Forest Knowledge Know-how METLA Well-being

Structural acclimation and photosynthesis of tree canopies in changing climate

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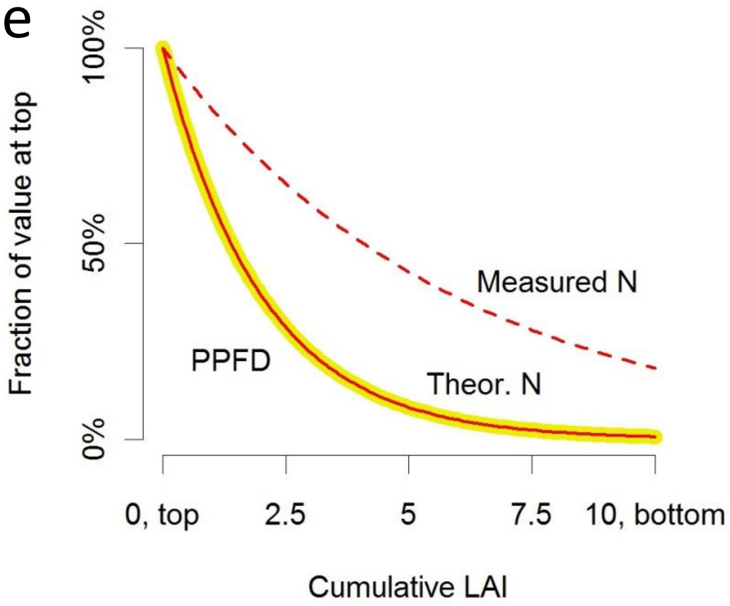
Tackling Climate Change: The Contribution of Forest Scientific Knowledge

Introduction

- Today's plant species have a long evolutionary history
  - Selection has favoured individuals with high fitness
  - One can assume that plants operate and structured optimally (under given environment conditions)…or at least they are close to local fitness optimum.
- Can we learn something about if we assume a plant is optimal?
  - Reason and consequences for observed structures
    - Deviations from optimum may reveal us something new
  - Upper limit for the effects of structural acclimation under climate change
  - Model simplification

Example of optimal assumption

- Bigleaf-models assume *N* follows light distribution.
  - *N* is bound in chlorophyl; sets the max. rate of photosynthesis
- Empirical canopy *N* gradient is much flatter than optimal. IS THERE A PROBLEM?



Intro + AIMS

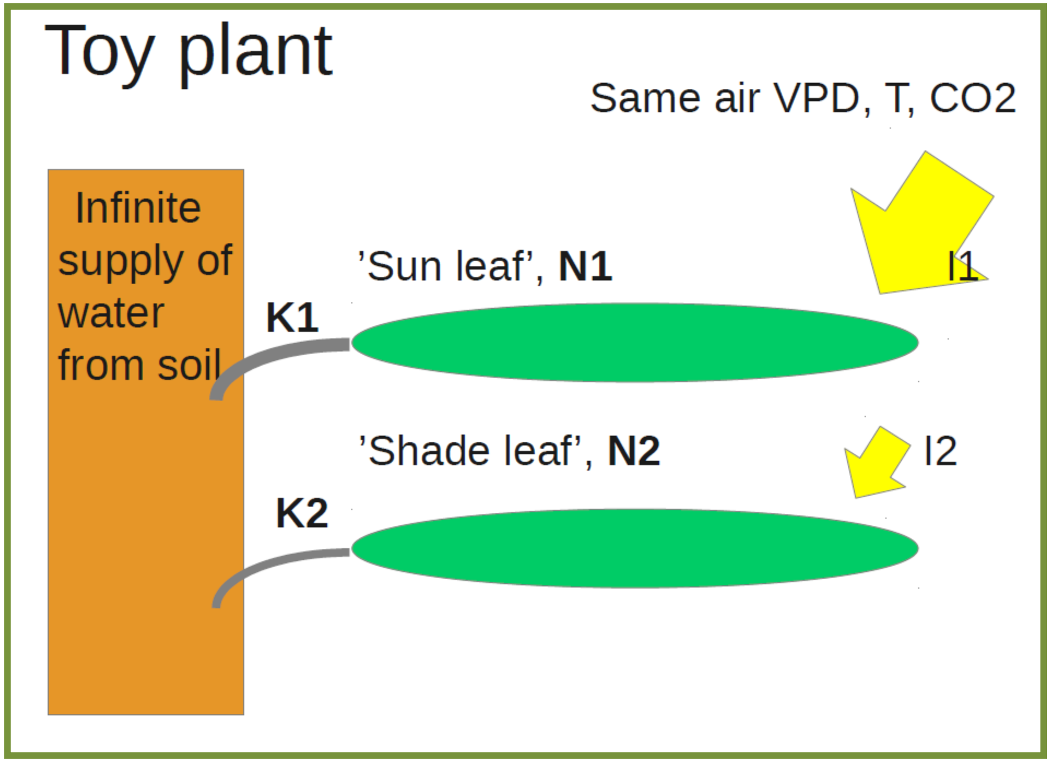
- In real plants, photosynthesis (*A*) is linked to transpiration (*E*)
  - High *A* leaves should be serviced by more water
  - Implies higher hydraulic (root to leaf) conductance (*K*)
    - High *K* is generated by allocating carbon resources to xylem growth
- We asked what explains measured flat N?
  - Can hydraulic contraints explain it?
  - What would be the co-optimal distribution of *N* and *K*?
  - How the co-optimal *N* and *K* distributions change with increasing CO_2?

MATERIALS AND METHODS

- We built a simple canopy model linking leaf-level photosynthesis to hydraulics
- In each leaf, *A* and *E* are predicted by solving 5 equation set, including
  - Farquhar model
  - g_s = *f*(leaf water potential) (Tuzet et al, 2003)
  - Hydraulic equation with soil-to-leaf conductance , *K*

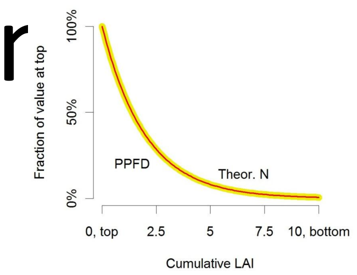
Co-optimal canopy model, *’KNopt’*

- Model has two leaves i

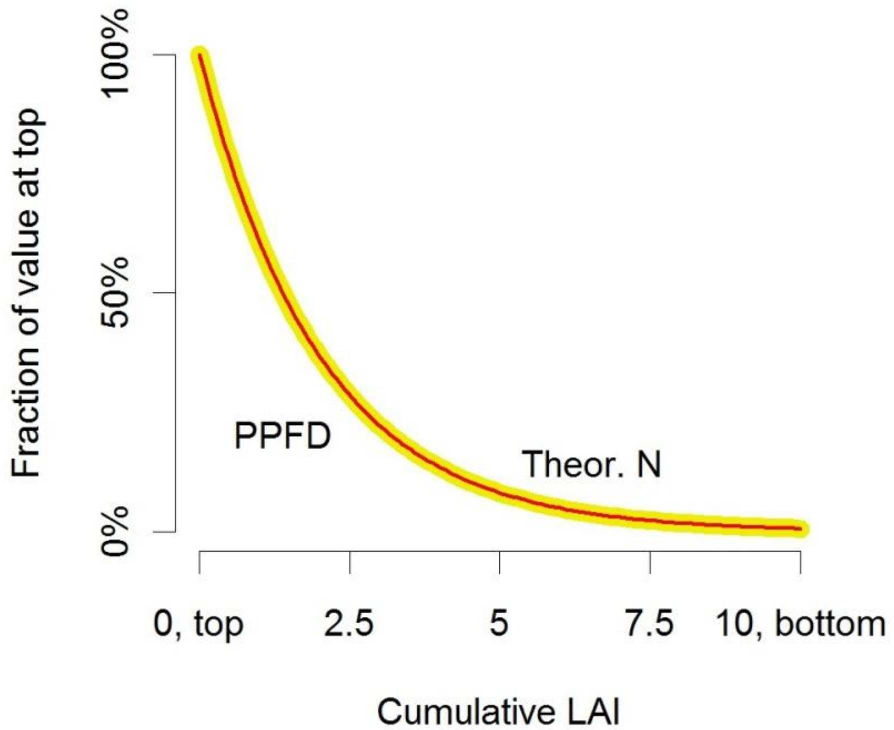


- Maximize ΣA_i of plant to get optimal K_i and N_i TOTAL *K* AND *N* CONSTRAINED.
- Full canopy solution MULTIPLE LEAF PAIRS COMPARED UNDER DIFFERENT *I*

Can hydraulic structure influer distribution in the canopy?

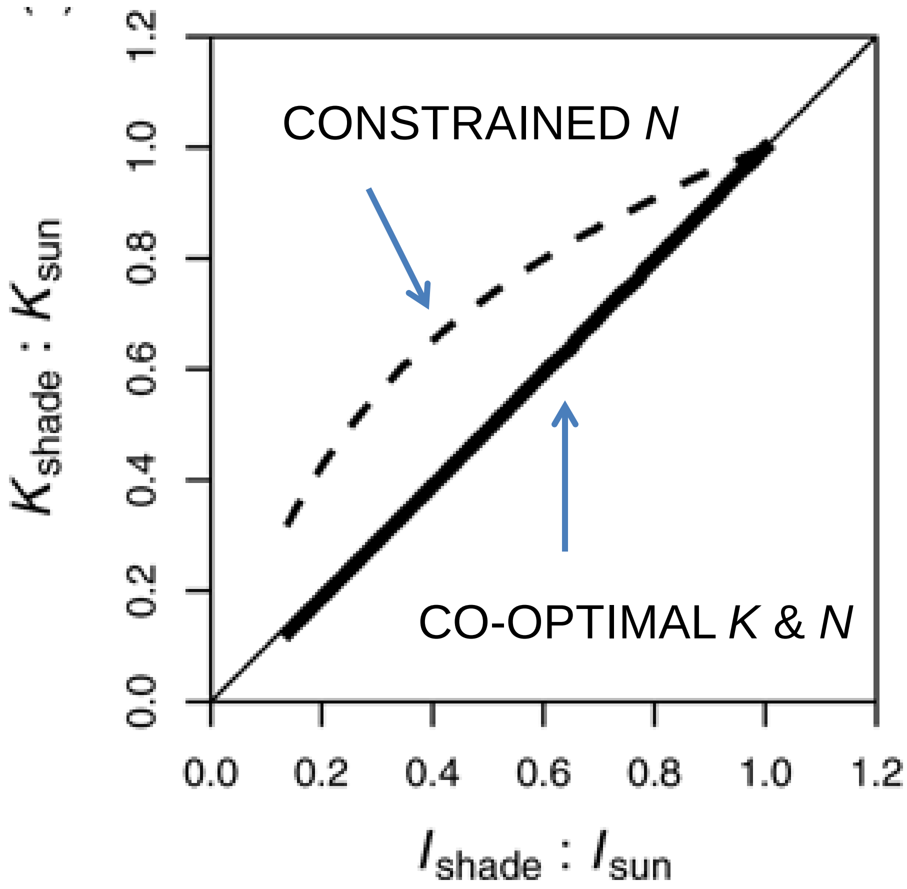


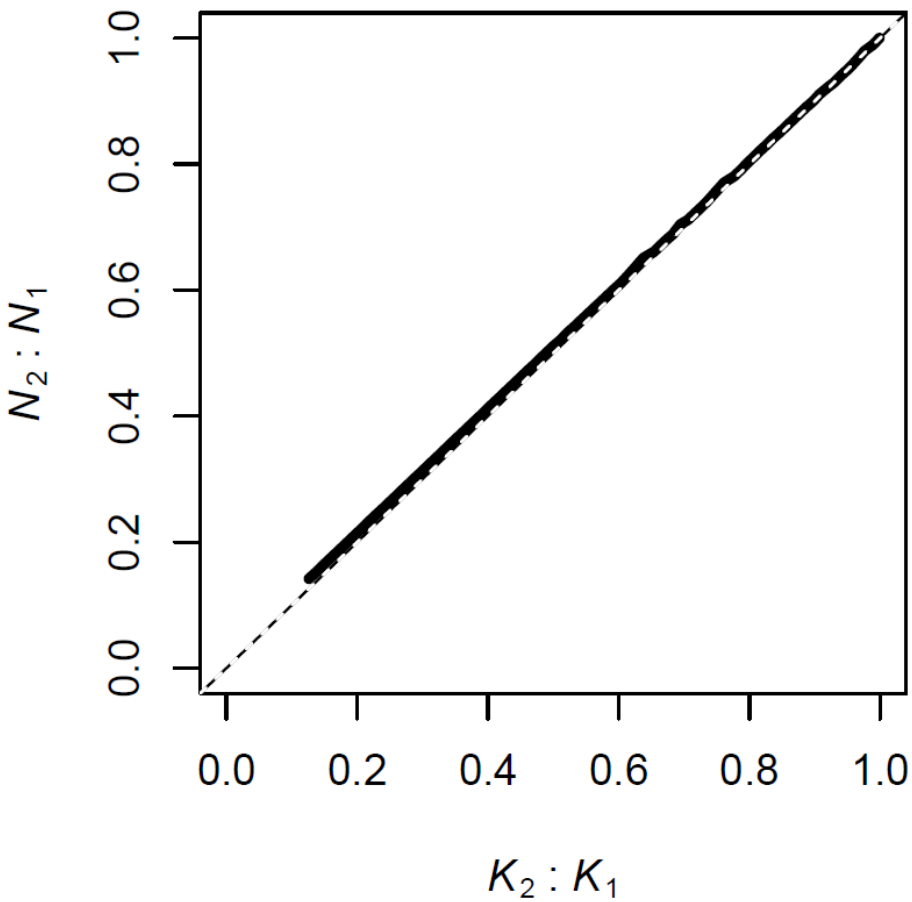
- Yes:
  - More *N* in shade if sun leaf gets too little water (*K* are equal)
  - Even more N in shade if *K* follows path-length^{-1}



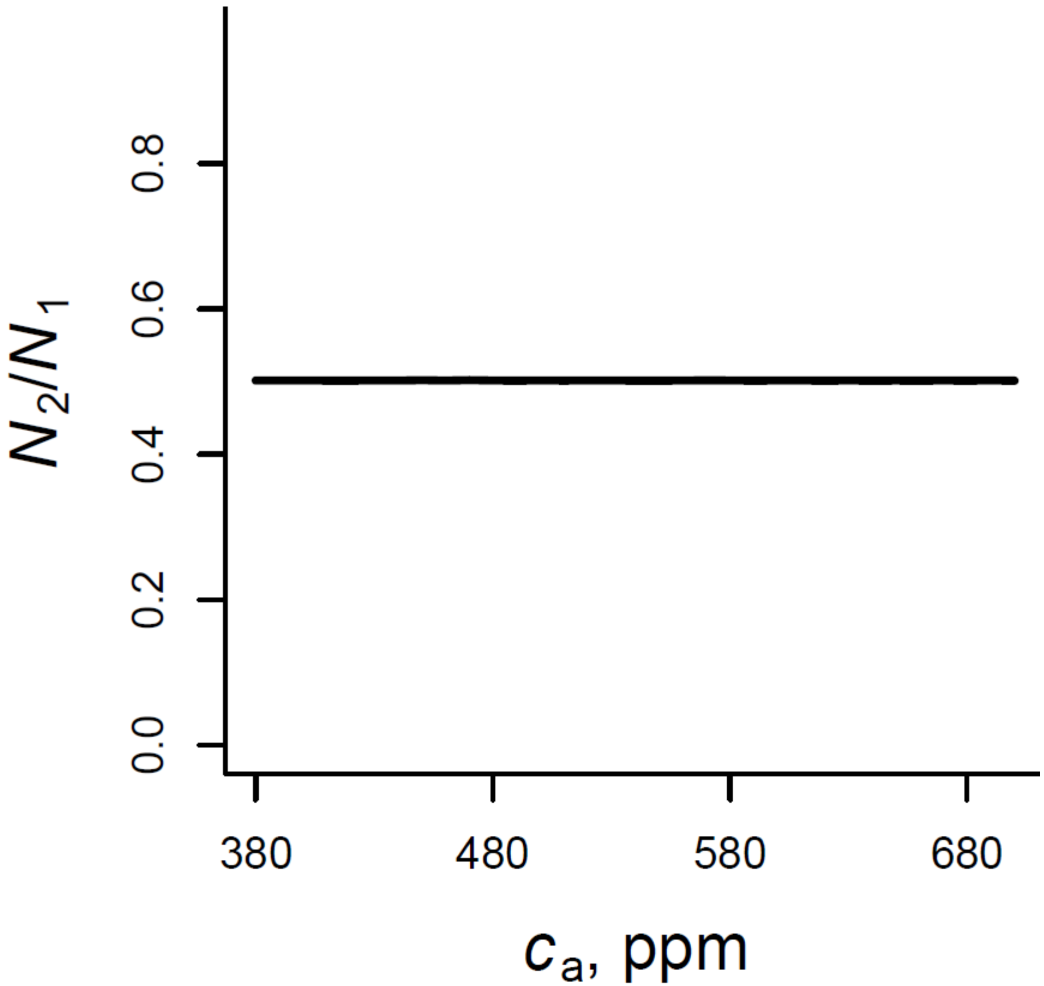
- When *N* and *K* are co-(follows light distribution

So, what is co-optimal *K*?





Effect of elevated CO_2 on co-optimal canopy structure?



Discussion

- Sub-optimal distribution of xylem conductivity influences allocation of photosynthetic resources in plant canopies
  - Provides a new explanation to flat *N* gradients in canopies
  - Total amounts of *K* and *N* irrelevant for their co-optimal allocation
  - In the co-optimal case, both *K* and *N* follow light
- Support for bigleaf-models of photosynthesis, given *K* is not constrained in plants.

Discussion

- So, are plants (co-)optimal?
  - Both higher *N* and *K* are frequently measured in sun
- In reality, there are
  - other constraints operating; e.g. growth related
  - differential costs and co-benefits in plant canopies
  - Further explanations to flat *N* can be seeked from costs and other constraints operating in a plant.
- Focus on constraints and deviations from optimum

THANKS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Research paper

Co-optimal distribution of leaf nitrogen and hydraulic conductance in plant canopies

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