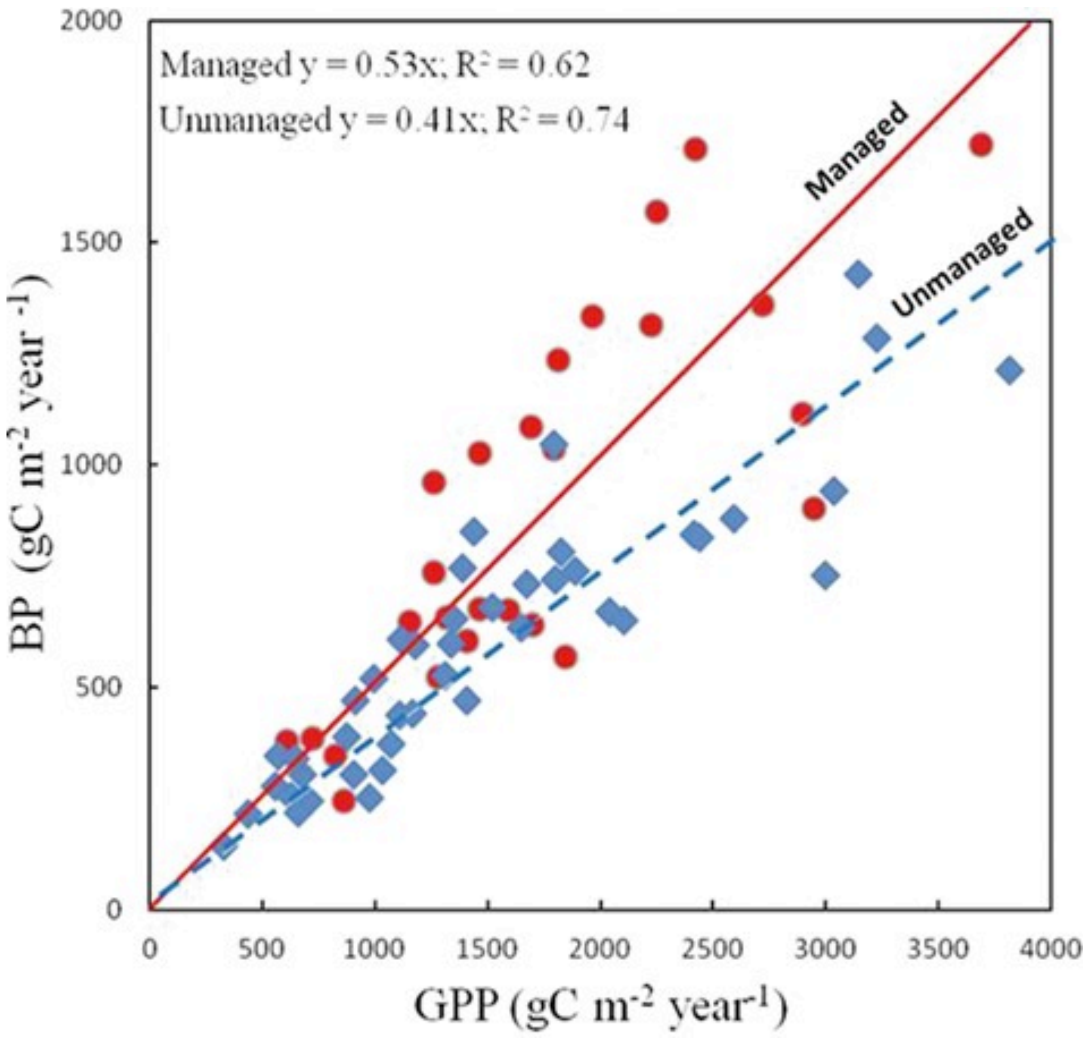
Collalti and Prentice (2019)

NPP – GPP relationship varies slightly by soil resources



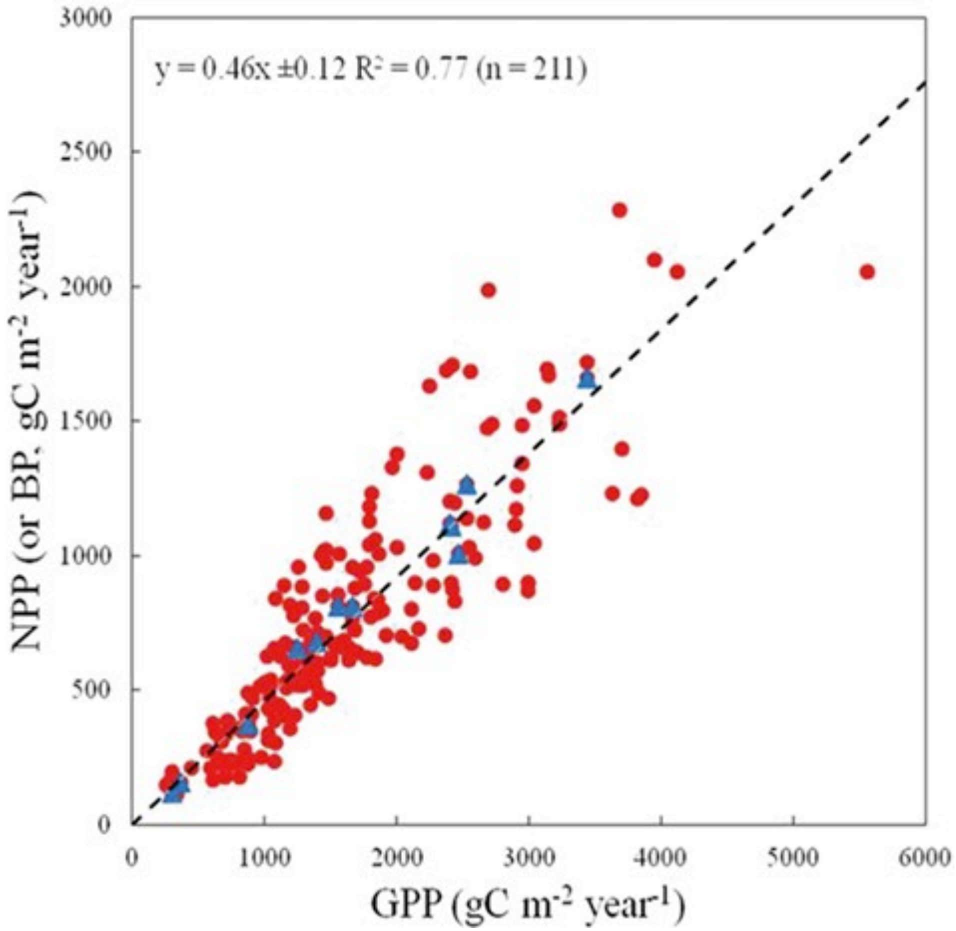
Collalti and Prentice (2019)

NPP – GPP relationship varies slightly by management



Collalti and Prentice (2019)

With more data, the relationship on average is still close to Waring's



Collalti and Prentice (2019)

What drives NPP?

- Over short time scales (seconds to days)
  - Photosynthesis
  - Light, temperature, atmospheric conditions
- Over long time scales (weeks to months)
  - LAI
  - Growth demand
  - Management
  - Soil resources

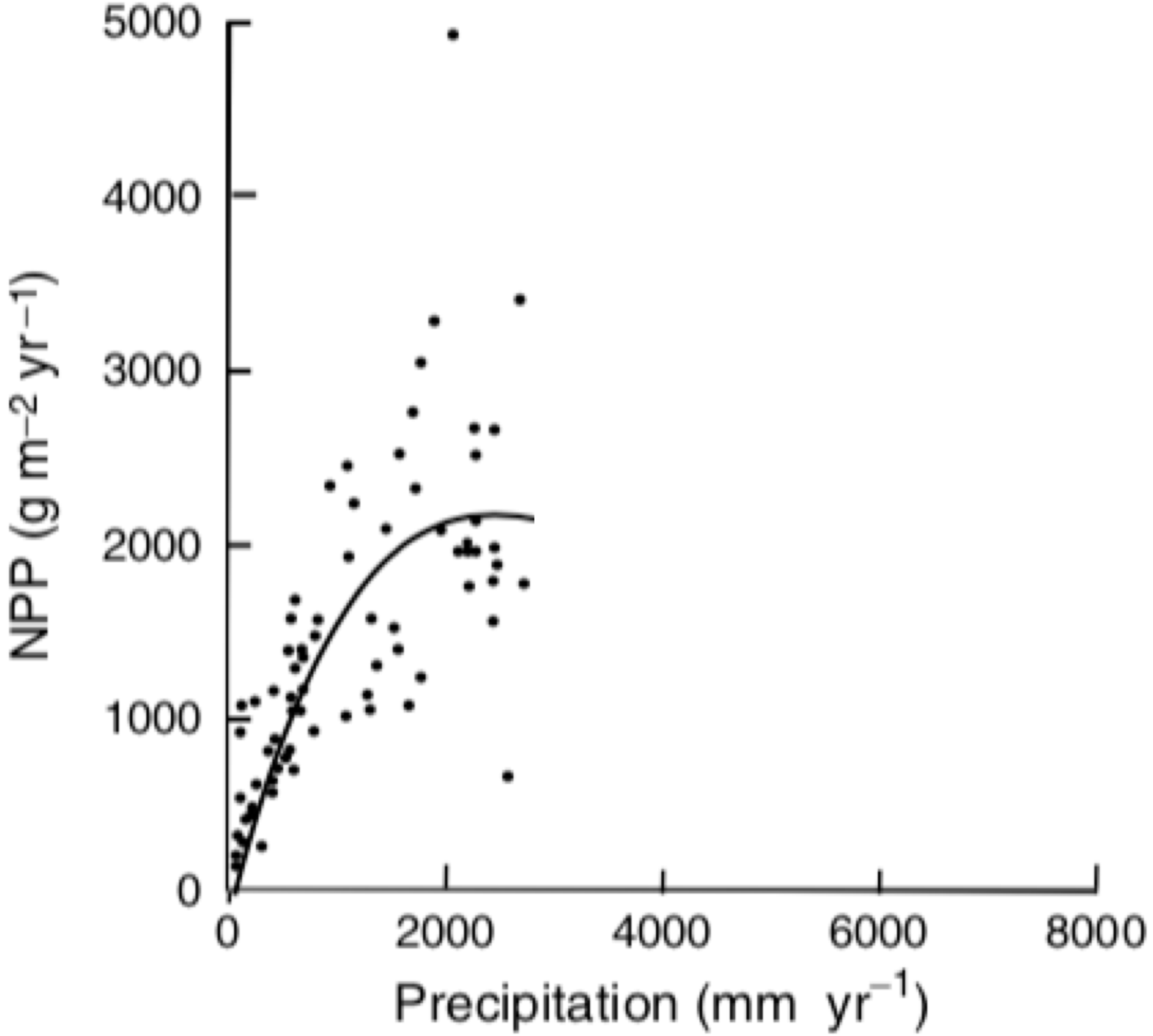


Figure 6.3 from book

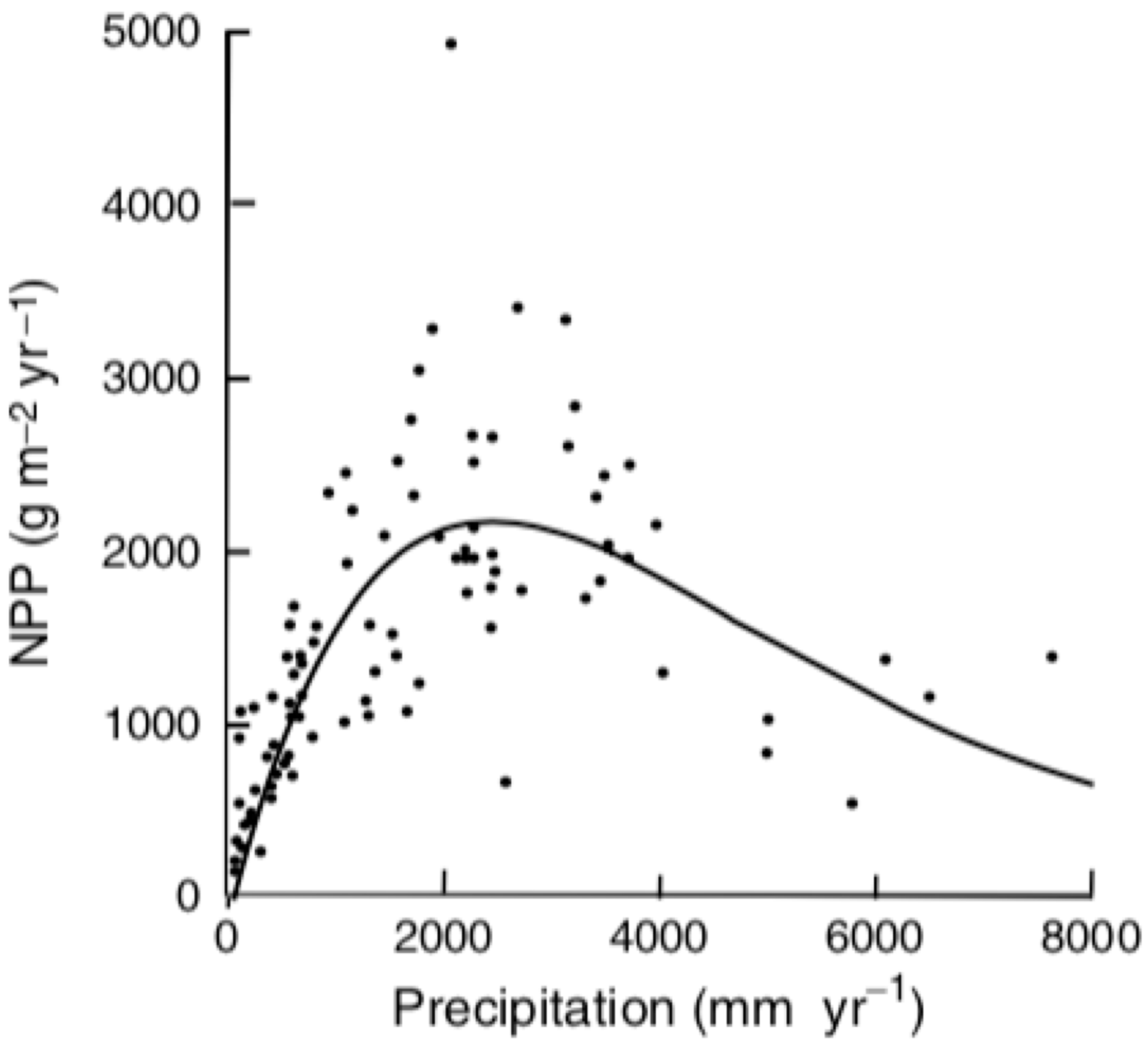
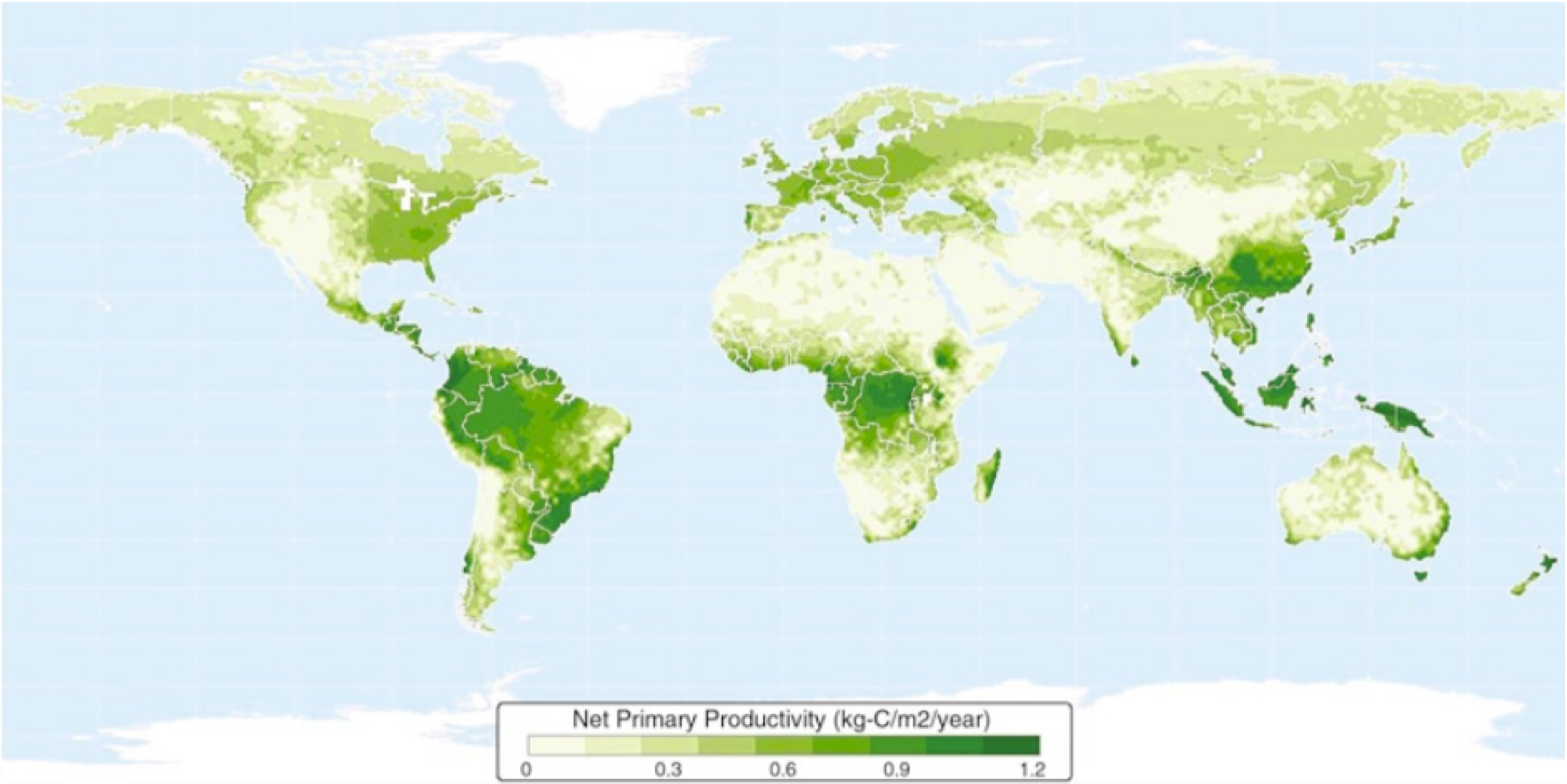


Figure 6.3 from book


Net Primary Productivity (kg-C/m2/year)
0
0.3
0.6
0.9
1.2