Leaf traits, trade-offs and plant performance across rain forest species

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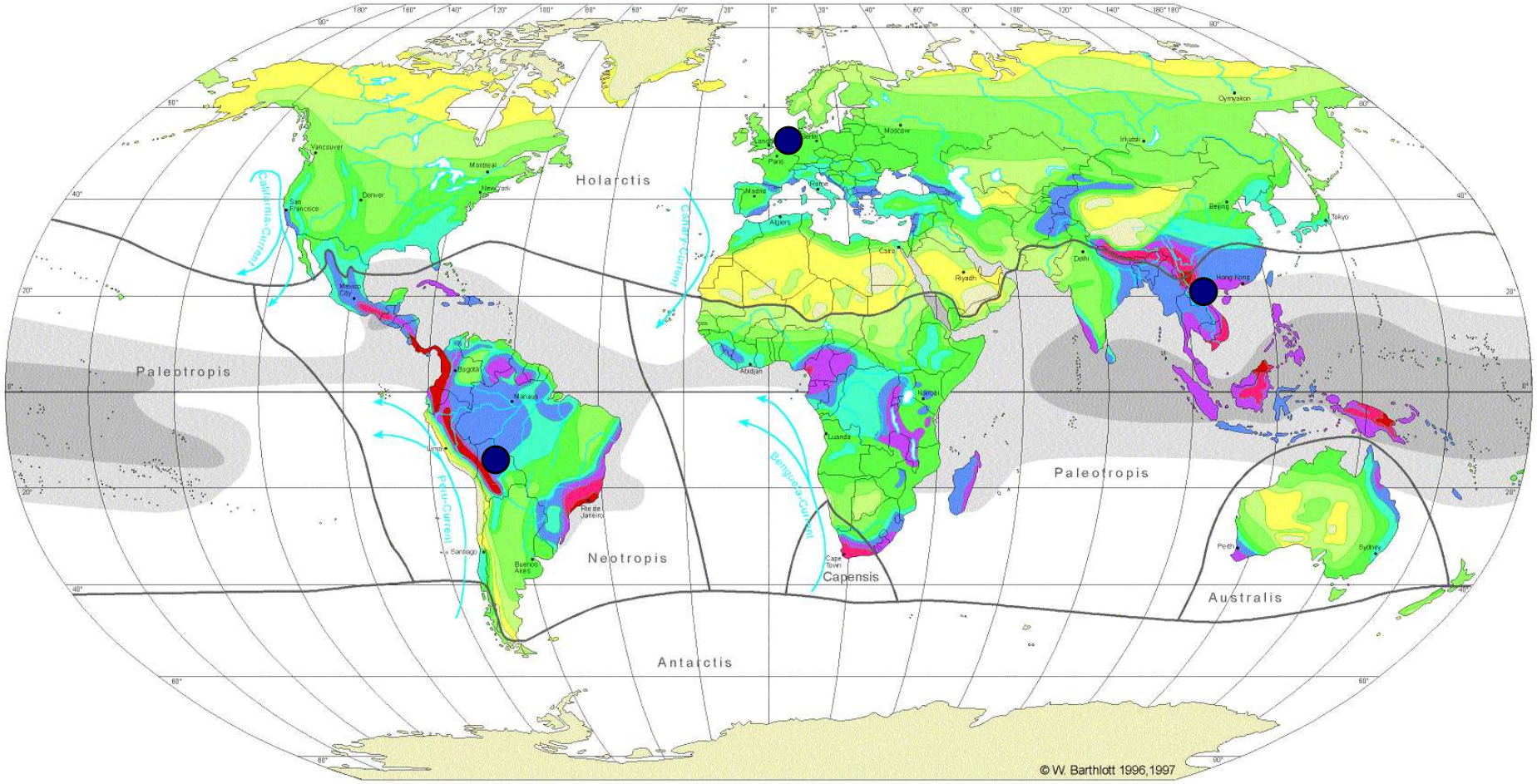
Overview ….

- How do so many species coexist in the tropics?
- Resource partitioning; the horizontal light gradient
- Mechanisms of resource partitioning; trade-offs and the carbon balance of the plant
- Leaf traits; consequences for growth and survival

High species richness in tropical forests



Diversity Zones (DZ): Number of species per 10.000km^2

DZ 1 (<100)	DZ 5 (1000 - 1500)	DZ 9 (4000 - 5000)
DZ 2 (100 - 200)	DZ 6 (1500 - 2000)	DZ 10 (≥5000)
DZ 3 (200 - 500)	DZ 7 (2000 - 3000)	
DZ 4 (500 - 1000)	DZ 8 (3000 - 4000)	

Capensis floristic regions

- Origin
- Maintenance

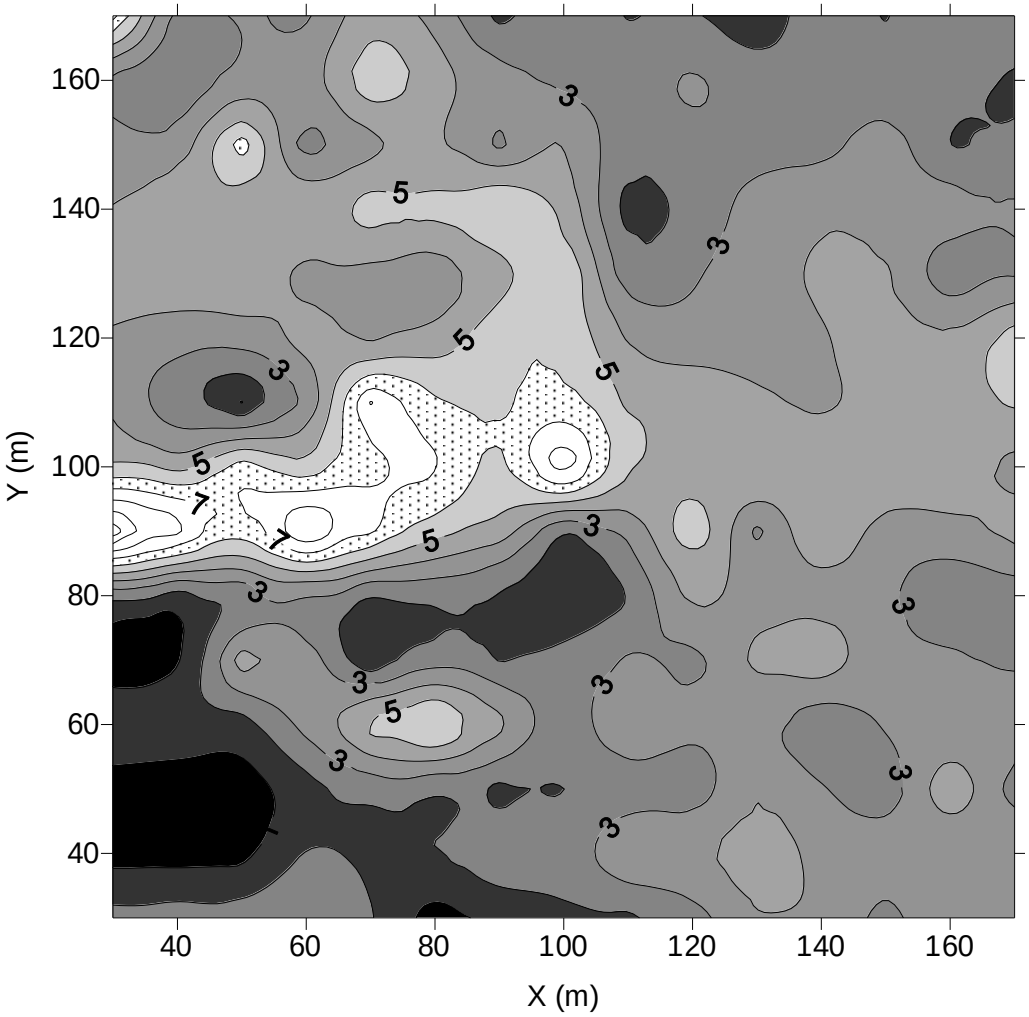
How do so many species coexist?

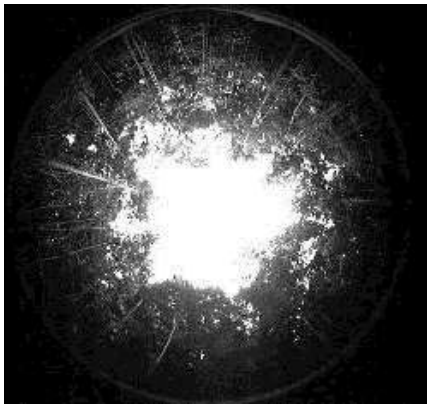
- Density-dependent mortality (Janzen 1970)
- Intermediate disturbance (Connell 1978)
- Chance (Hubbell & Foster 86)
- Recruitment limitation (Paccala & Hurt 1995)
- Niche partitioning (MacArthur 1969)

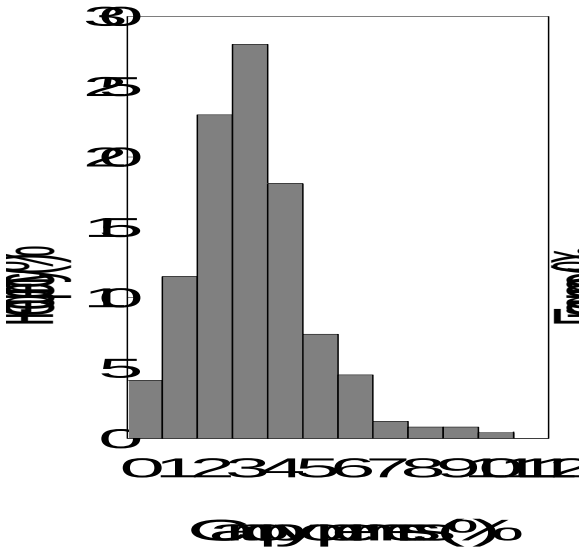
Resource partitioning: three conditions

1. Spatial or temporal gradients in resources
2. Species compete for limiting resources
3. Species is most abundant where it is the best competitor

Horizontal gradient

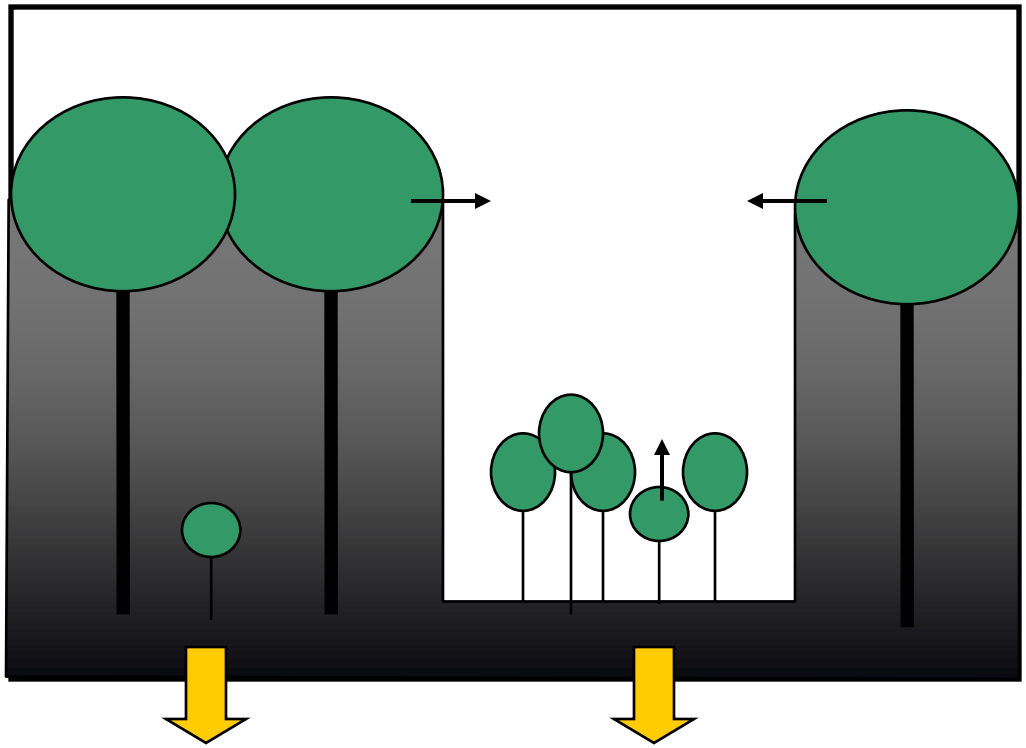






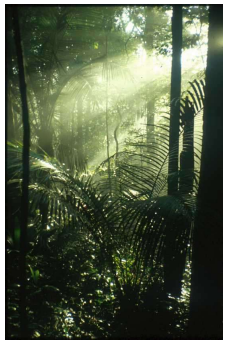
Poorter & Arets (2003)

Coexistence along the horizontal light gradient: two regeneration strategies



shade tolerant spp in understorey
↓
predictable low irradiance
↓
high survival important

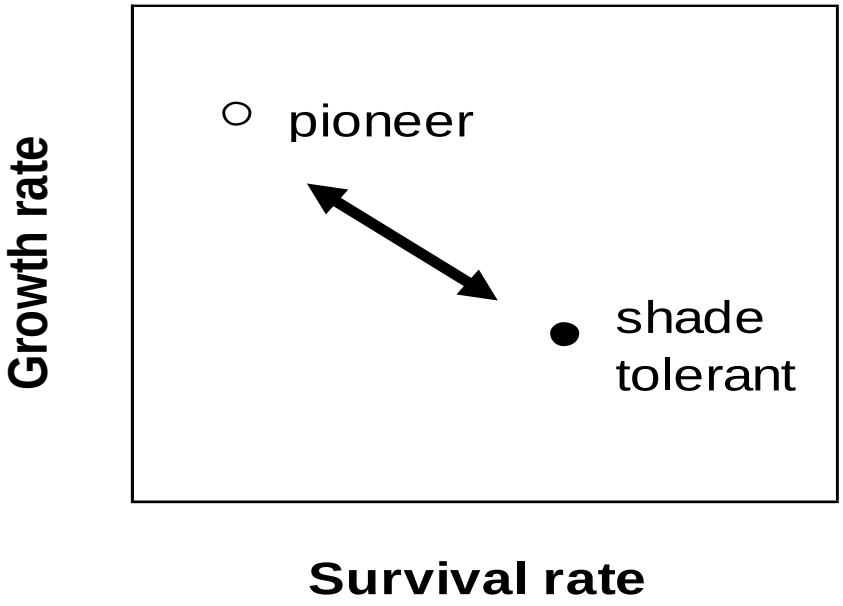
pioneer spp in gaps
↓
ephemeral high irradiance
↓
high growth important



Trade-offs explaining coexistence along the horizontal light gradient

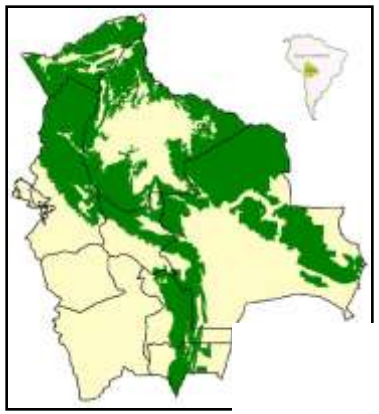
- between traits

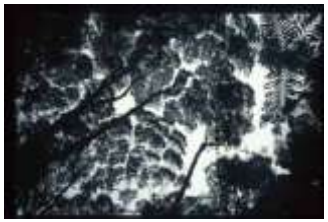
r-K (MacArthur & Wilson 1967)

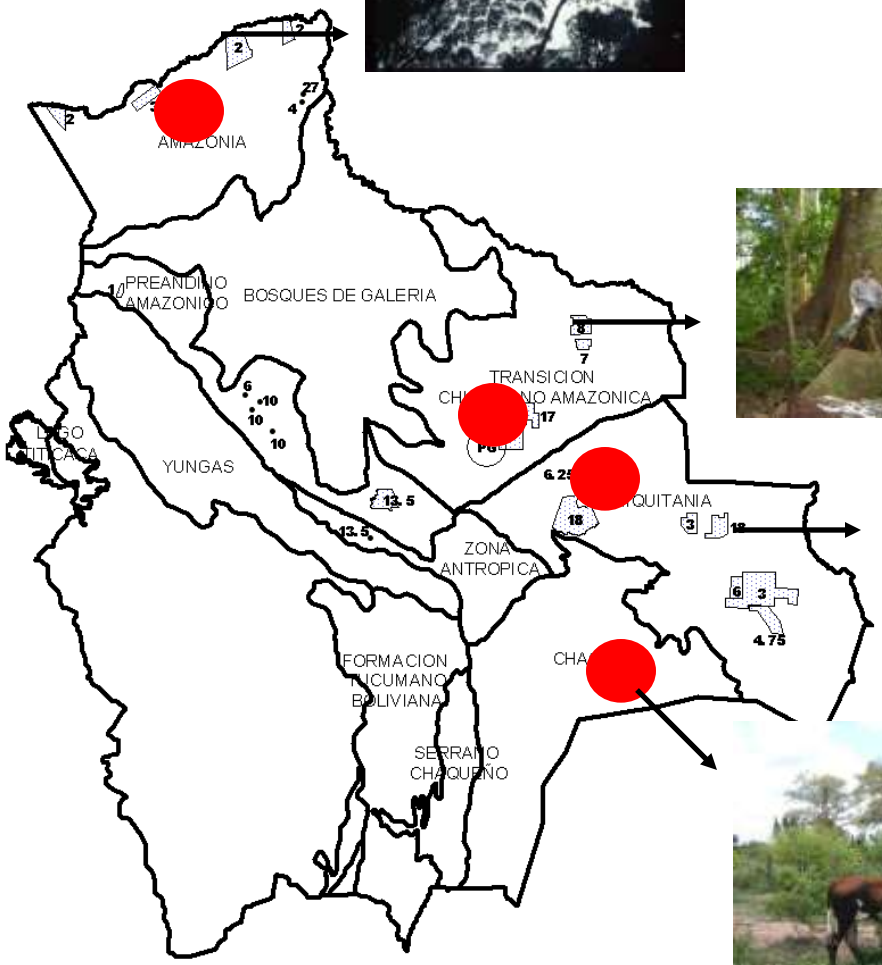


Kitajima & Poorter (in press)

A case study; Bolivia
4 ecoregions, 4 sites



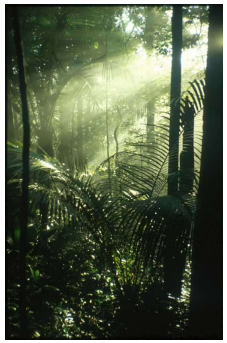




La Chonta

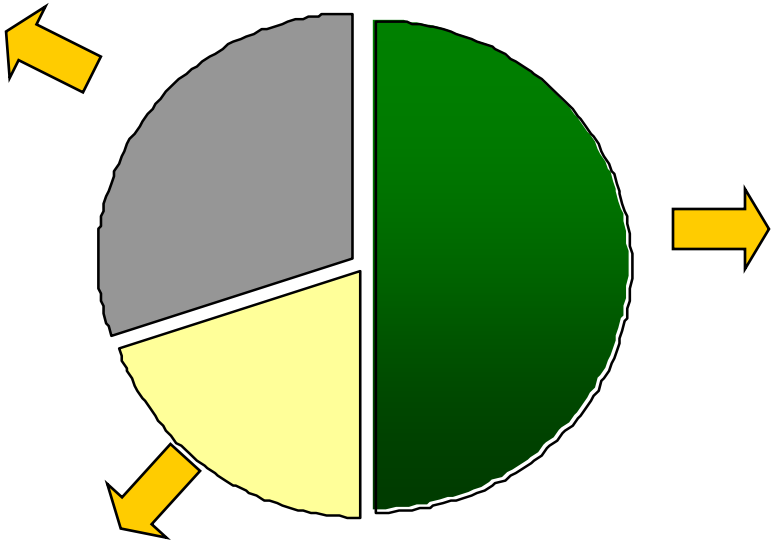
Research approach

- 59 species differing in shade tolerance and max.height
- represent 86% of the stems
- 312 ha permanent sample plots IBIF
- screen 20+ functional traits
- experiments and field measurements



You can not have it all; carbon-based trade-off

defense

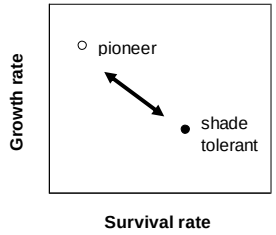


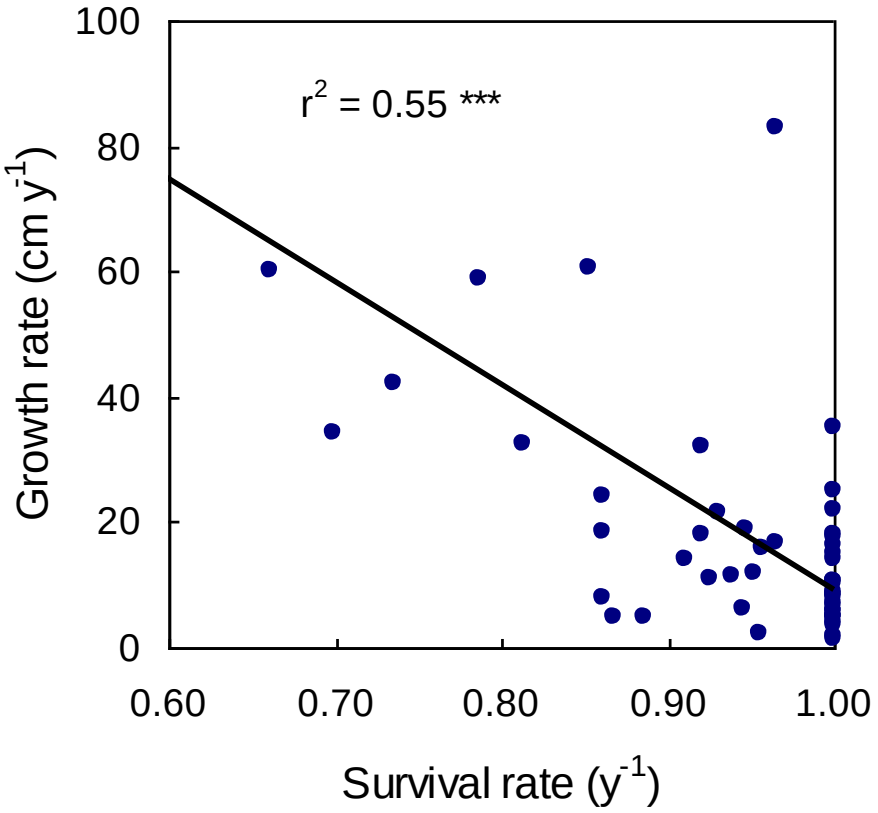
growth

reserves (starch)

Kitajima (1996)

Between-trait trade off?



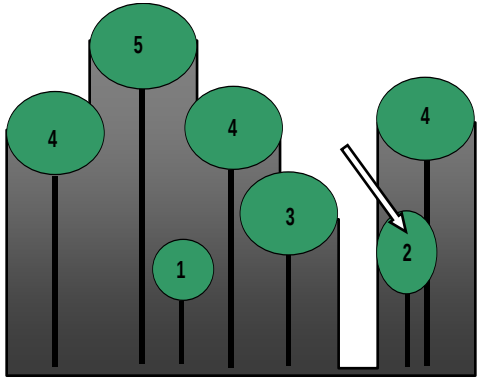


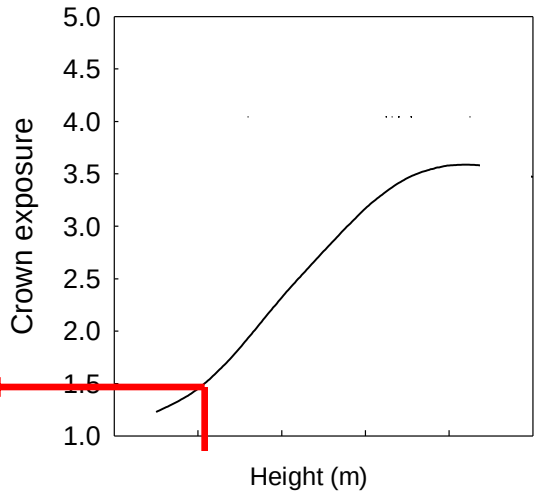
Between-trait trade offs may explain coexistence

Poorter & Bongers (2006) Ecology

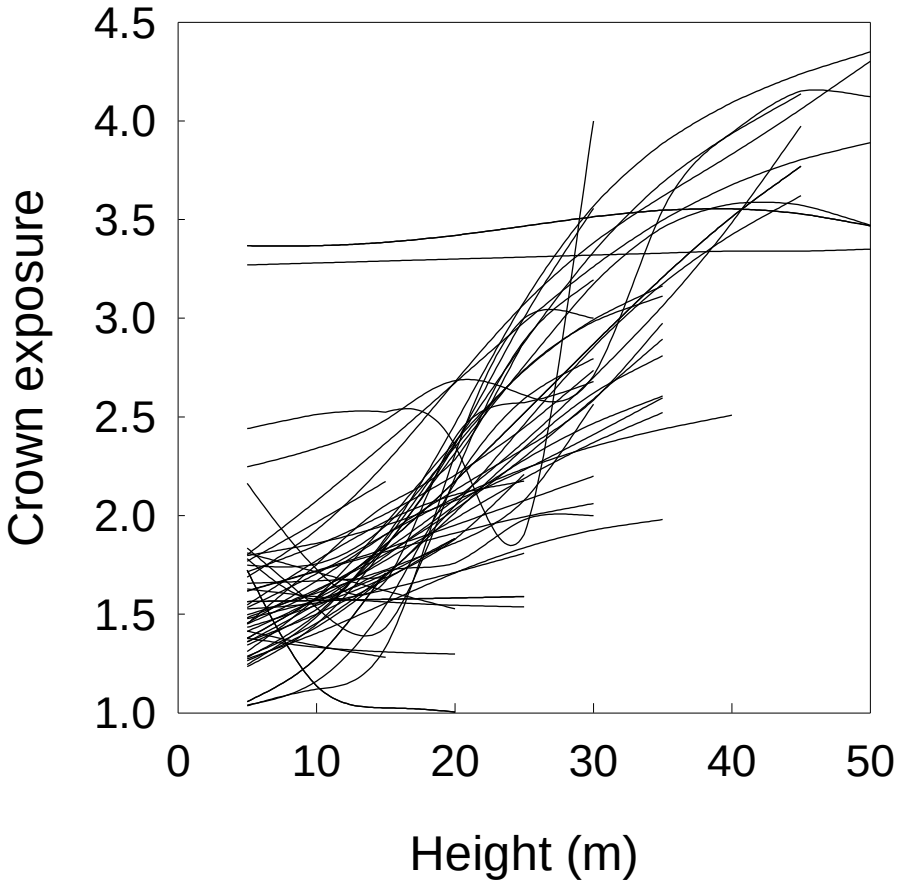
How to quantify the light requirements?

Crown Exposure



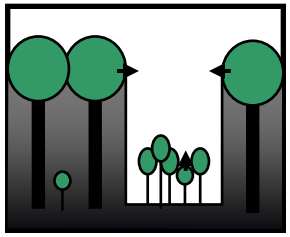


juvenile CE

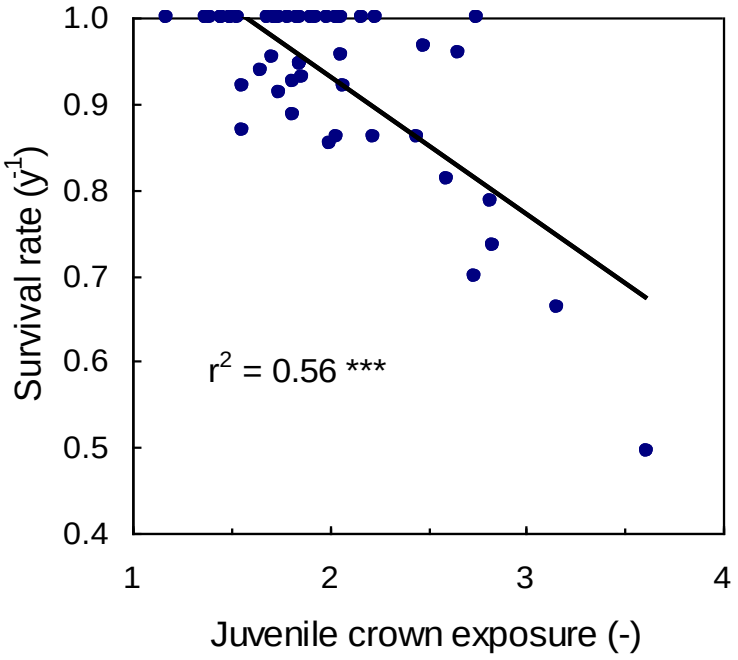


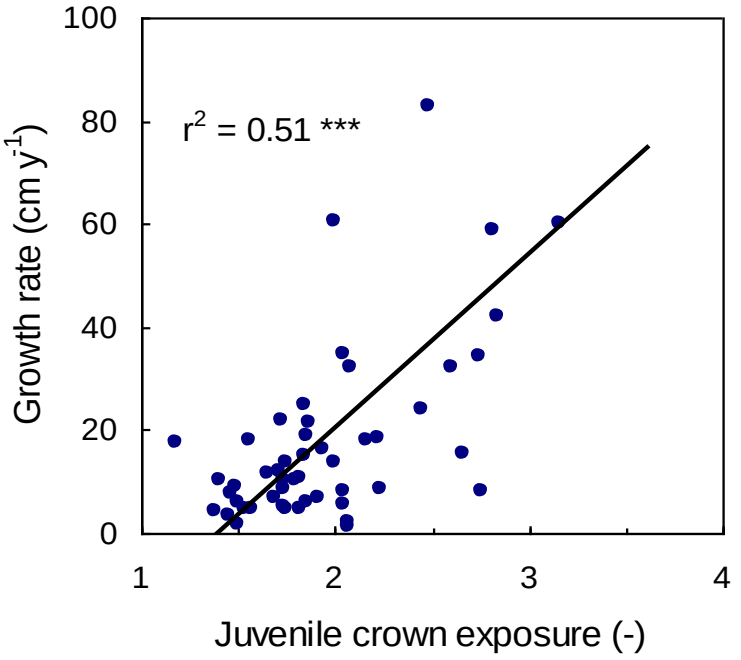
Sheil et al. (2006) J of Ecology

Poorter et al. (2005) J of Ecology



Growth-survival trade-off determines the light niche





For shade tolerants survival is important

For pioneers growth is important

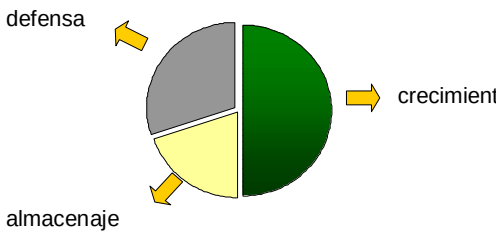
Poorter & Bongers (2006) Ecology

What underlies the growth-survival trade-off?

A still hopeful
Urera caracasana
pioneer tree

Are leaf traits related to species light requirements?

Resource economy: on being fast and slow



Gaps: high resource availability and fast height growth rates

→ Short leaf lifespan

→ Cheap construction costs

→ High assimilation rates

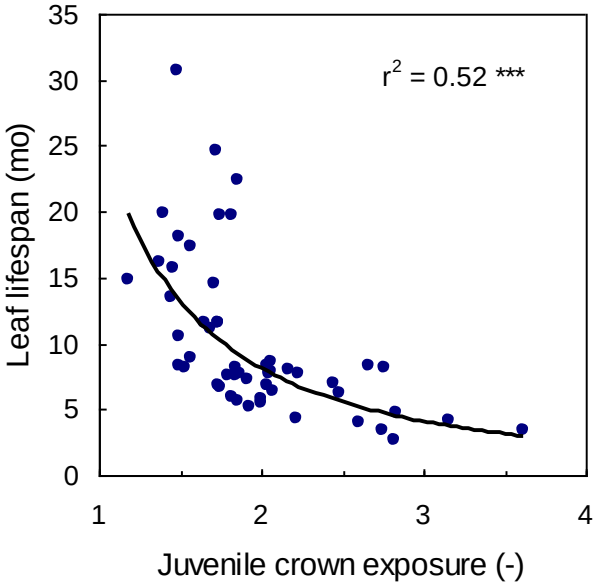
Understory: low resource availability → long time to recuperate investments

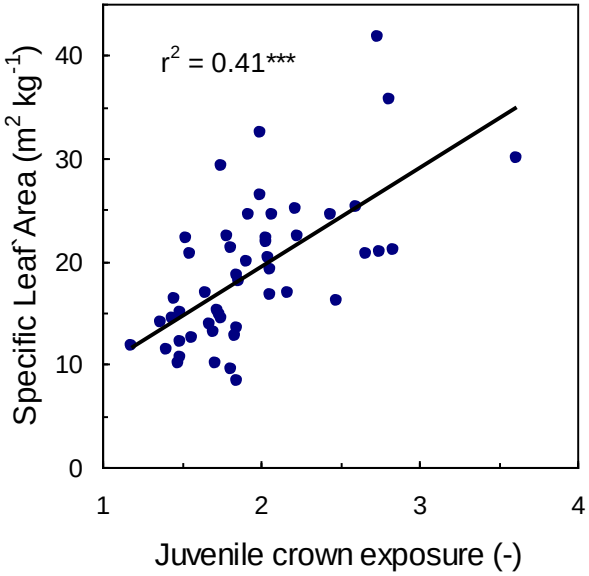
→ Long-lived leaves

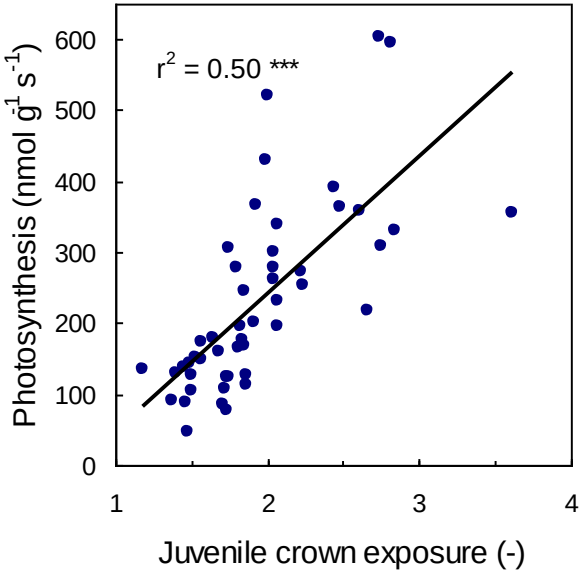
→ Tough leaves

→ Low respiration rates

slow vs. fast



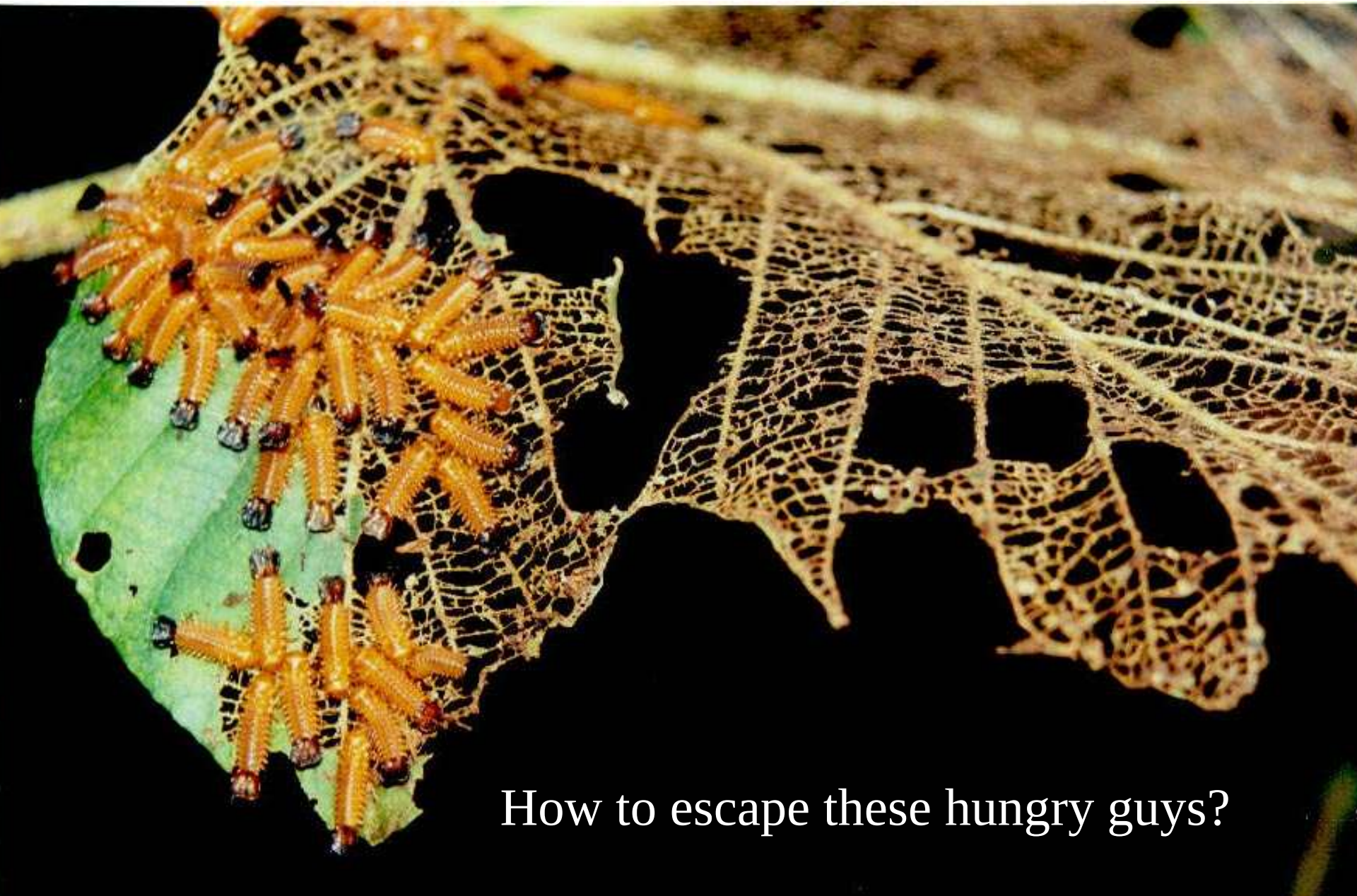




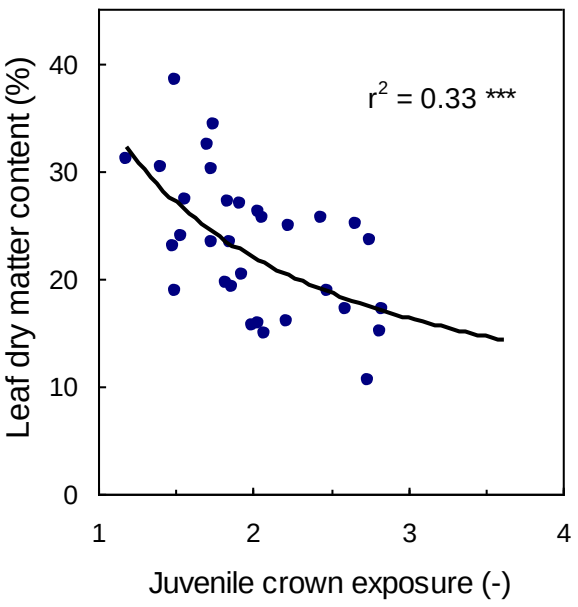
Light demanding species have short-lived, cheap, and productive leaves

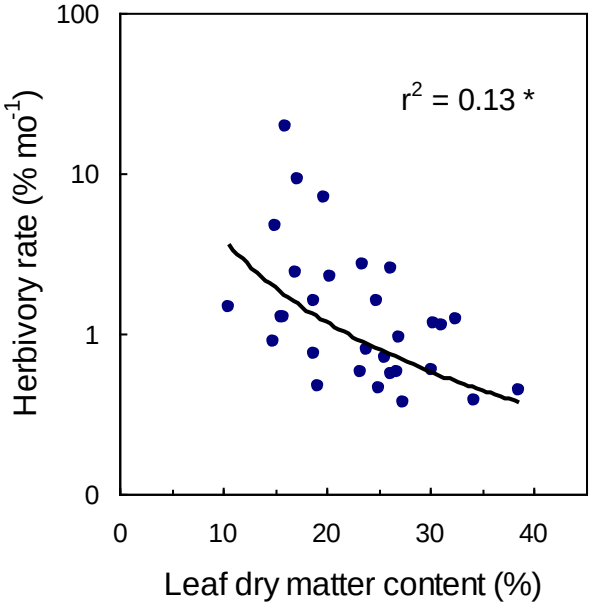
Poorter & Bongers (2006) Ecology

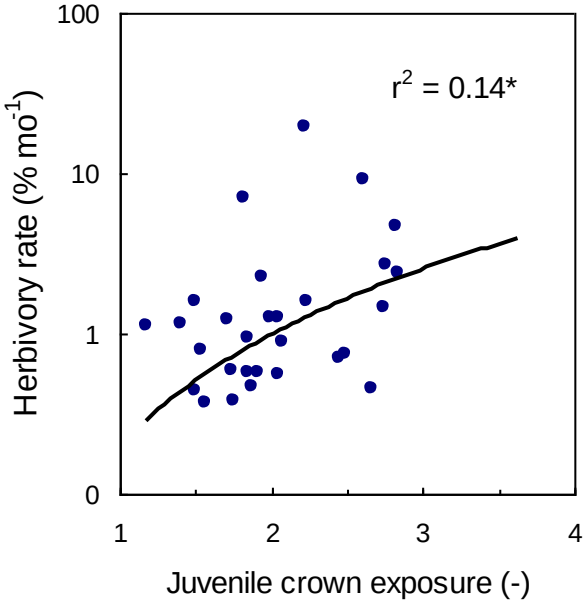
On being a long-lived leaf…



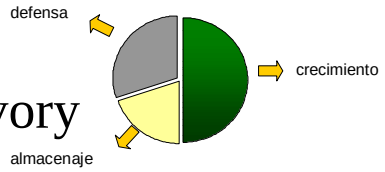
Are leaves of shade-tolerants tougher? And is it of any help?





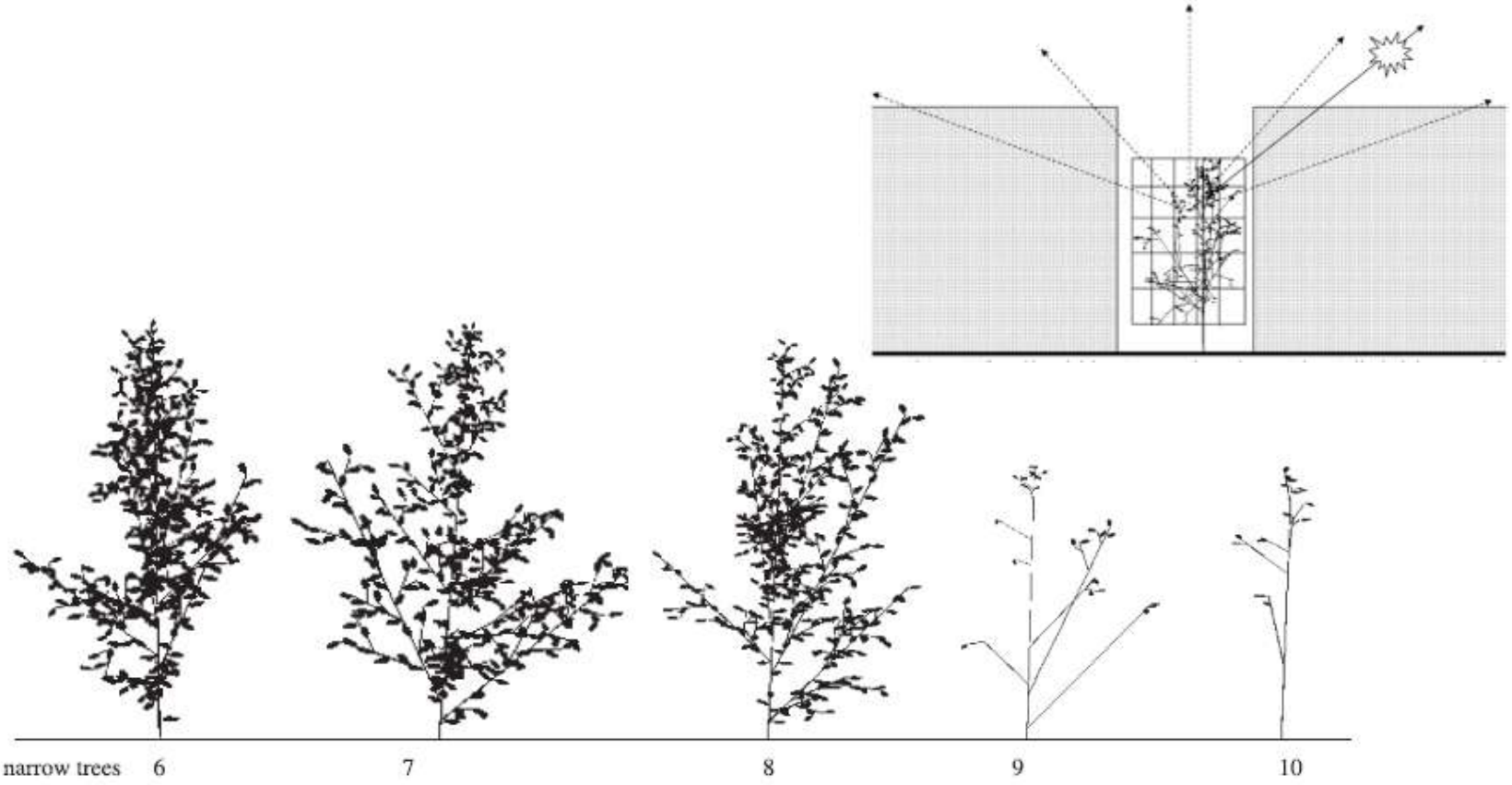


Shade-tolerant species have tough leaves and suffer little herbivory



Diego (2005) Tesis UAGRM

Do leaf trade-offs underlay the growth-survival trade-off?

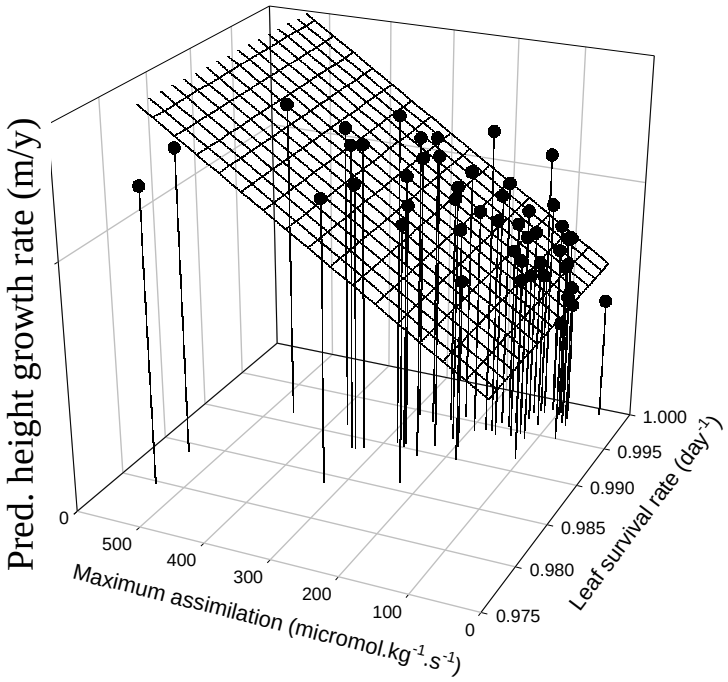


Sterck, Poorter & Schieving (2006)

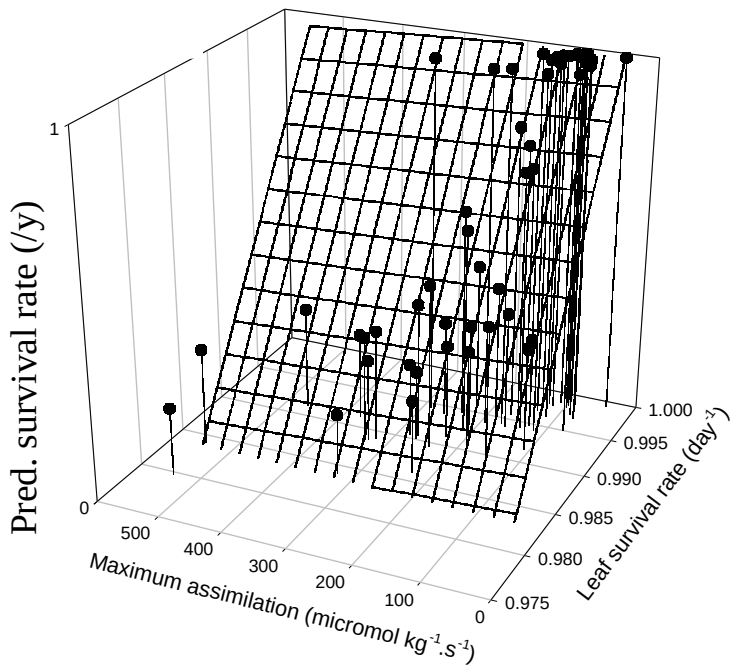
the American Naturalist

What do virtual plants do with real traits?

gap



understory

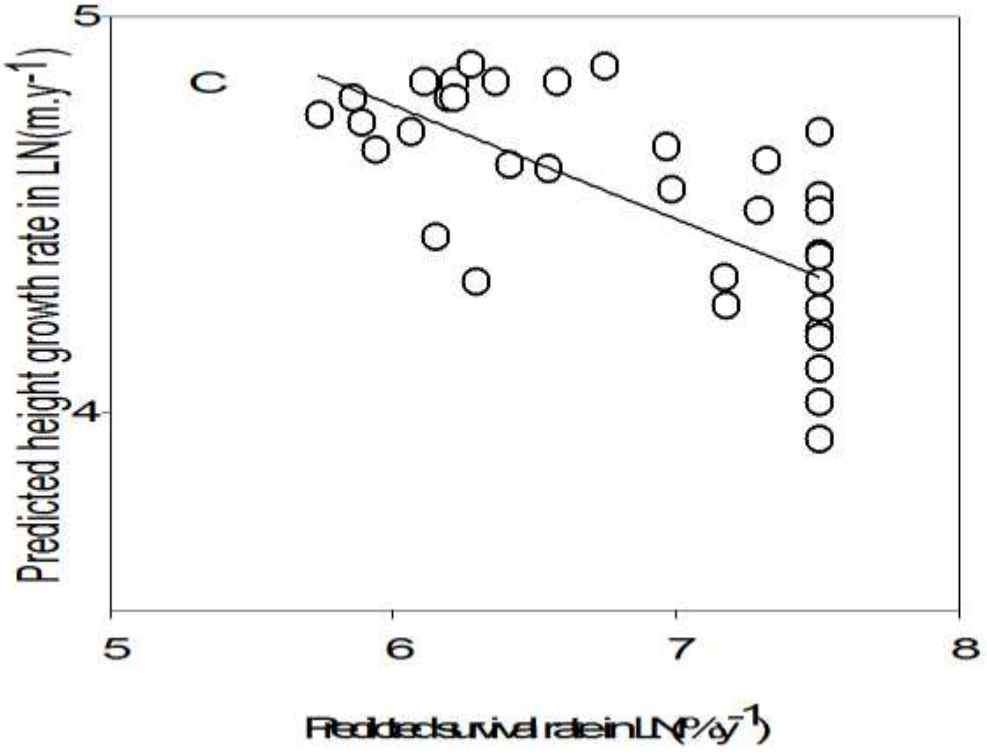


Height growth rate in gaps is determined by a high assimilation rate
Survival rate in the understory is determined by a high leaf lifespan

Sterck, Poorter & Schieving (2006)

the American Naturalist

Do virtual plants suffer from real-life problems?



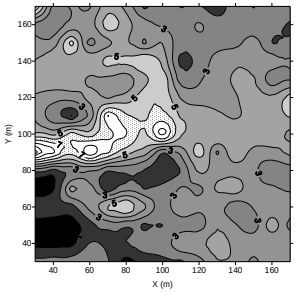
Leaf traits alone explain the growth-survival trade-off

Sterck, Poorter & Schieving (2006)

the American Naturalist

Conclusions

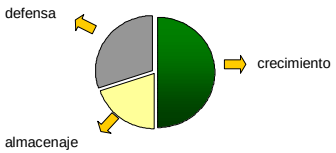
- The three conditions for resource partitioning are met→ niches contribute to the maintenance of a high species richness



- Species partition the horizontal light gradient

- Trade-off between growth and survival explains species coexistence along the light gradient

- Resource economy underlies the growth-survival trade-off



Thanks to ...

Serebo

Momoqui

Negrillo tropero

Tajibo cabeza de mono

And all the others who suffered in the experiments……

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Juan Carlos Licona
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