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OP Vzdělávání
pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

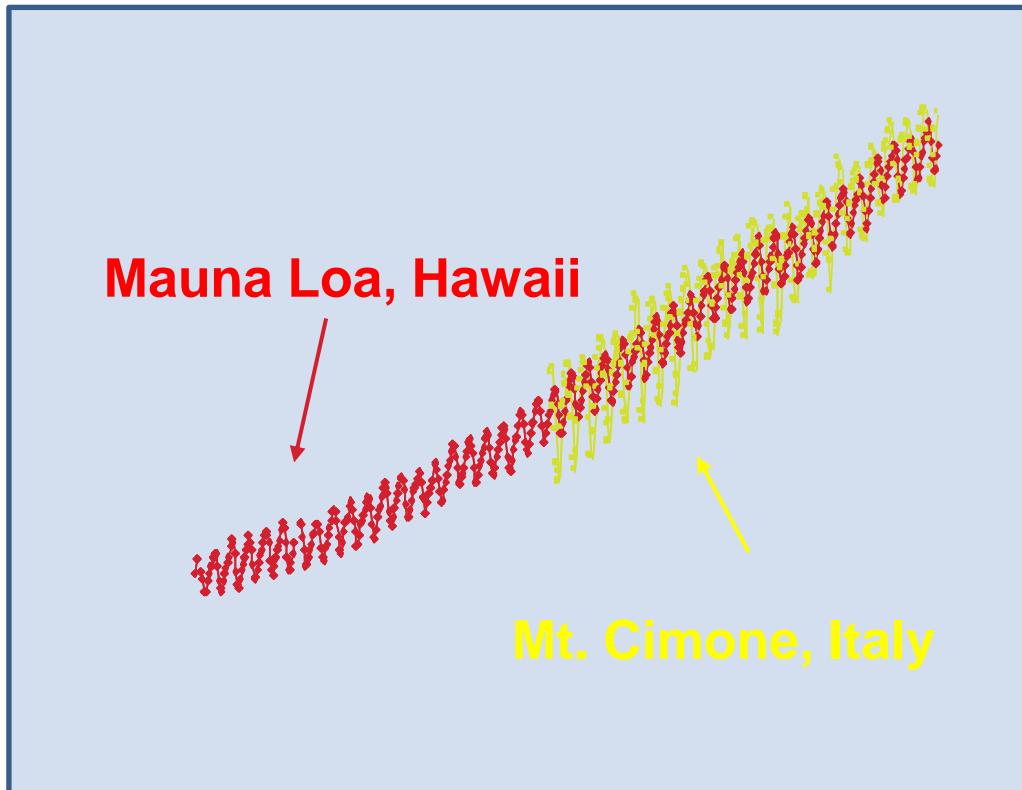
Effects of elevated CO₂ and air pollutants on plants

Carlo Calfapietra

Tato akce se koná v rámci projektu:

Vybudování vědeckého týmu environmentální metabolomiky a ekofyziologie a jeho zapojení do mezinárodních sítí (ENVIMET; r.č. **CZ.1.07/2.3.00/20.0246**) realizovaného v rámci Operačního programu Vzdělávání pro konkurenceschopnost.

Increasing atmospheric [CO₂]



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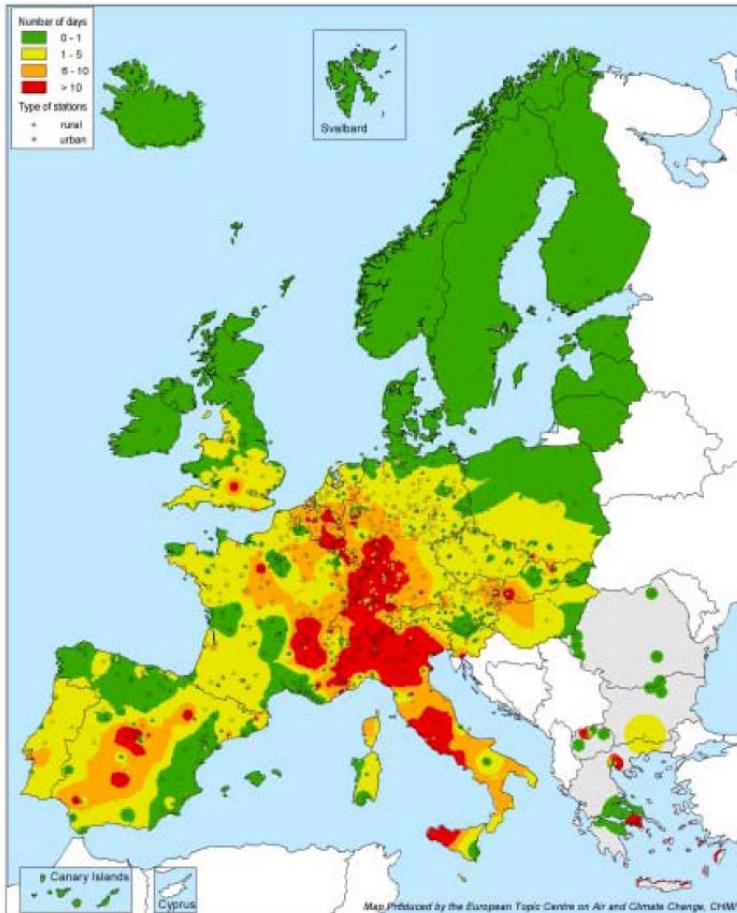


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Tropospheric O₃



Number of days when concentration exceeded the threshold value for information of the public (1-hour ozone concentration $> 180 \mu\text{g}/\text{m}^3$) in 2003 (April–August)

European Environment Agency, 2003



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Evidence of global warming ☺



Manipulative experiments

- Need to design manipulative experiments appropriate for the scientific questions being



- **seedlings/tree scale studies**



**forest stand and
ecosystem scale studies**

Natural springs



Open-Top Chamber (OTC)



Free Air Enrichment System (FACE)



FACEs

- large scale facility
- studies conducted at ecosystem level
- does not perturb the climatic and soil conditions
- allows a real multidisciplinary and holistic approach

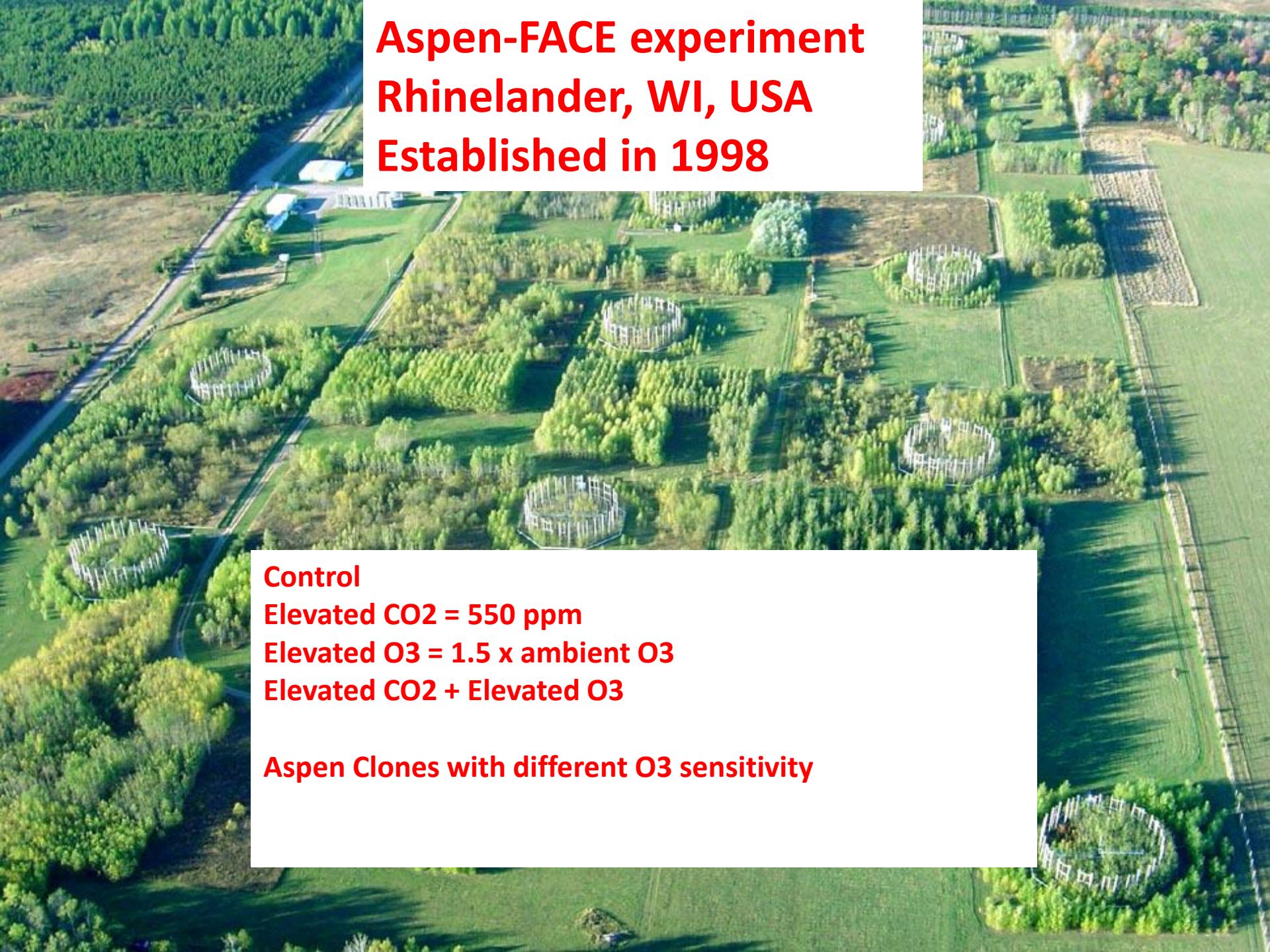


POPFACE EXPERIMENT

Tuscania (VT), Italy



September 1999



Aspen-FACE experiment

Rhineland, WI, USA

Established in 1998

Control

Elevated CO₂ = 550 ppm

Elevated O₃ = 1.5 x ambient O₃

Elevated CO₂ + Elevated O₃

Aspen Clones with different O₃ sensitivity

Key FACE experiments

- DukeFACE Orange County, NC, USA
 - Ambient + 200ppm, Loblolly pine forest, established 1996
- Aspen FACE Rhinelander, WI, USA
 - Ambient + 200ppm, Aspen plantation, established 1998
- Oak Ridge FACE Roane County, TN, USA
 - Ambient + 200ppm, Sweetgum plantation, established 1998
- Nevada Desert, Mojave Desert, NV, USA
 - 550ppm, Desert ecosystem, established 1997
- - POP/EUROFACE Viterbo, Italy
 - Ambient + 200ppm, Poplar plantation, established 1999
- Biosphere 2, Oracle, AZ, USA
 - 400-800-1200ppm, Poplar plantation, established 2000
- Basel Web-FACE, Basel, Switzerland
 - 530ppm, Mixed broadleaf forest, established 2000
- BANGORFACE Abergwyngregyn, UK
 - 580ppm, Beech, birch and alder plantation, established 2005



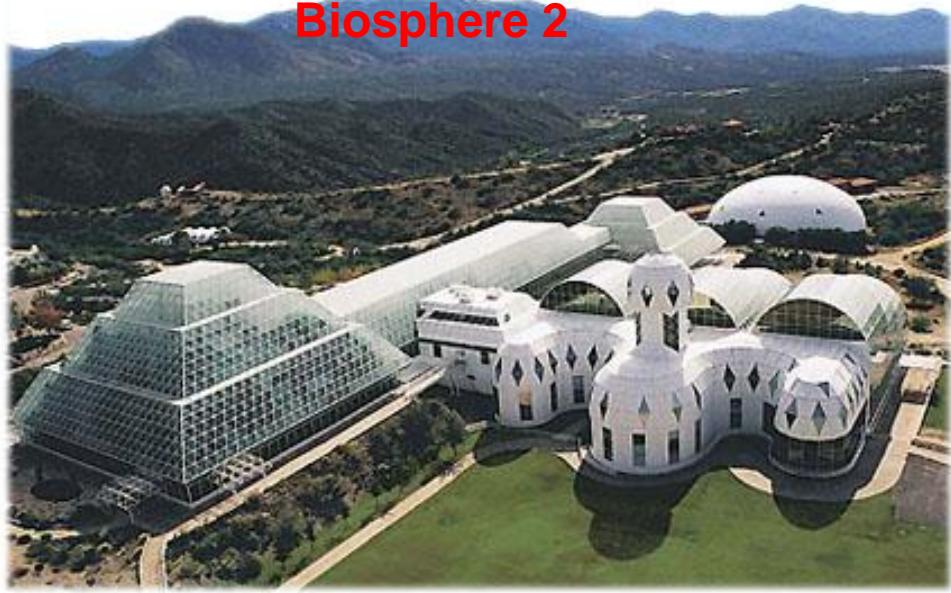
Duke



Oakridge



Biosphere 2



Basel Web-FACE



Nevada desert FACE

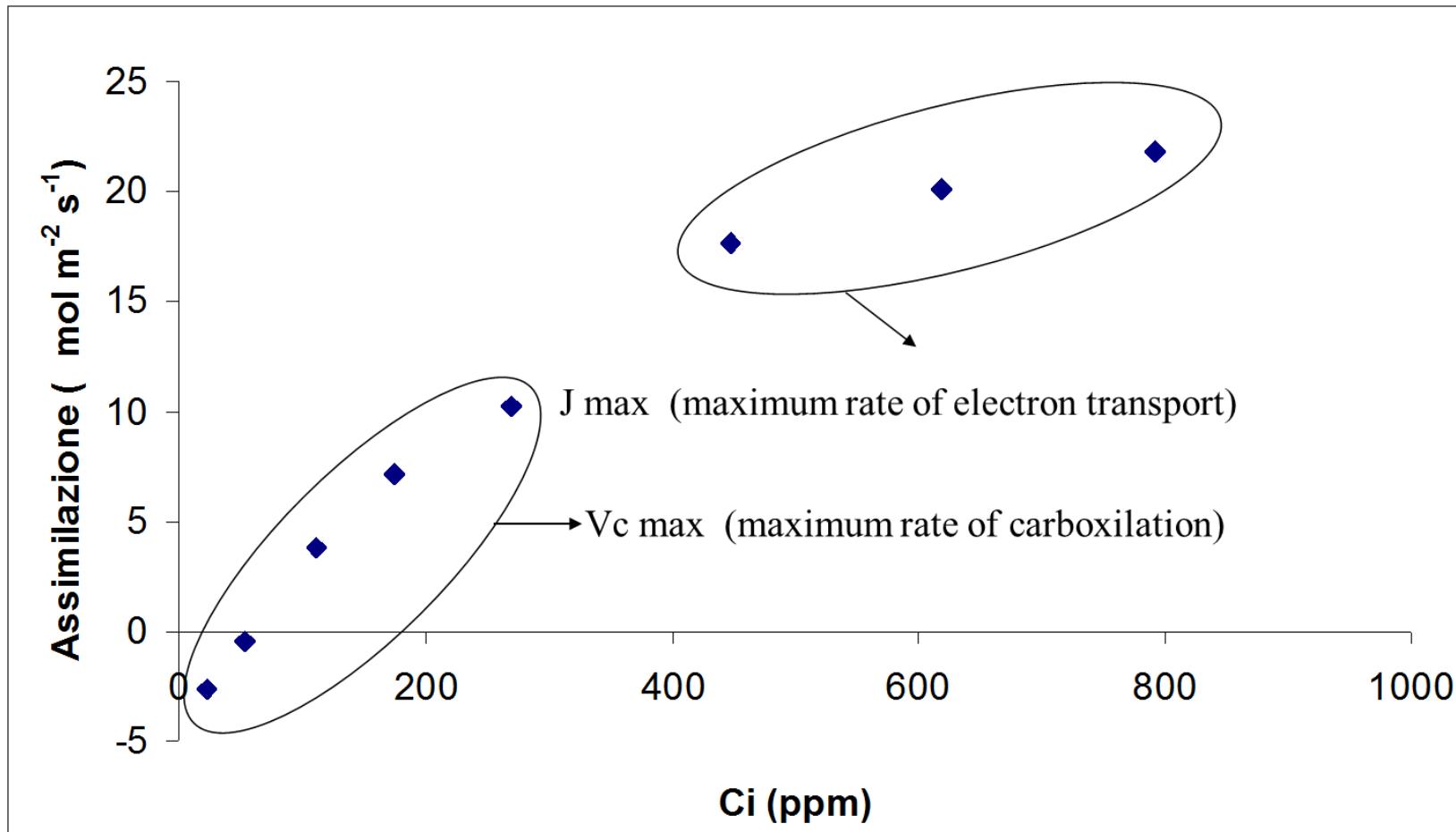


POP/EUROFACE

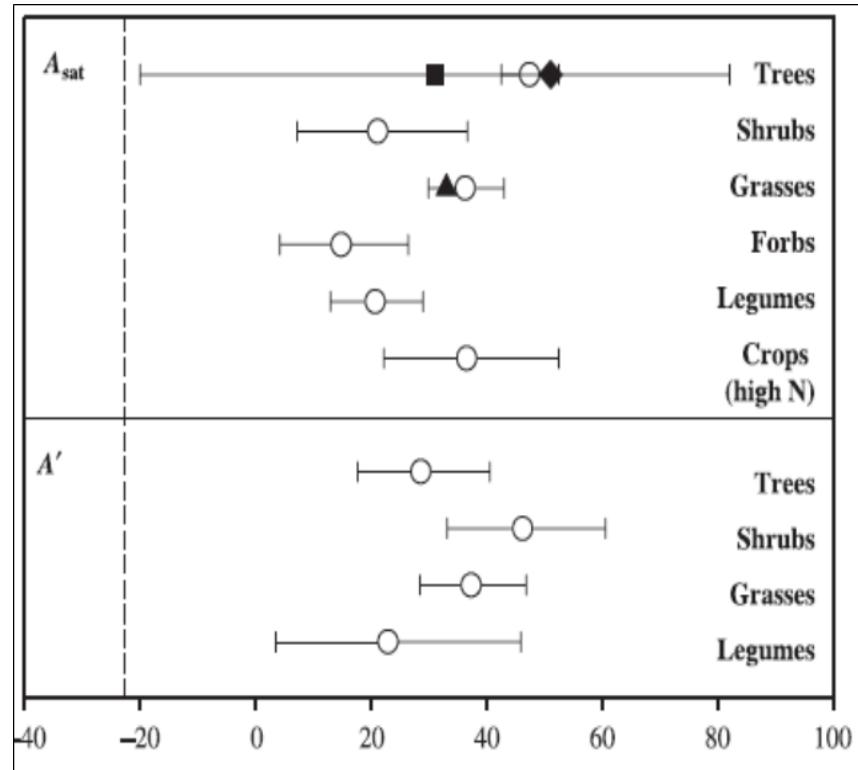
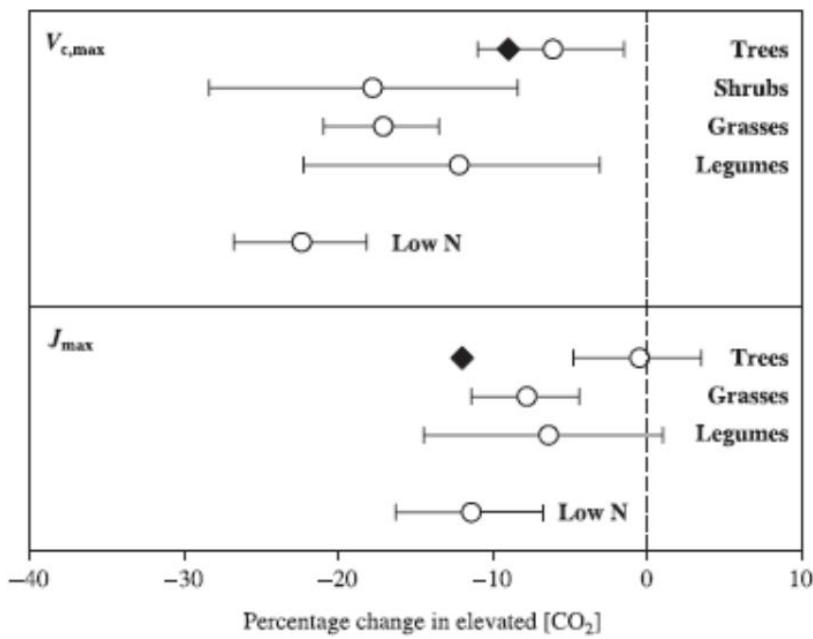


photo by Stephen Bunn

CO_2 effect on photosynthesis



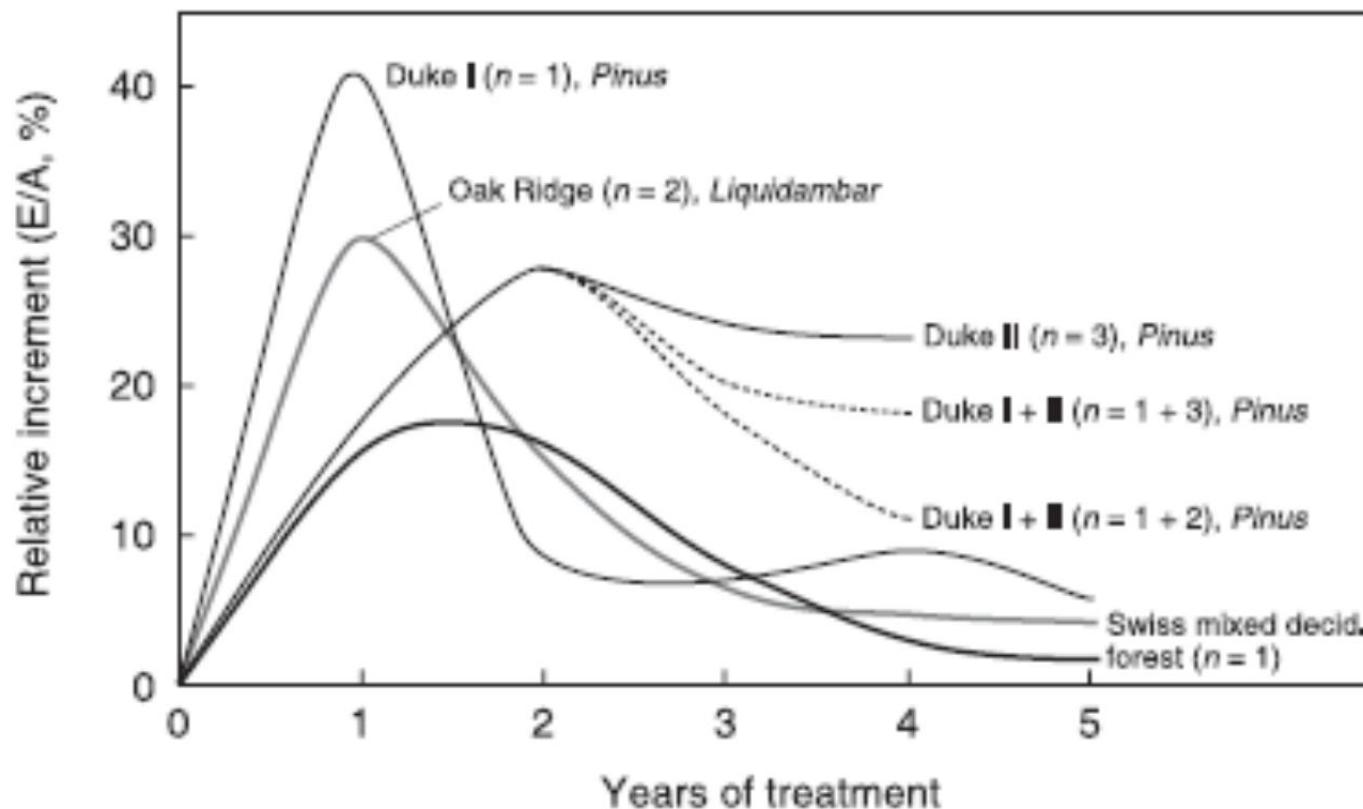
Species variations



Sink strength of trees allows greater CO_2 stimulation comparing to grasses or crops and less “down-regulation”

(Ainsworth & Long 2005)

An effect of time

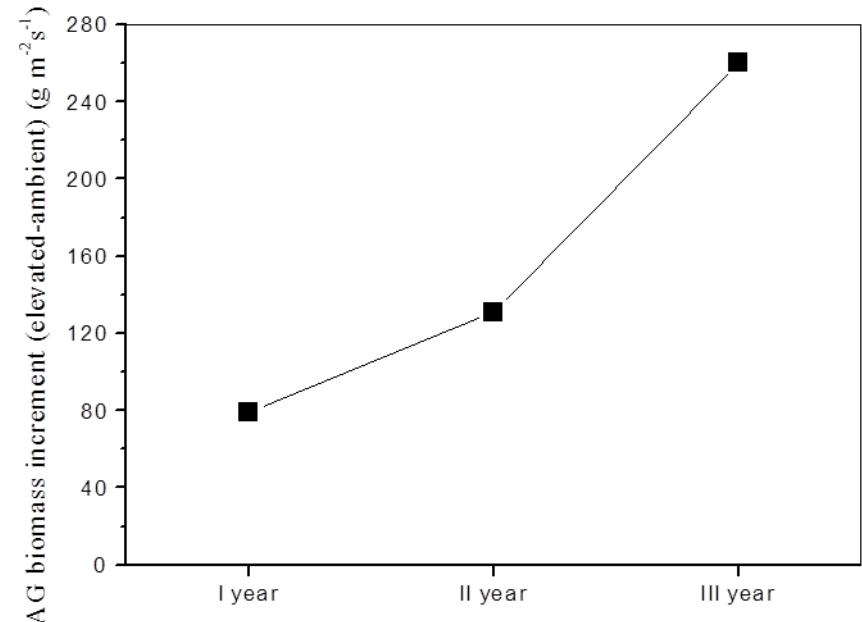
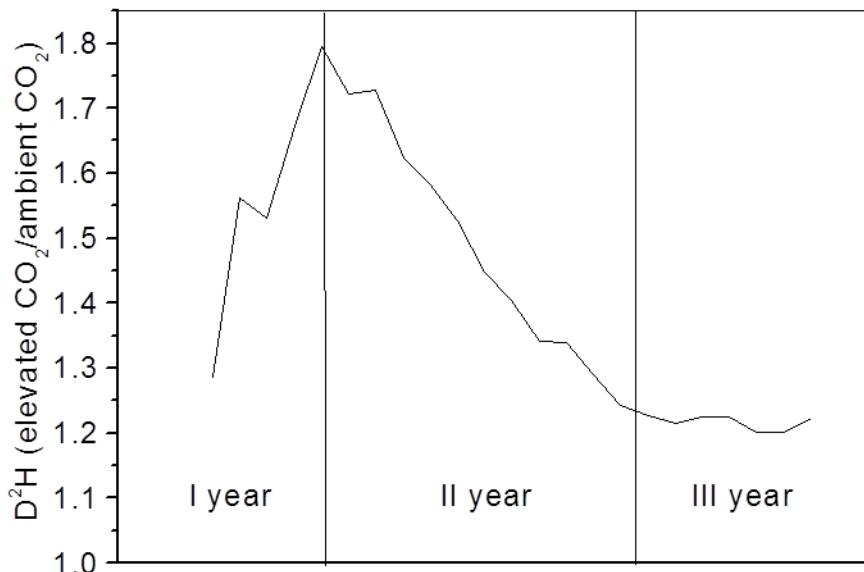


The stimulatory effect of elevated CO₂ decreases with time as competition increases and the sink strength decreases

(Körner et al. 2006)

Relative vs. absolute increments

absolute C-sequestration keeps growing under elevated CO₂



(Calfapietra et al. 2003a, 2003b; Gielen et al. 2005)



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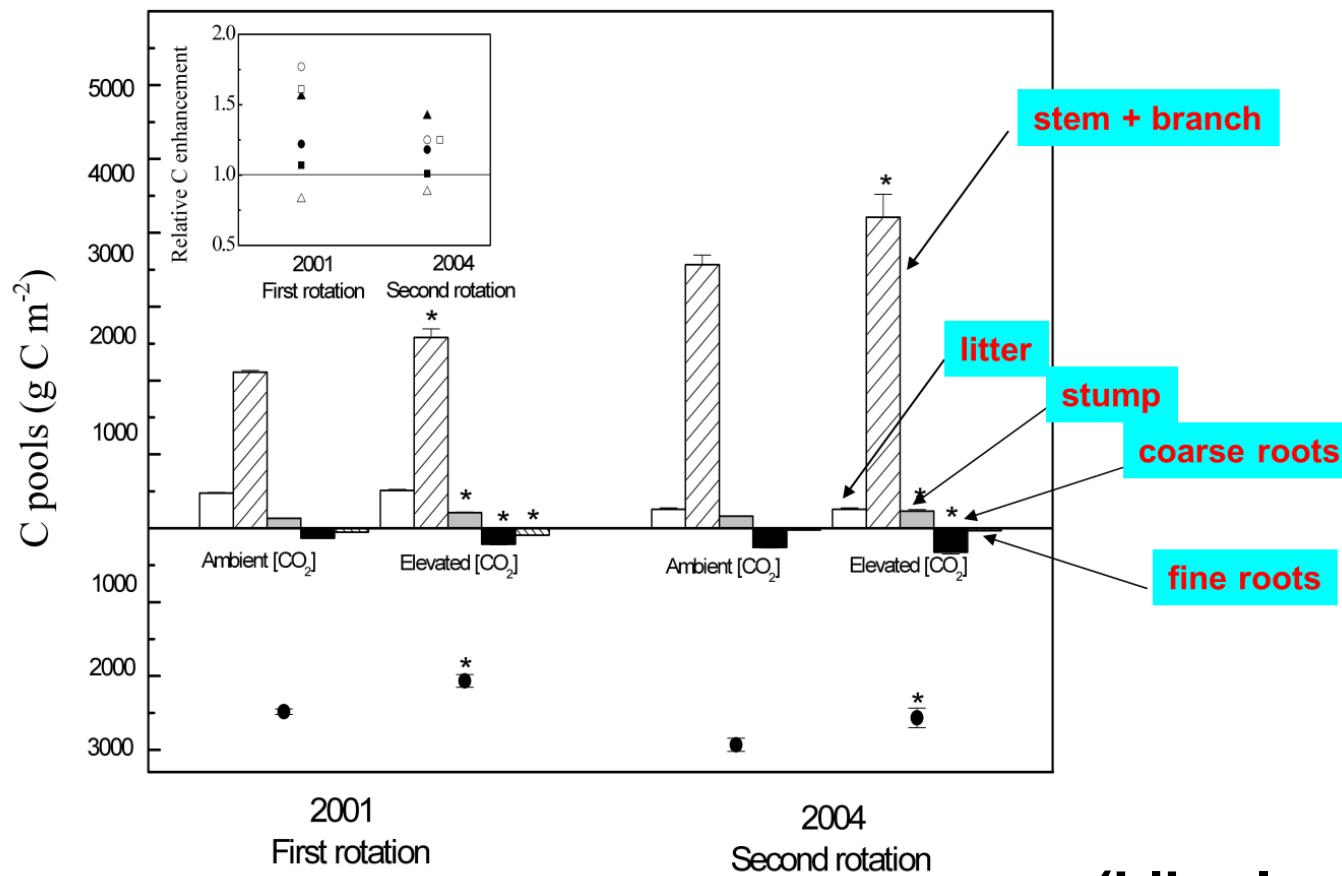


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First and second rotation cycles

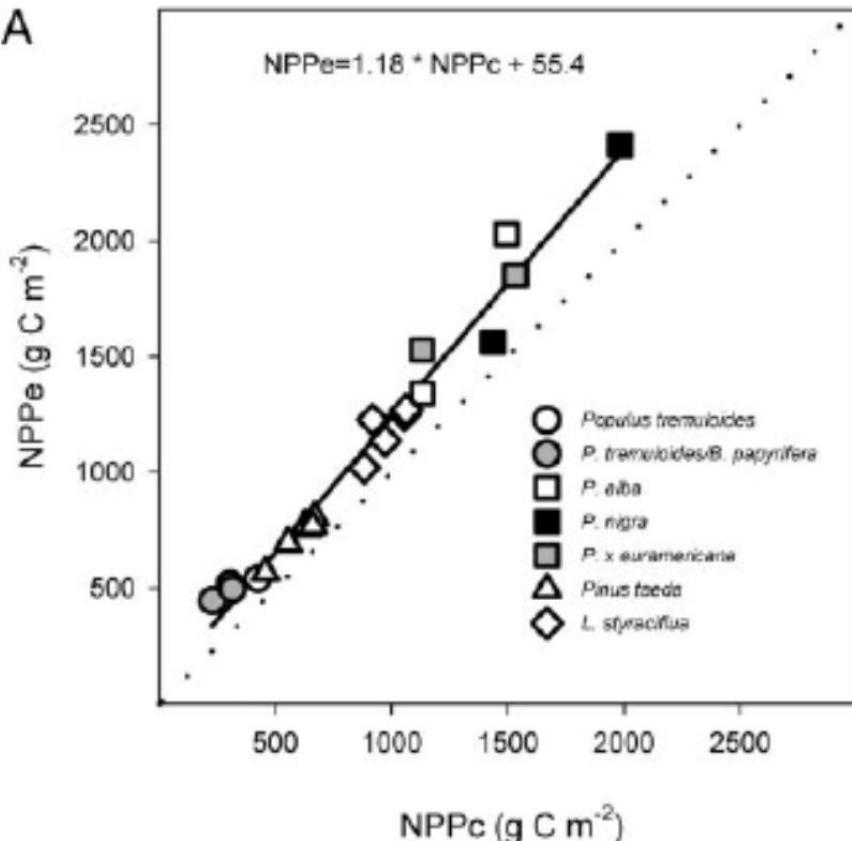
relative C-enhancement decreases from 2001 to 2004 but the Δ between treatments still increases



(Liberloo et al. 2009)

Net Primary Production

A



- NPP stimulation by FACE is conserved across a broad range of ecosystems and productivities
- at the median the stimulation is around 23%
- graph reports only data from the years when canopy was closed

(Norby et al. 2005, PNAS)



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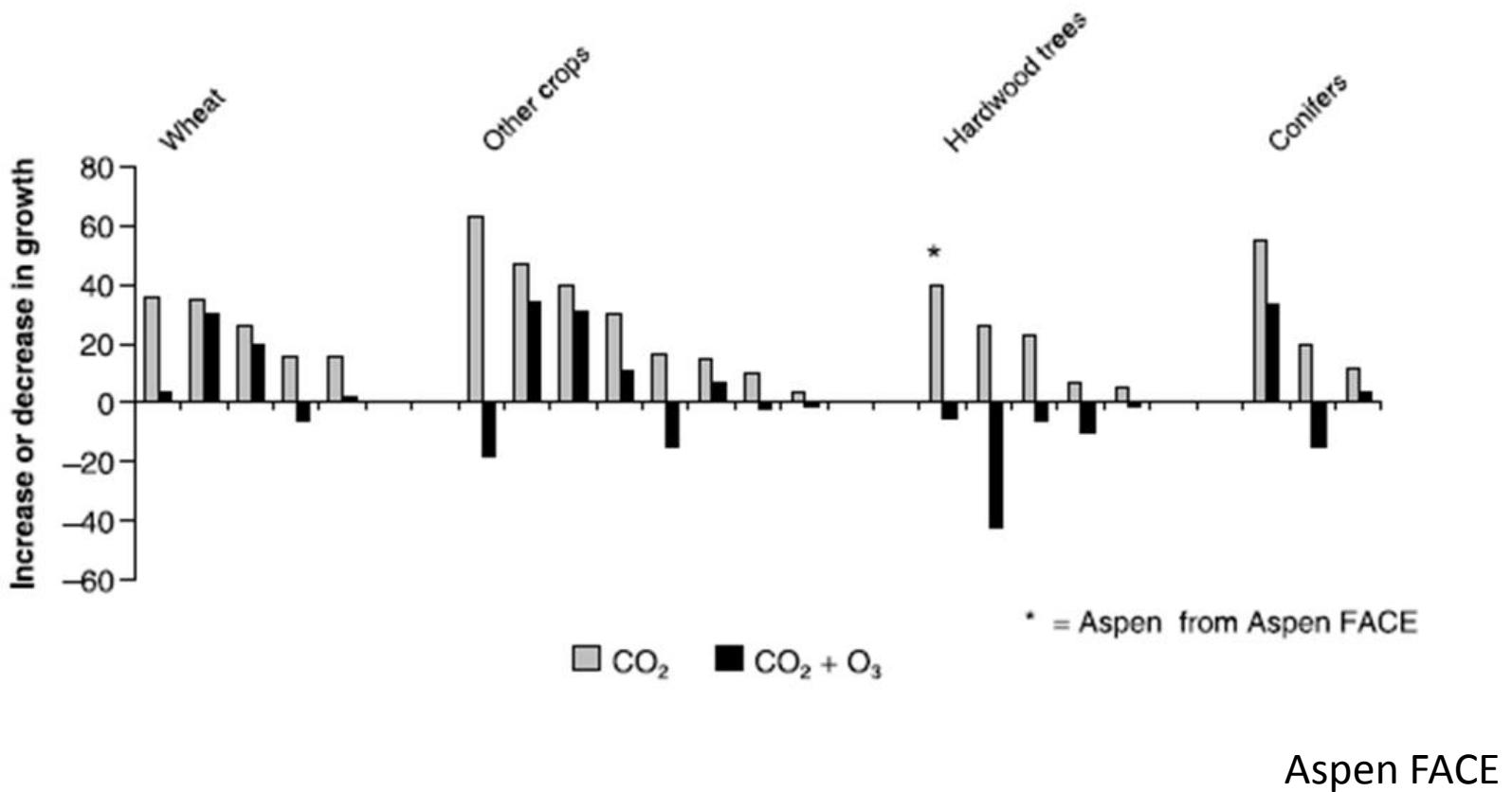


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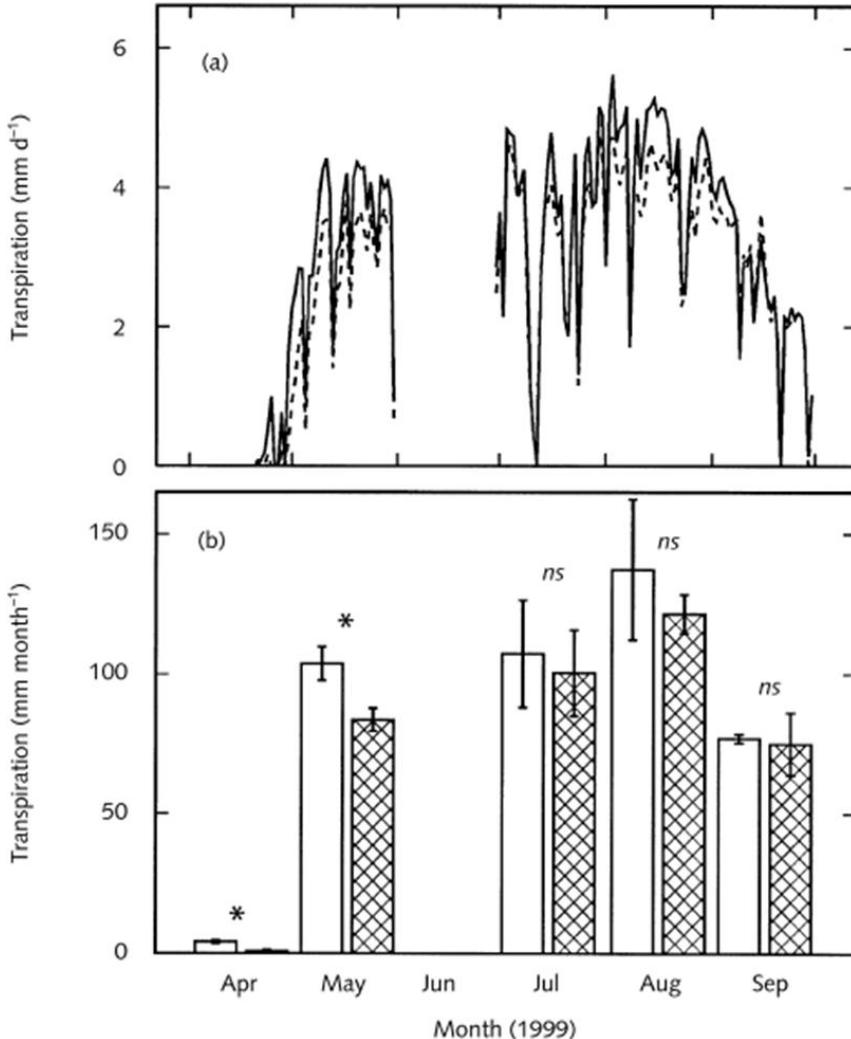
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O_3 limits CO_2 stimulation

(Karnosky et al. 2003)

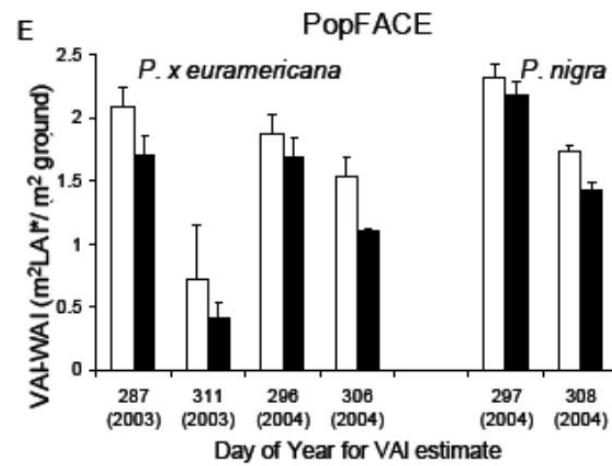
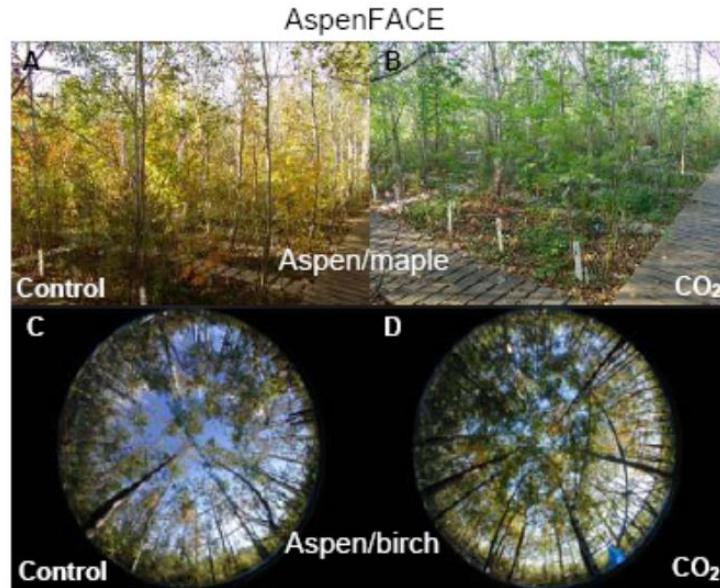


Effect on Water Use Efficiency



- Sweetgum FACE
- Stand level (solid line Ambient CO₂)
- Tree level (empty bar Ambient CO₂)
- Wullschleger & Norby 2001

Effect on leaf senescence



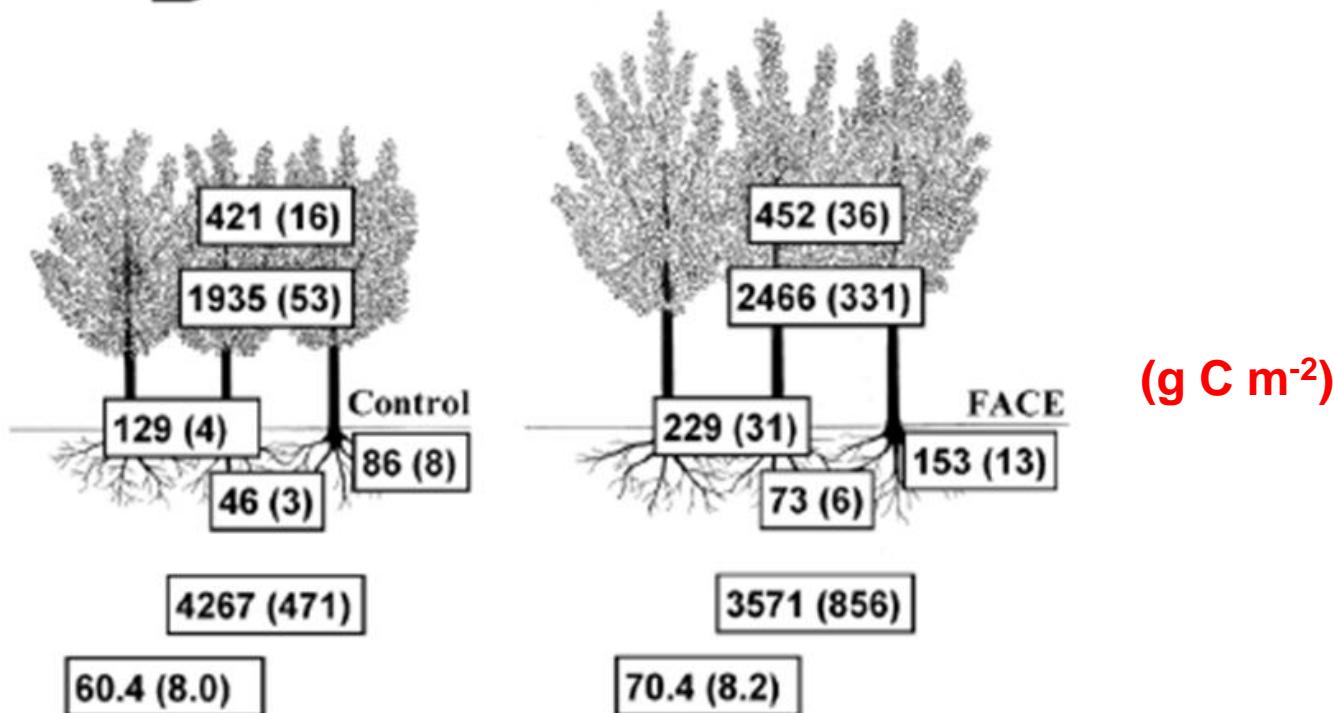
elevated CO₂
tend to delay
leaf senescence

(Taylor et al. 2008)

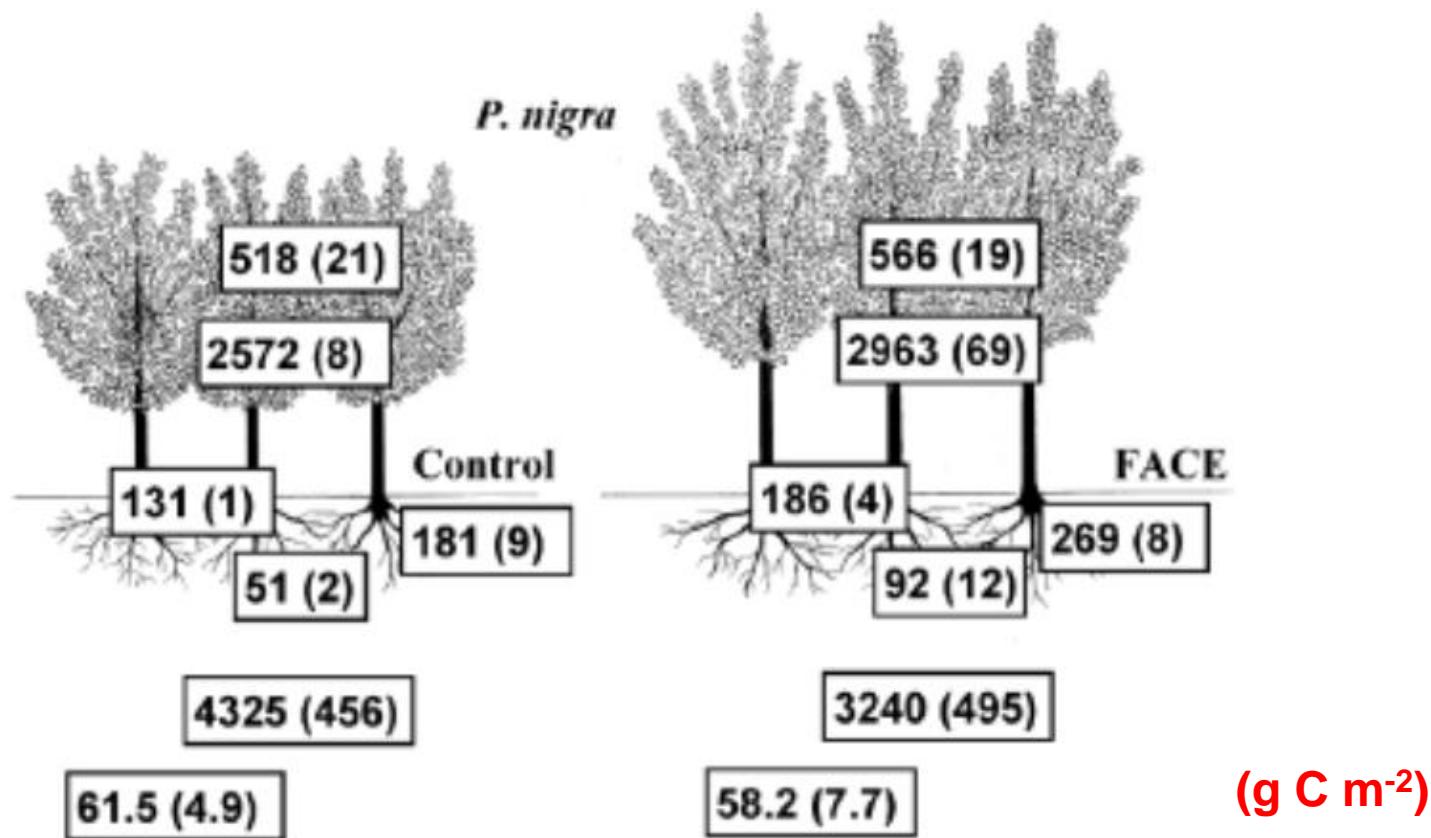
C allocation – *Populus alba*

B

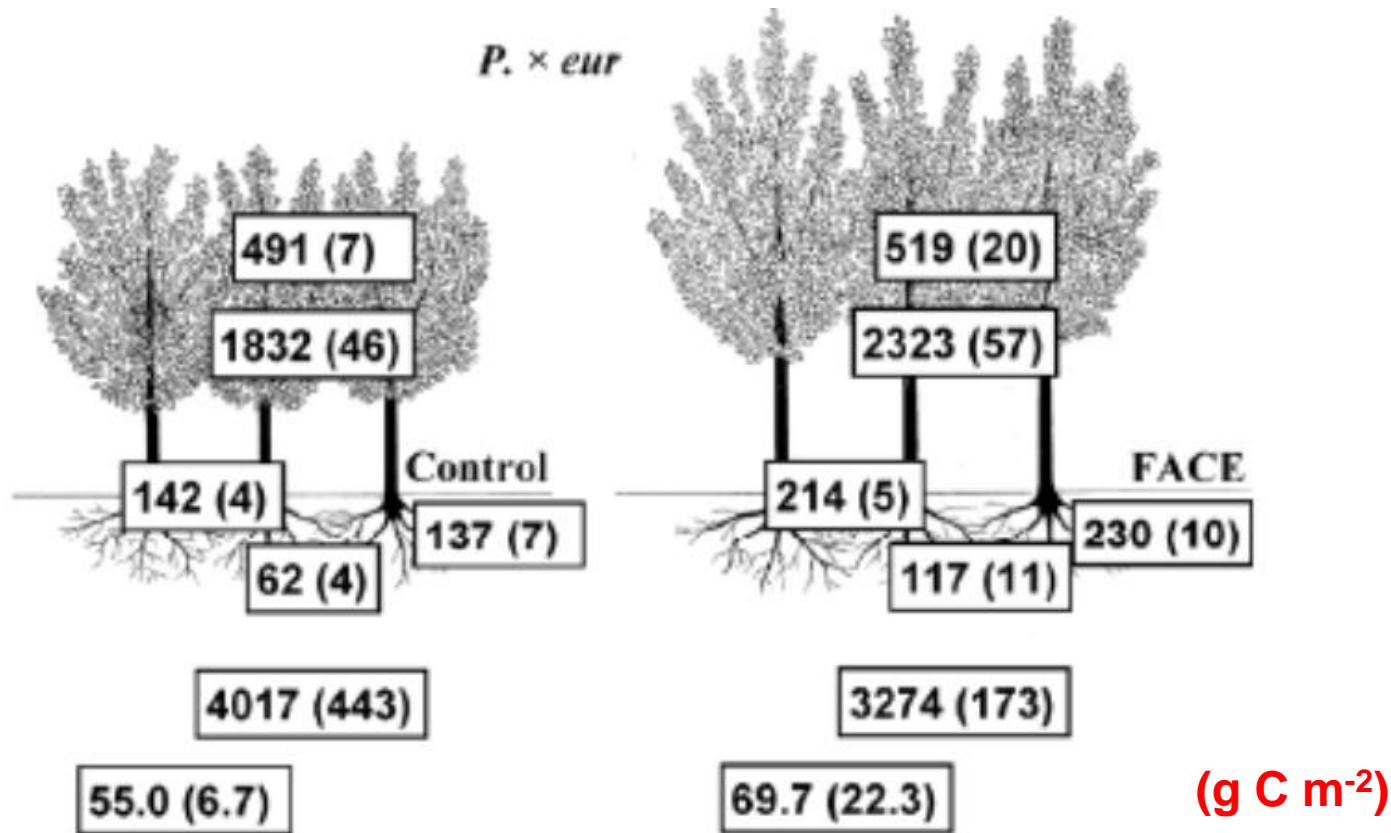
P. alba



C allocation – *Populus nigra*



C allocation – *Populus x euramericana*



Effect on root biomass

	FACE Effect	
	Low N	High N
<i>P. alba</i>	+ 29%	+36%
<i>P. nigra</i>	+ 23%	+78%
<i>P. X euramericana</i>	+40%	+56%

	N Effect	
	Control	FACE
<i>P. alba</i>	-23%	-19%
<i>P. nigra</i>	-50%	-28%
<i>P. X euramericana</i>	-13%	-4%