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OP Vzdělávání pro konkurenceschopnost

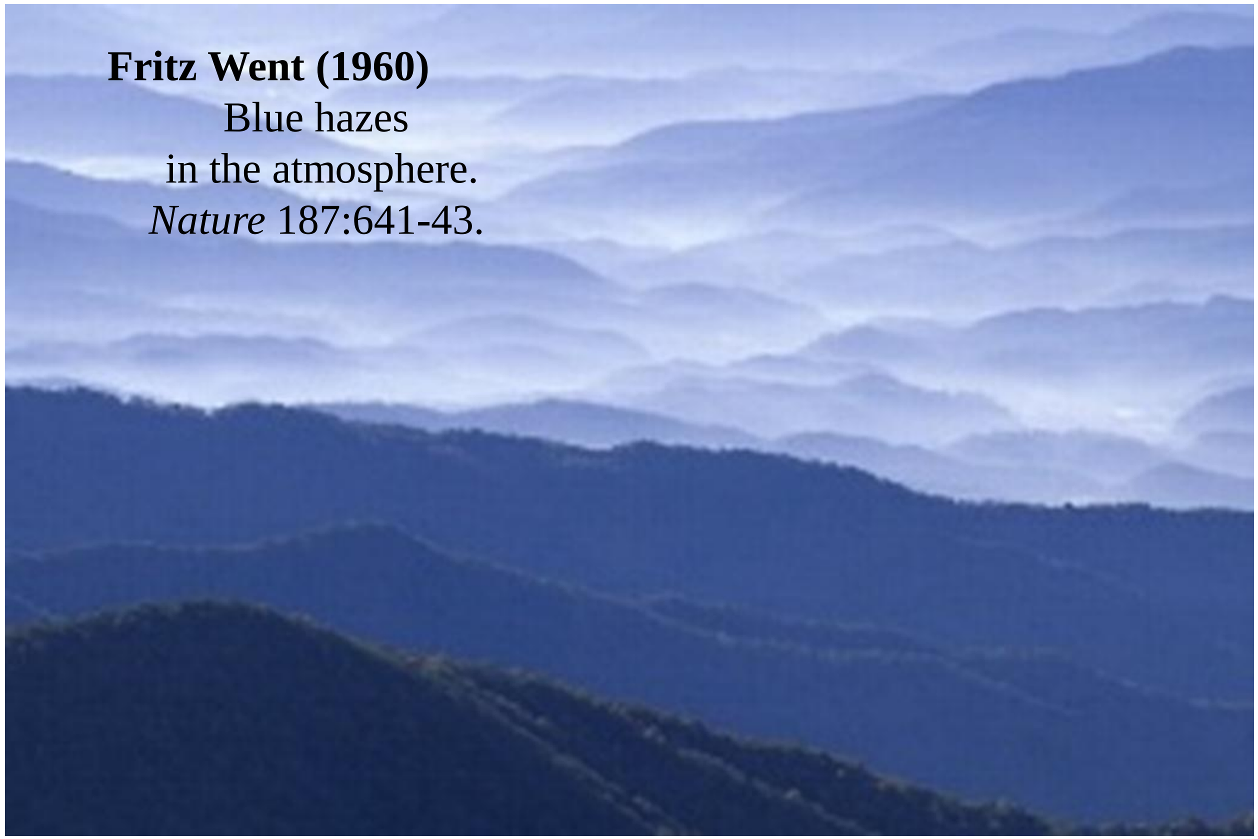
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Biogenic Volatile Organic Compounds (BVOCs)

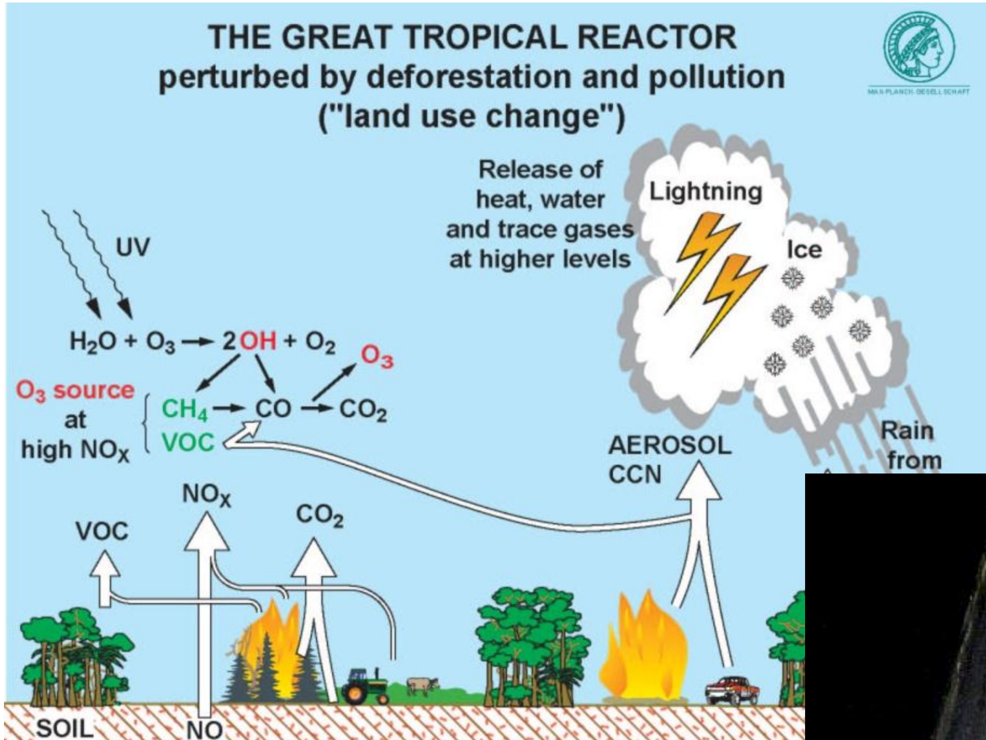
Carlo Calfapietra

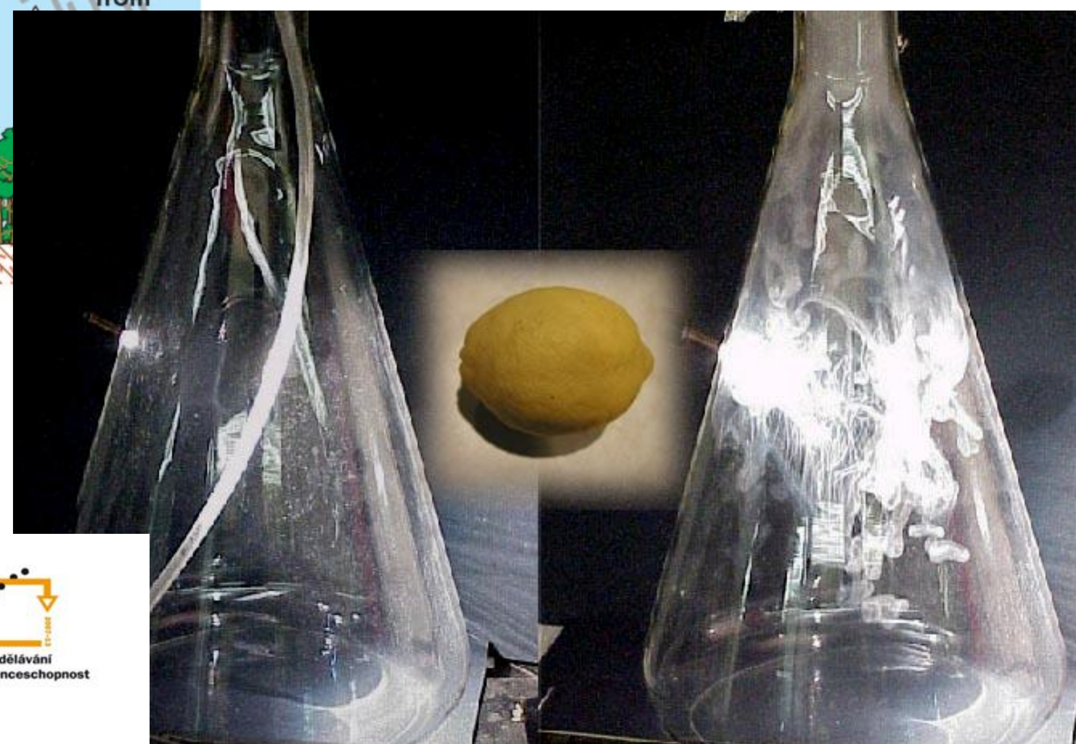
Tato akce se koná v rámci projektu:
Vybudování vědeckého týmu environmentální metabolomiky a ekofyziologie a jeho zapojení do mezinárodních sítí (ENVIMET; r.č. **CZ.1.07/2.3.00/20.0246**) realizovaného v rámci Operačního programu Vzdělávání pro konkurenceschopnost.

Introduction – first step



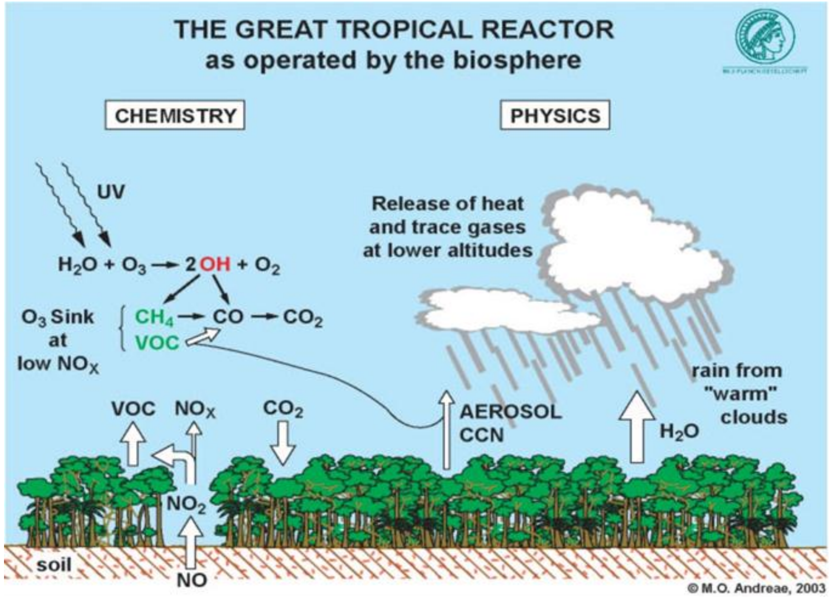
Introduction – Tyndall effect



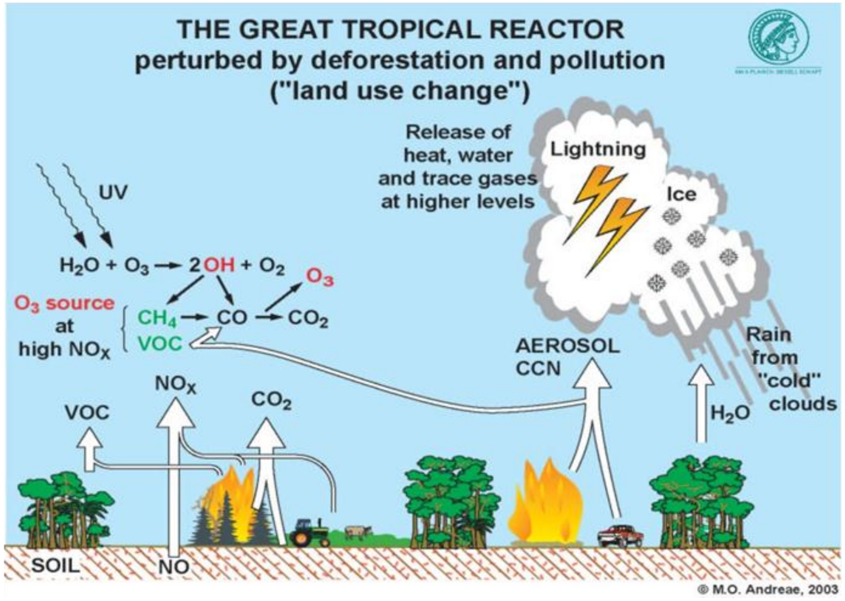


Introduction – formation of VOCs

Natural



Perturbed



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VOCs

- The biggest source is from plants, in particular trees
- Estimated emission from plants: 503 Tg C year-1 (Guenther et al., 1995) about double than anthropogenic emission
- In the USA 29 Tg C year-1 is the estimated biogenic emission whereas 19 Tg is the anthropogenic one (Kempf et al. 1996)
- The most important emitters are some species of oaks, poplars and eucalyptuses

- But not all the hydrocarbons emitted have the same OFP (Ozone-forming potential). The OFP (g O3 produced per g of molecule) is about 9,1 for the isoprene but only 3,3 for the ?-pinene (the most abundant monoterpene)

- The amount of VOC emitted together with the OFP determine the potential impact on the atmospheric chemistry by plants

Trees of the highest VOCs emissions

Quercus spp.

Platanus spp

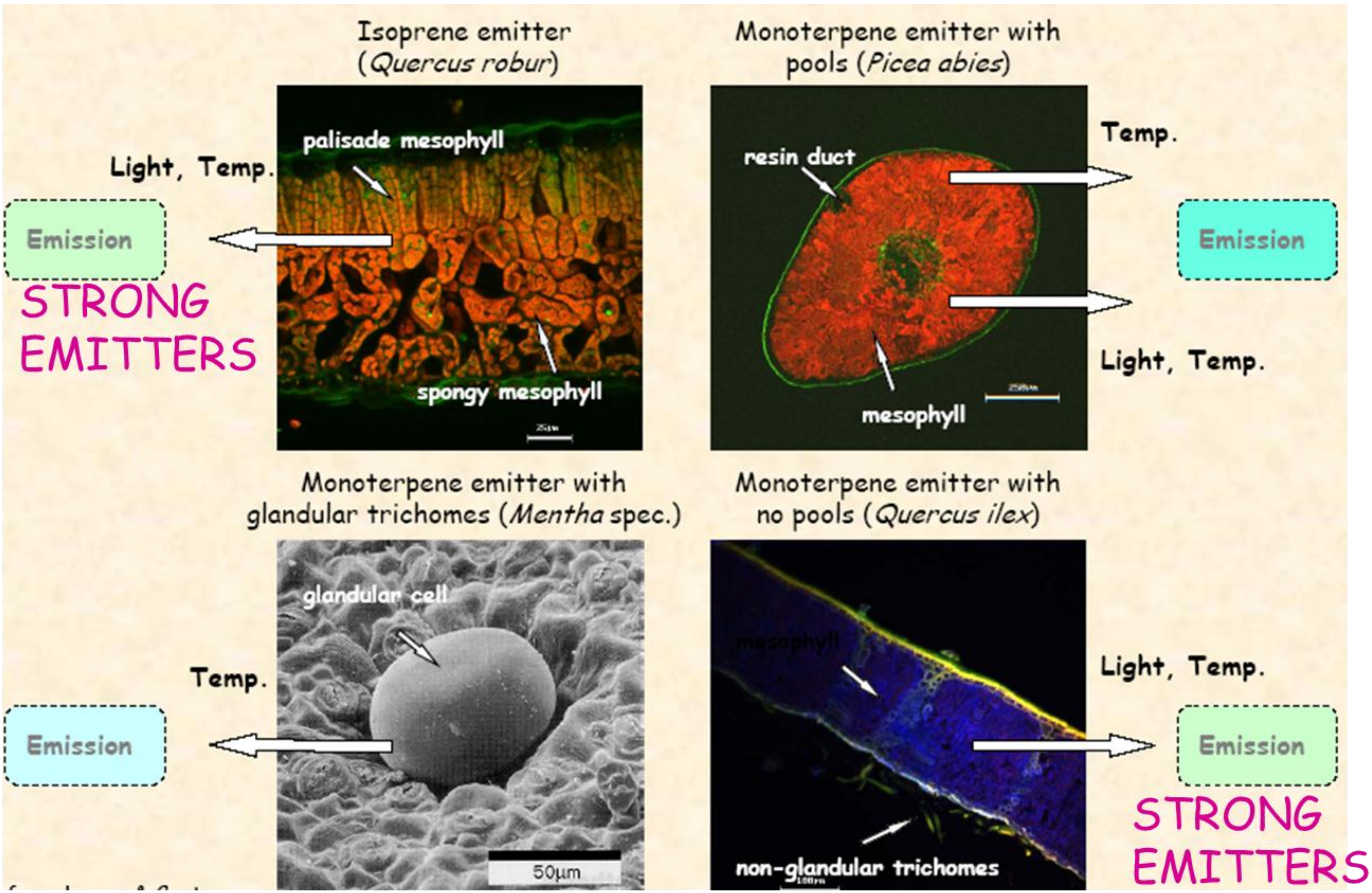
Populus spp

Salix spp.

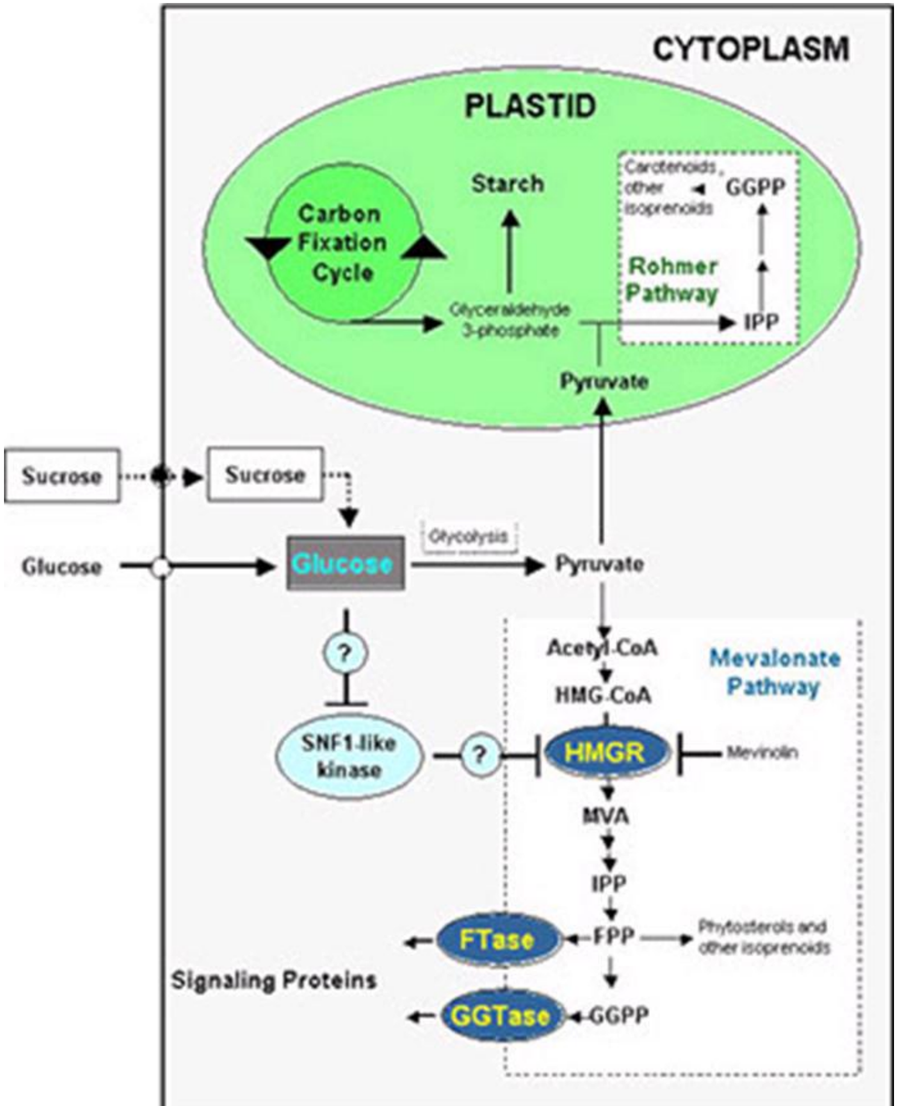
Reeds (Phragmites, Arundo….)

Eucalyptus spp.

Emitter classes



BVOCs pathway – cellular level



Non-stored isoprenoids are emitted through a chloroplastic pathway

Photosynthesis-dependent

(Lichtenthaler HK et al. 1997)

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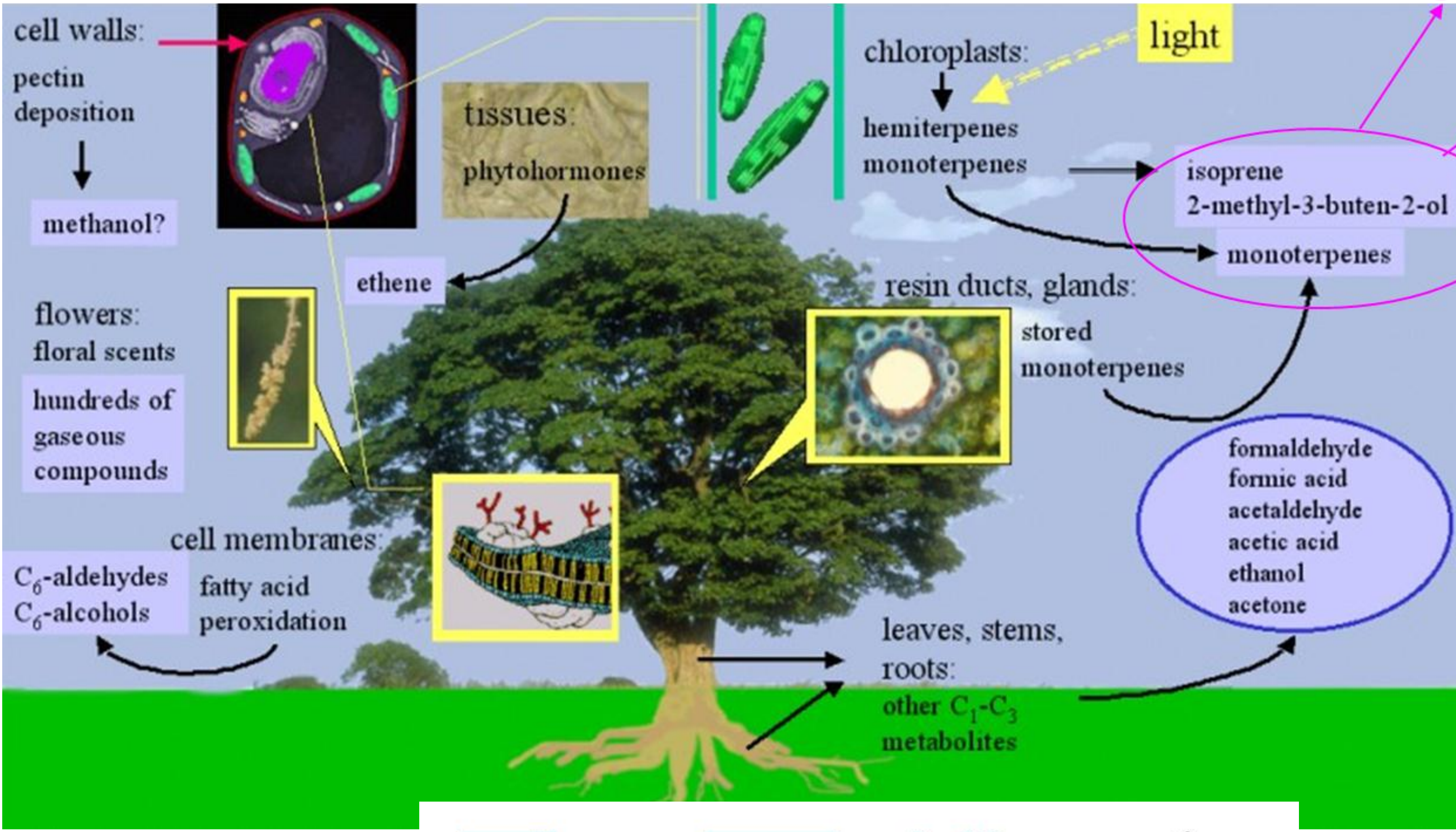
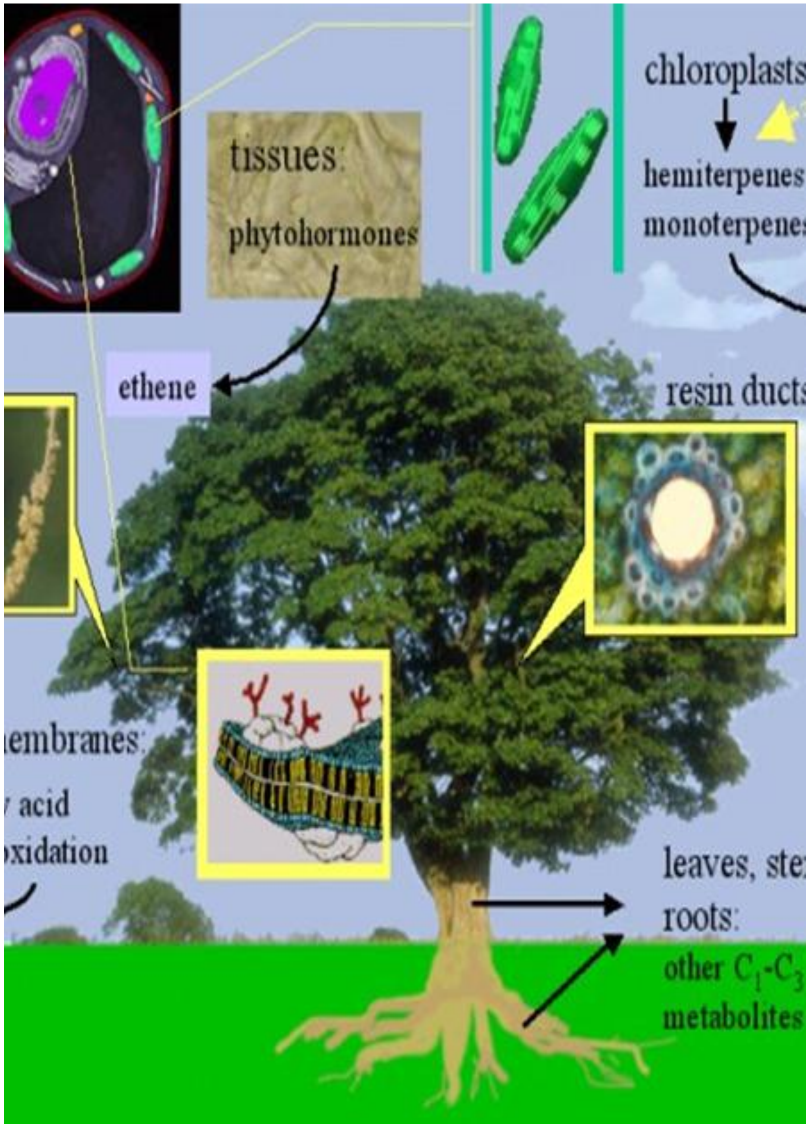
BVOCs pathway – ecosystem level



> 500 Tg C y^{-1}

1-10% of C fixed

BVOCs



- environmental conditions control
  - emission rates of BVOCs
  - biosynthesis of BVOCs
- BVOCs interact in the atmosphere
  - changes in atmospheric chemistry
- BVOCs functions
  - physiological aspects
  - plant-plant interactions
  - plant-herbivore interactions

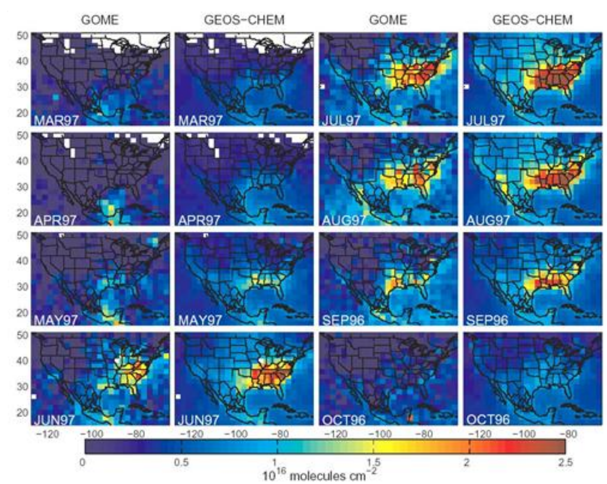
In vivo measurements of BVOCs

leaf/plant level

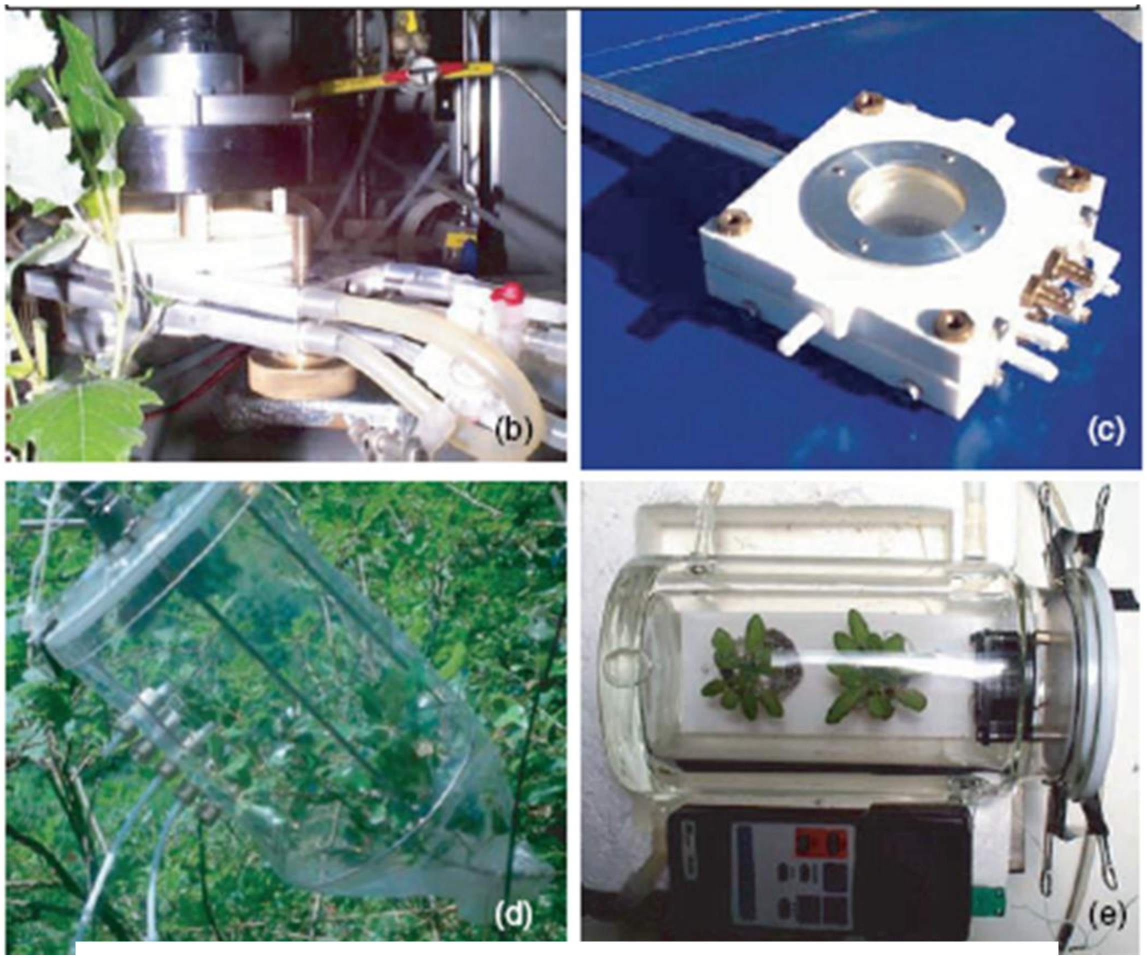
canopy level

long-distance transports

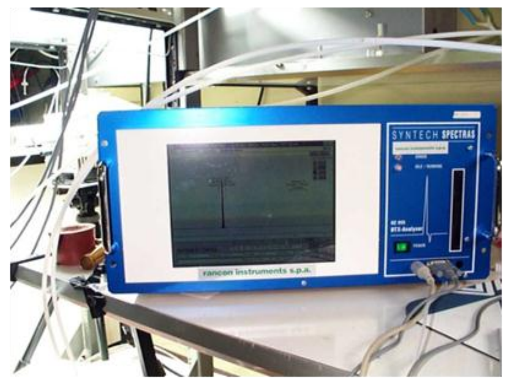
biosphere level



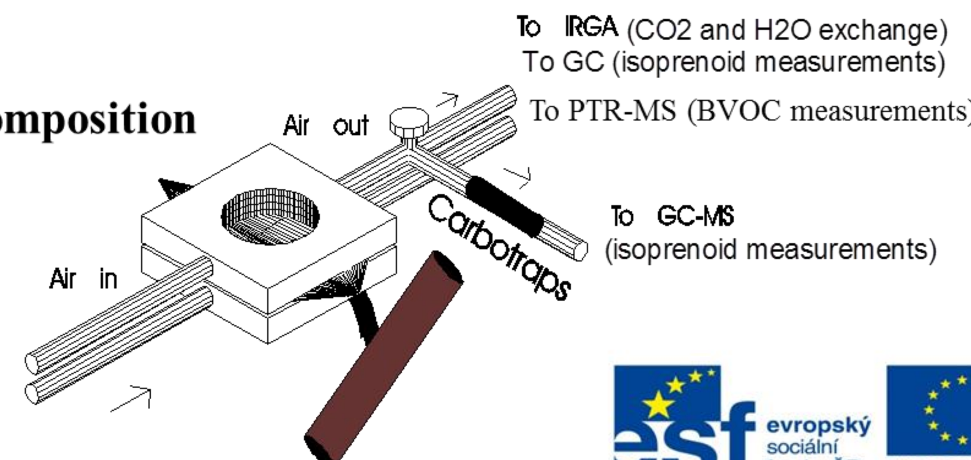
Chamber measurements



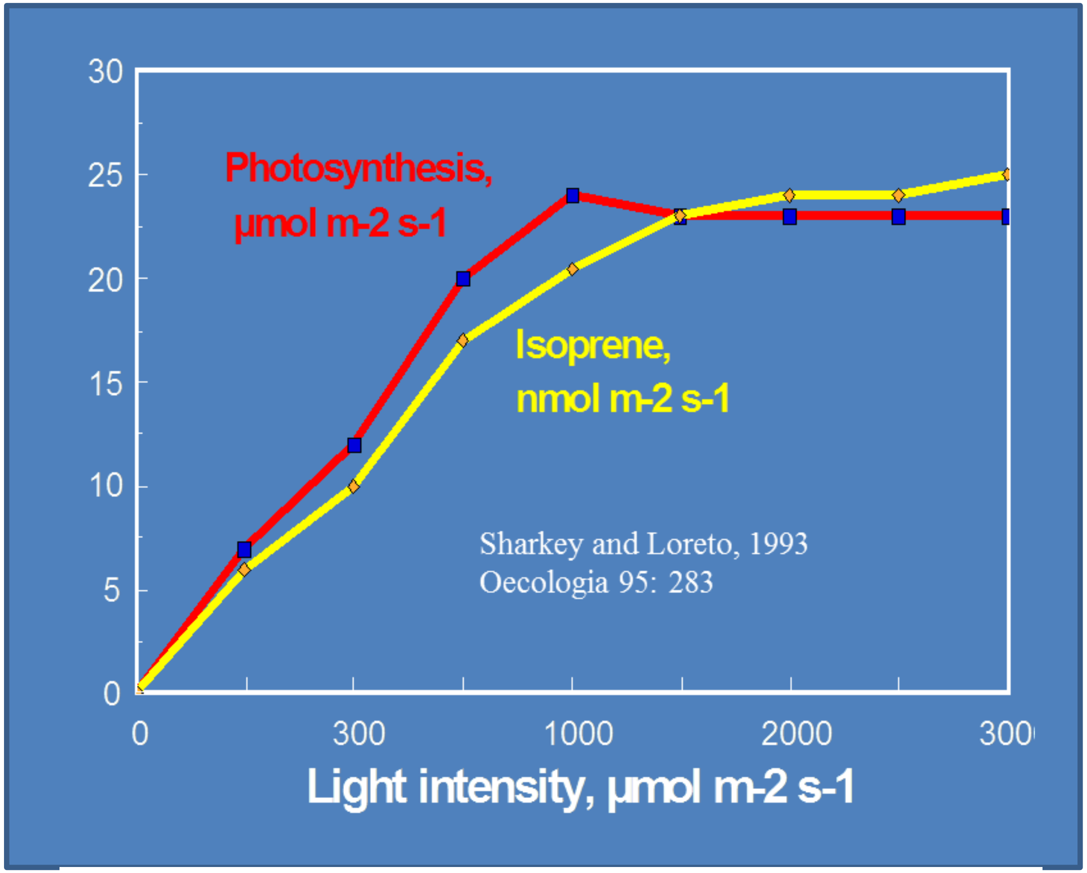
From traps to GC



Control:
Gaseous composition (CO2, O2)
RH
Light
Temp
Pollutants



Physiological aspects:
Light intensity



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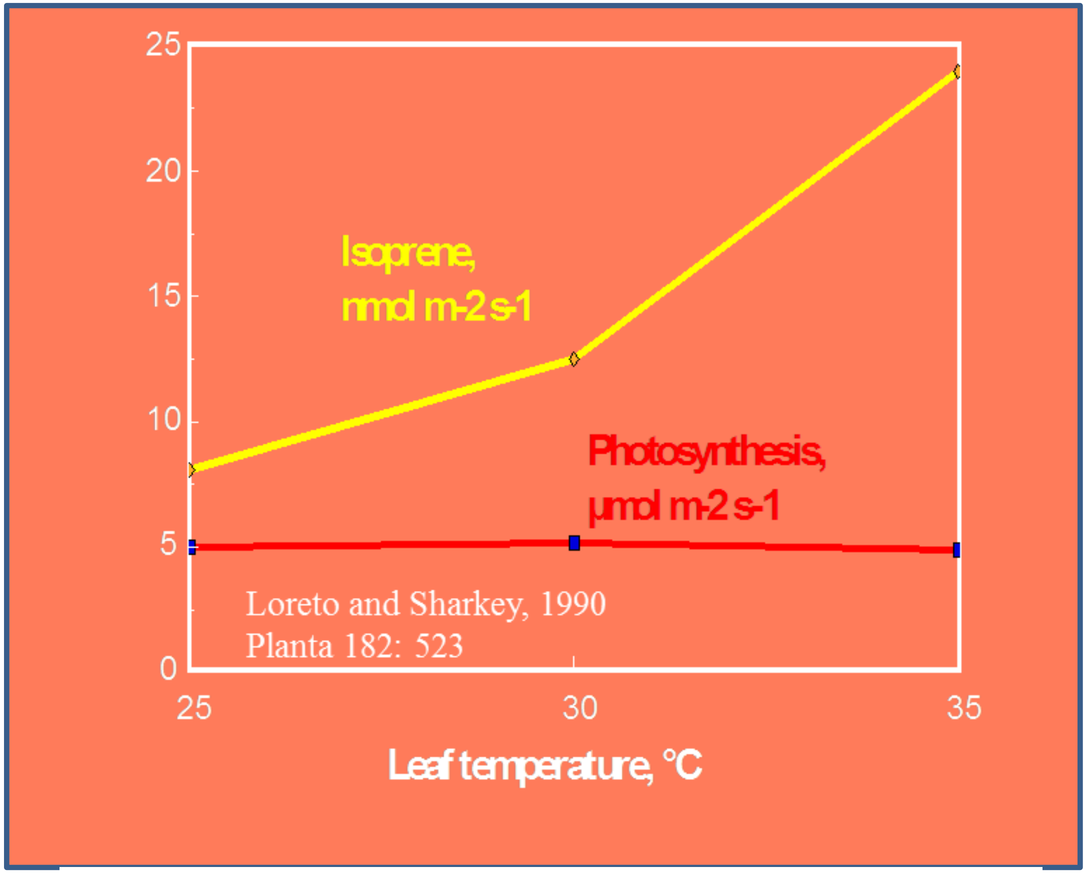
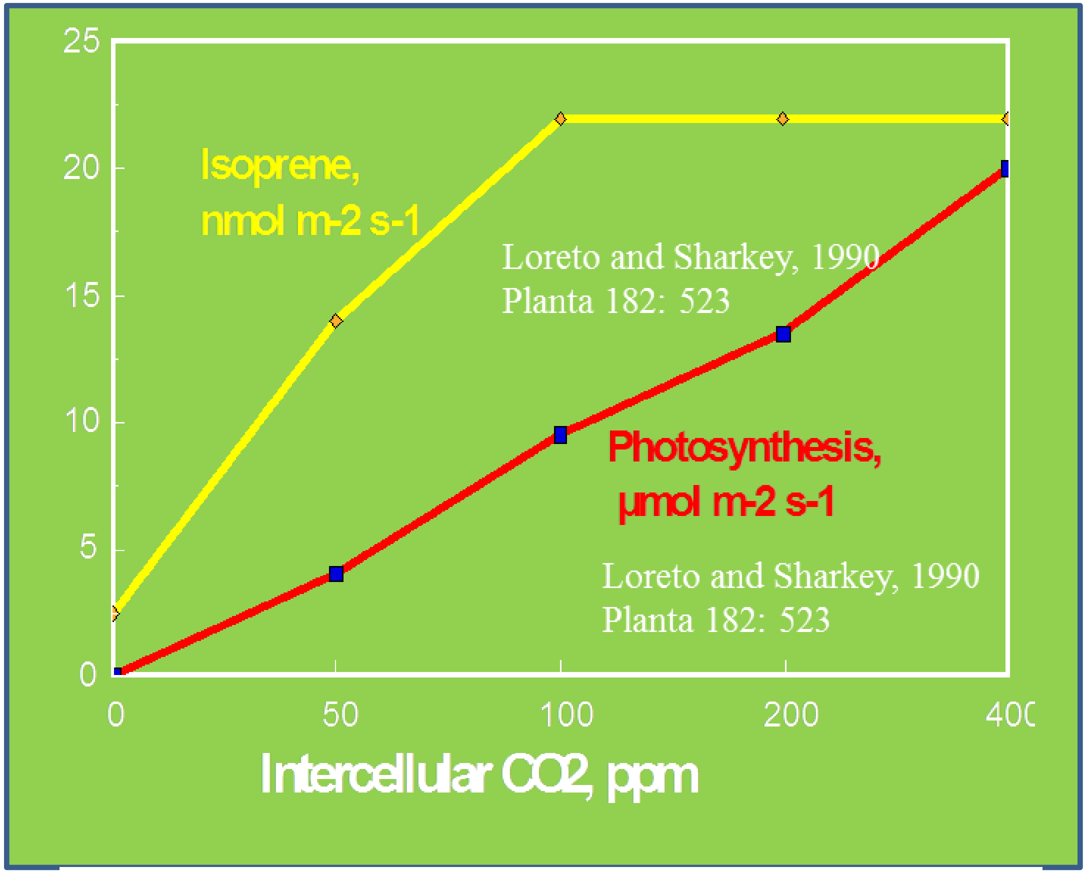
Physiological aspects:
Temperature



Physiological aspects:
CO_2 concentration



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Physiological aspects:
Drought stress

Isoprene is emitted at constant rates even when photosynthesis is inhibited by drought

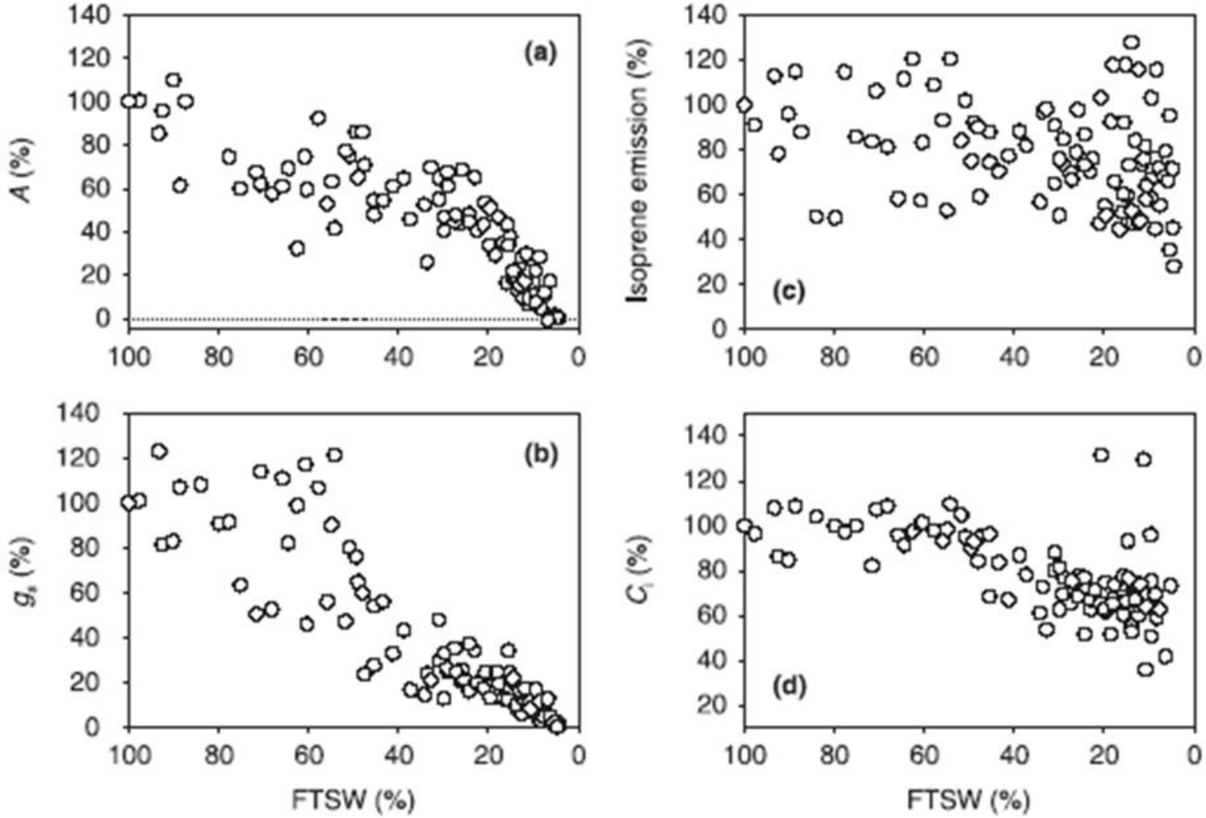
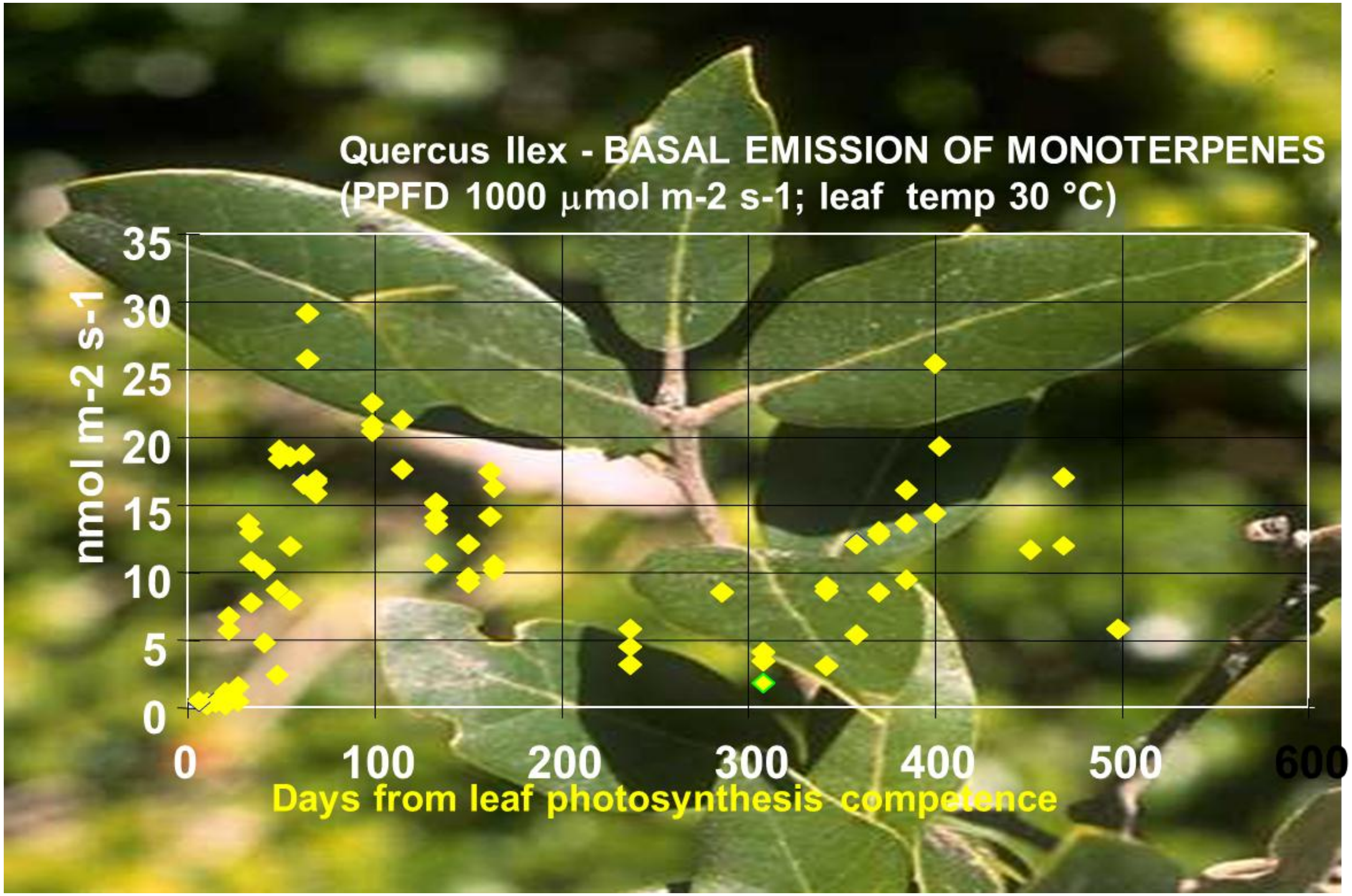


Fig. 1 Results for (a) normalized photosynthesis (*A*), (b) normalized stomatal conductance (g_s), (c) normalized isoprene emission, and (d) normalized intercellular CO_2 concentration (C_i) as a function of the fraction of transpirable soil water (FTSW) for *Populus alba* saplings.

Seasonal changes of emissions



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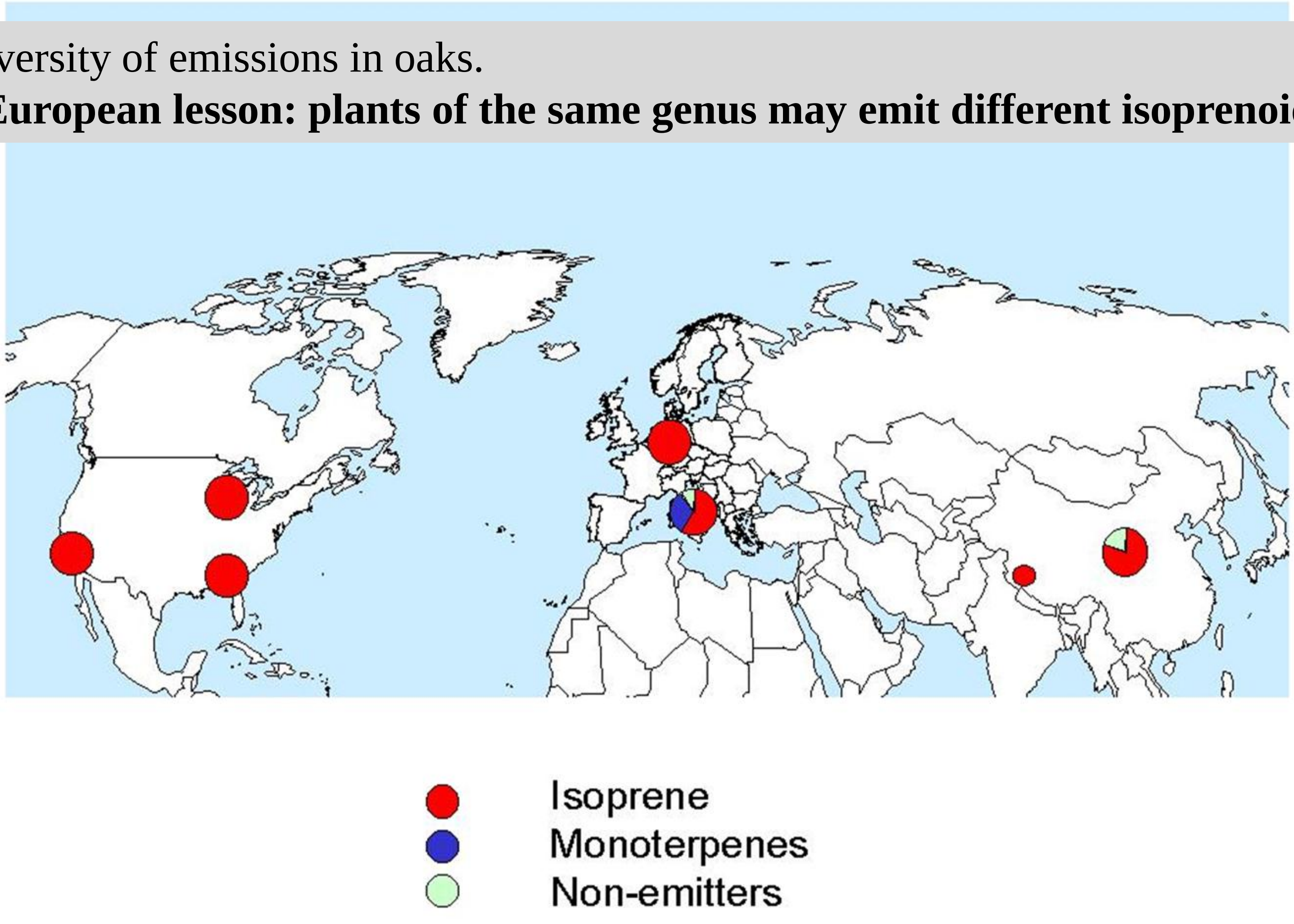
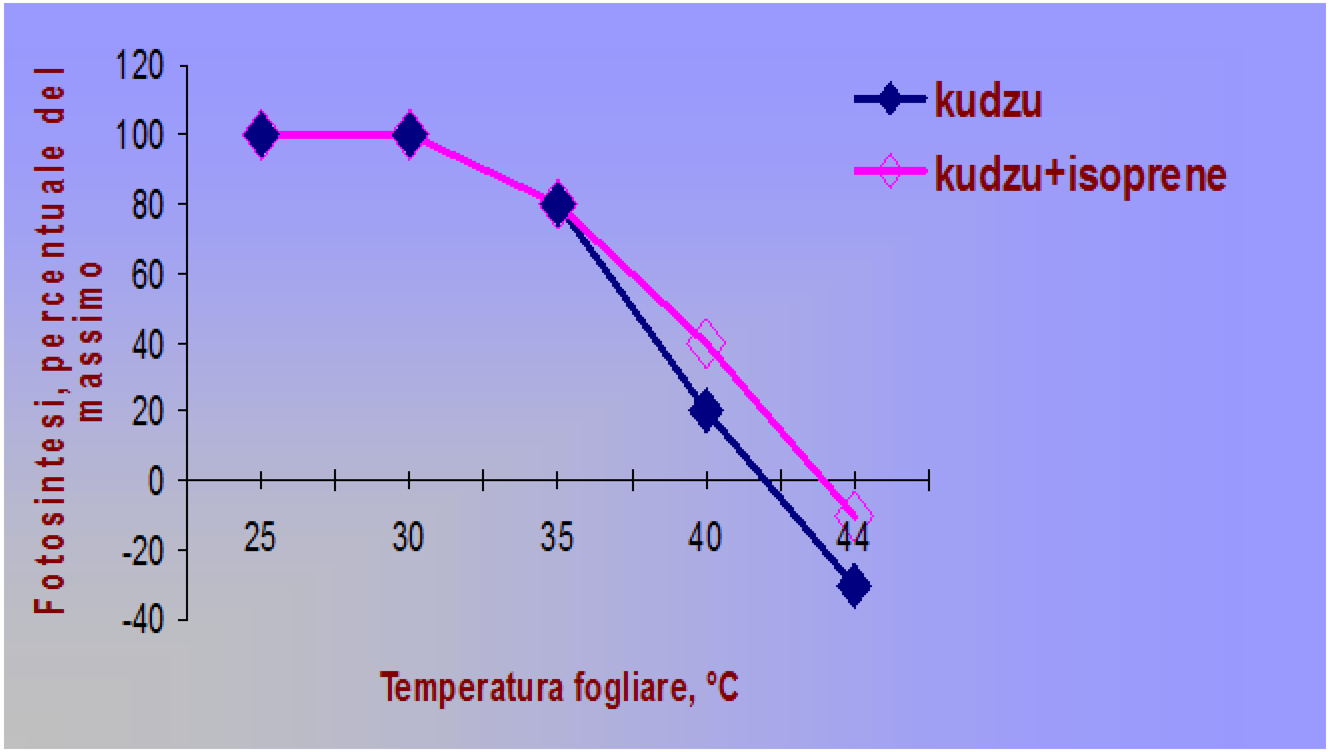
Biodiversity of BVOCs emissions

Biodiversity of emissions in oaks.
The European lesson: plants of the same genus may emit different isoprenoids



Isoprenoids and abiotic stress interaction: *Temperature*

(Sharkey and Singsaas, 1995)



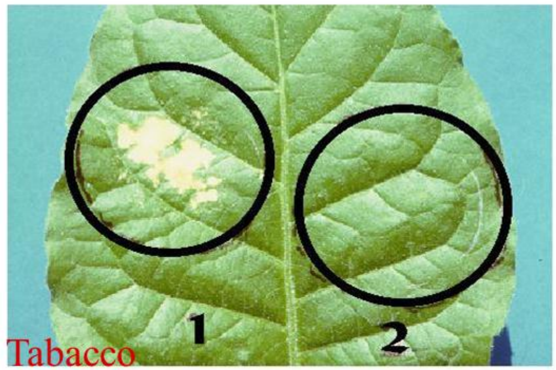
Isoprene increases thermotolerance

Isoprenoids and abiotic stress interaction: *Ozone*

(Loreto et al., 2001)

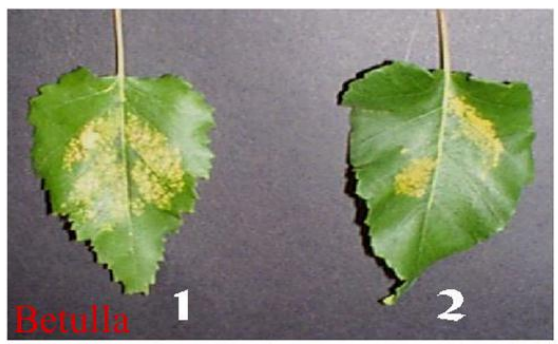
Ozone

(300ppb 3h)



Ozone
(300ppb 3h)
+
Isoprene
(3ppm)

= >> damage



= << damage

Isoprenoids reduce oxidative stress

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Isoprenoids and abiotic stress interaction:
Ozone – transgenic studies

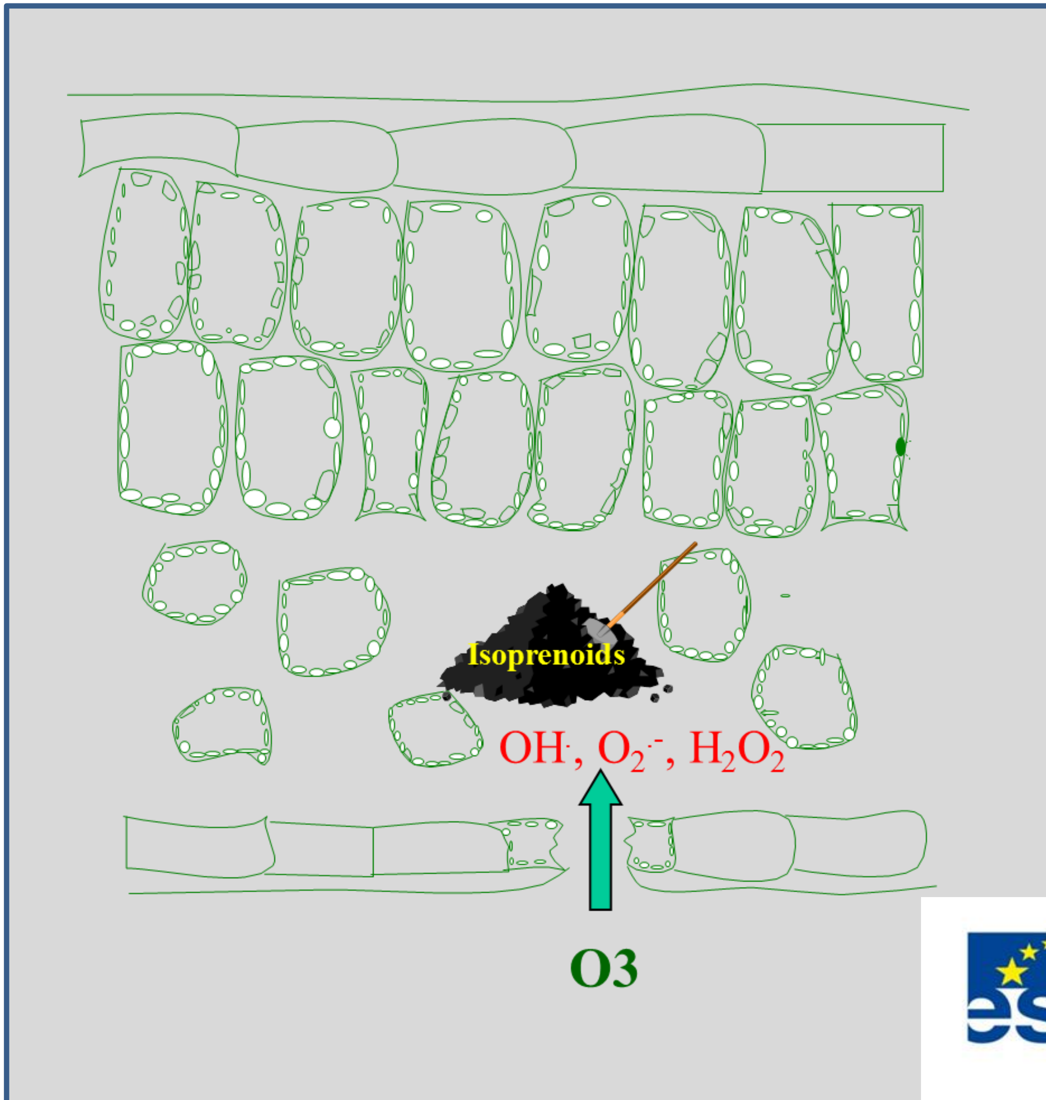
WT

Isoprene-emitting transgenic

Vickers et al. 2010

Isoprenoids and abiotic stress interaction:

Oxidative agents

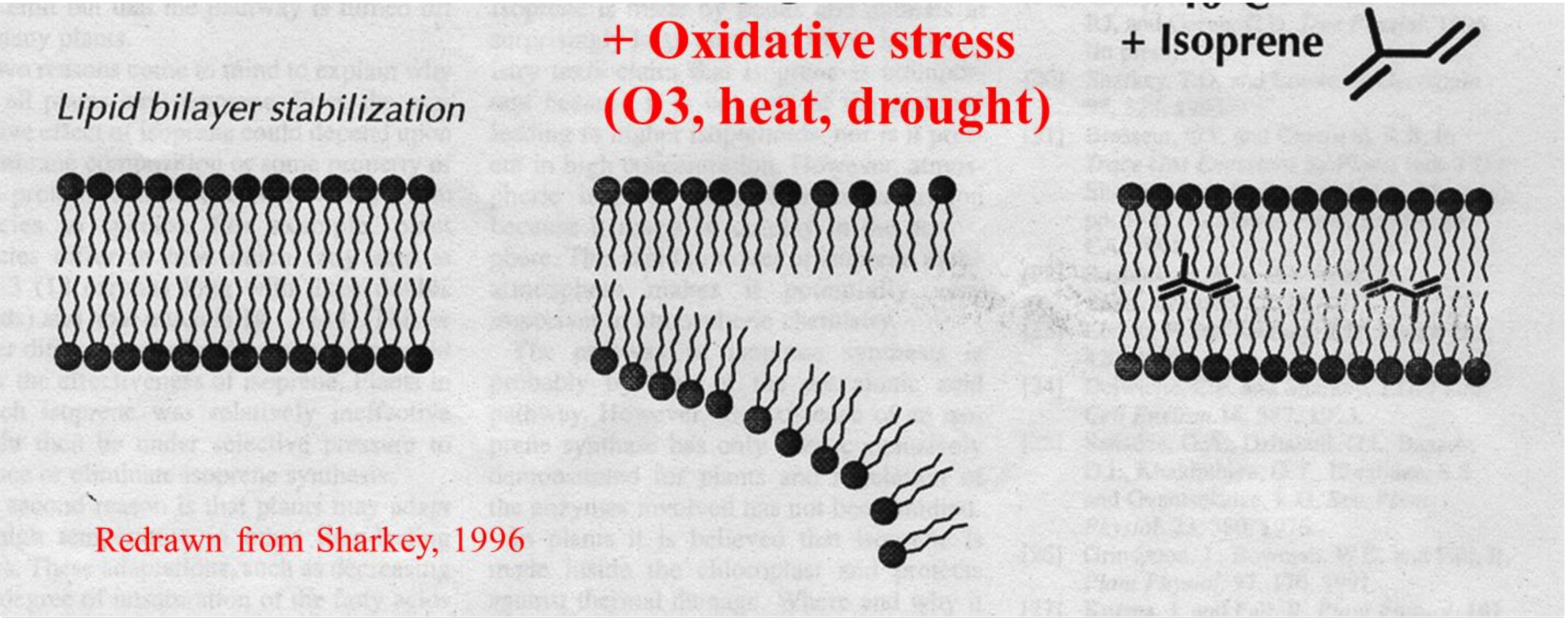


Isoprenoids react with the ROS already in the intercellular spaces and avoid their contact on cellular membranes

Loreto et al. (2001)

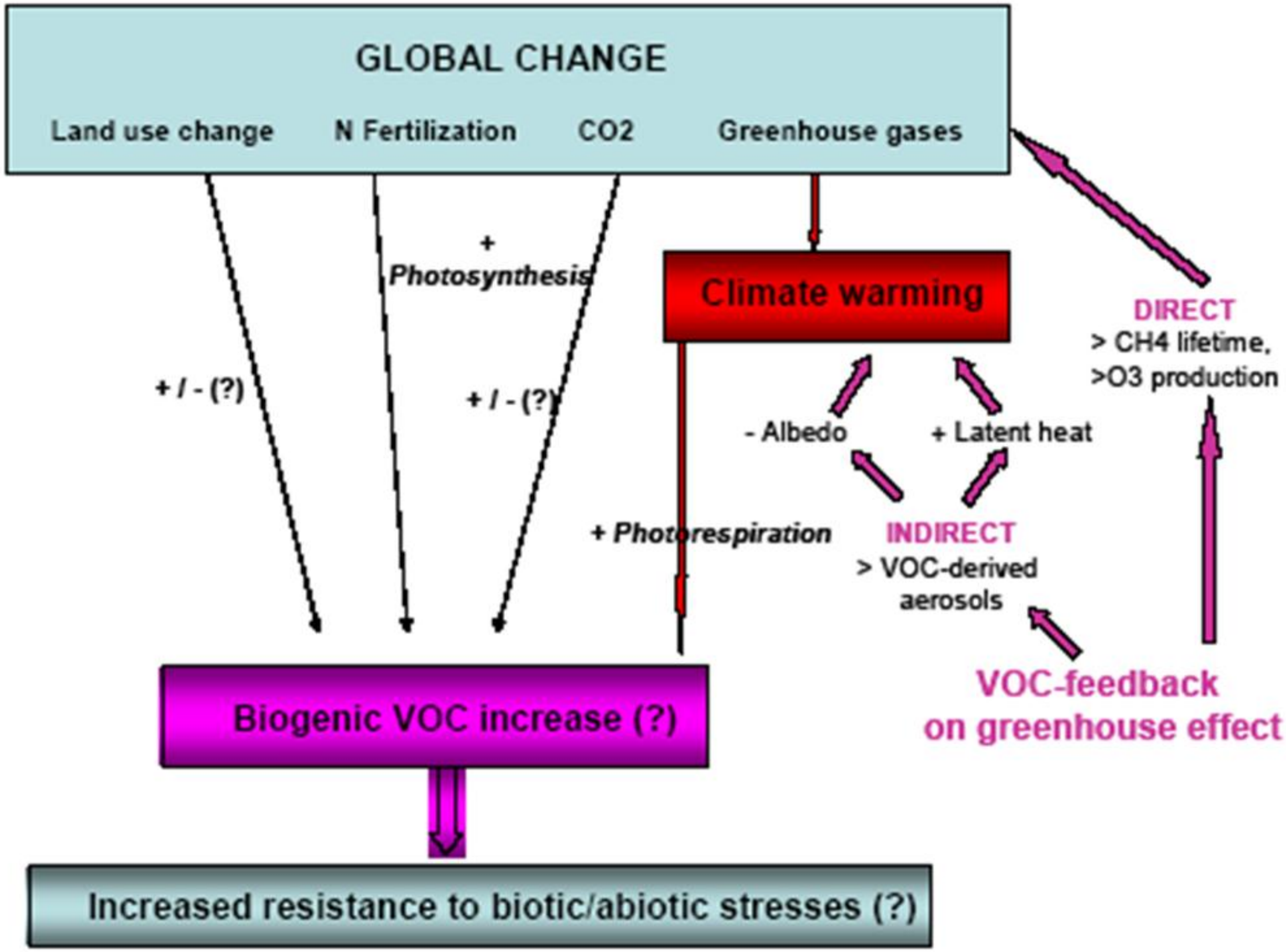
Isoprenoids and abiotic stress interaction: *oxidative stress*

Sharkey and Singsaas (1995), Sharkey (1996), Sharkey and Yeh (2000), Loreto and Velikova (2001)



Isoprenoids increase the cohesion between cellular structures: lipids-lipids; lipids-proteins; proteins-proteins.

Global change and BVOCs emissions



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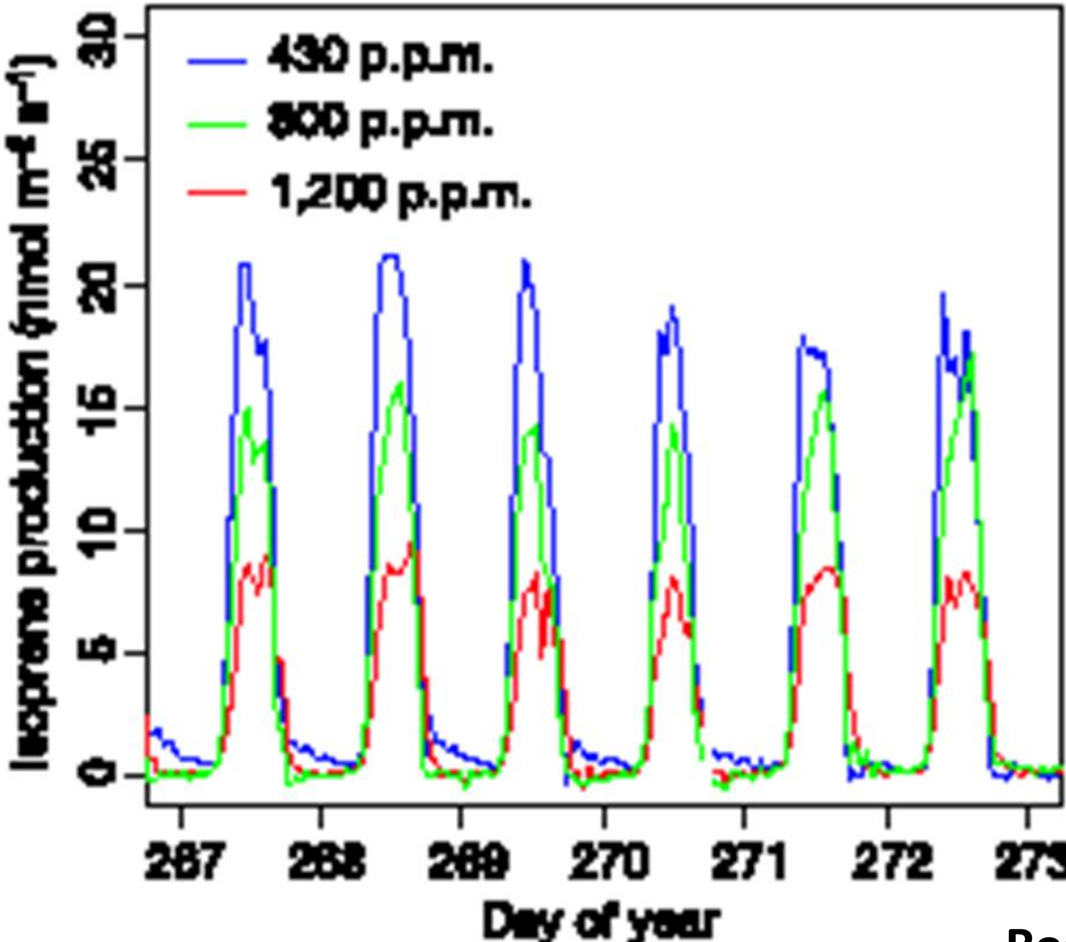
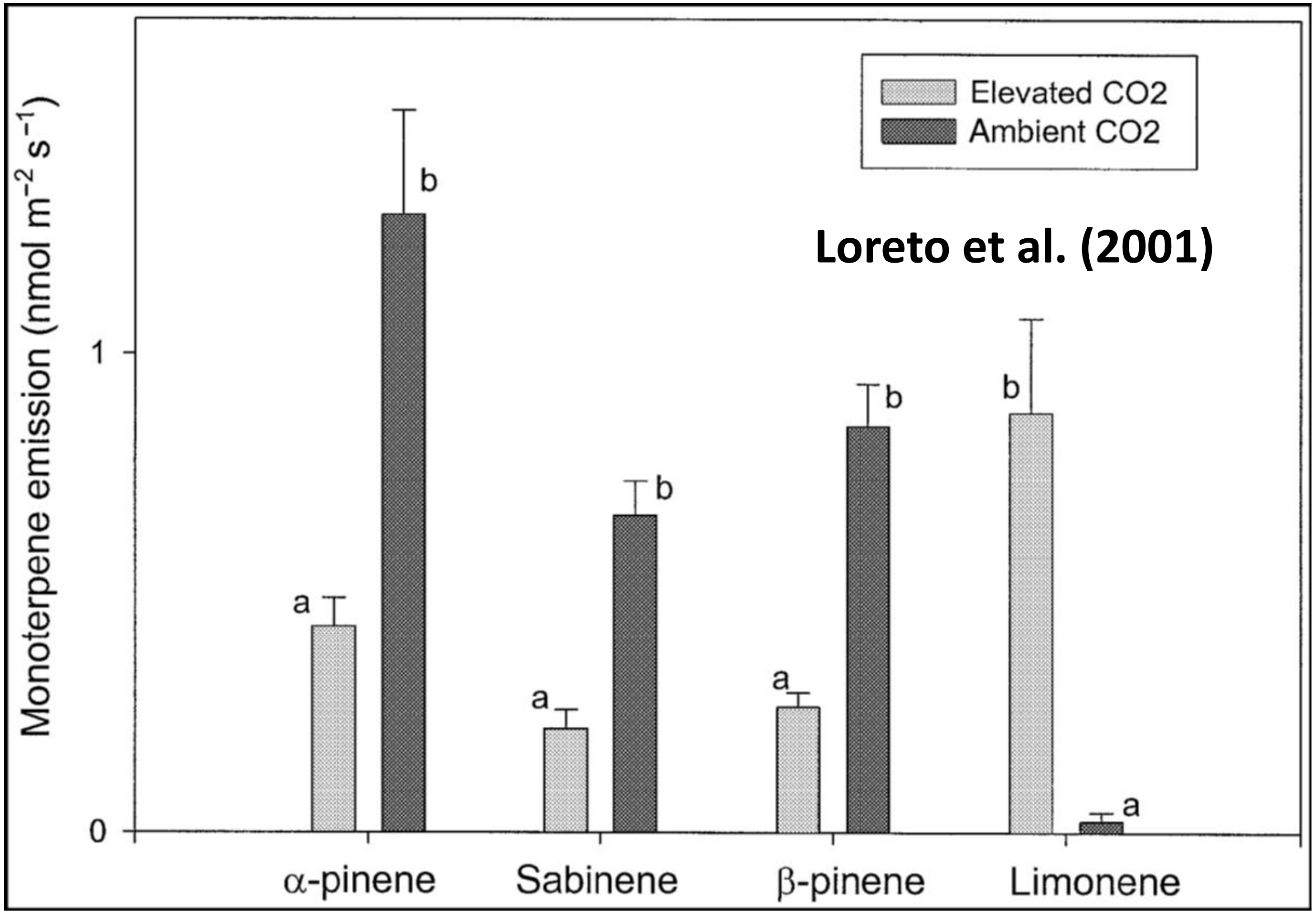
Effect of elevated CO_2 concentration



Rosenstiel et al. (2003)

Effect of elevated CO_2 concentration



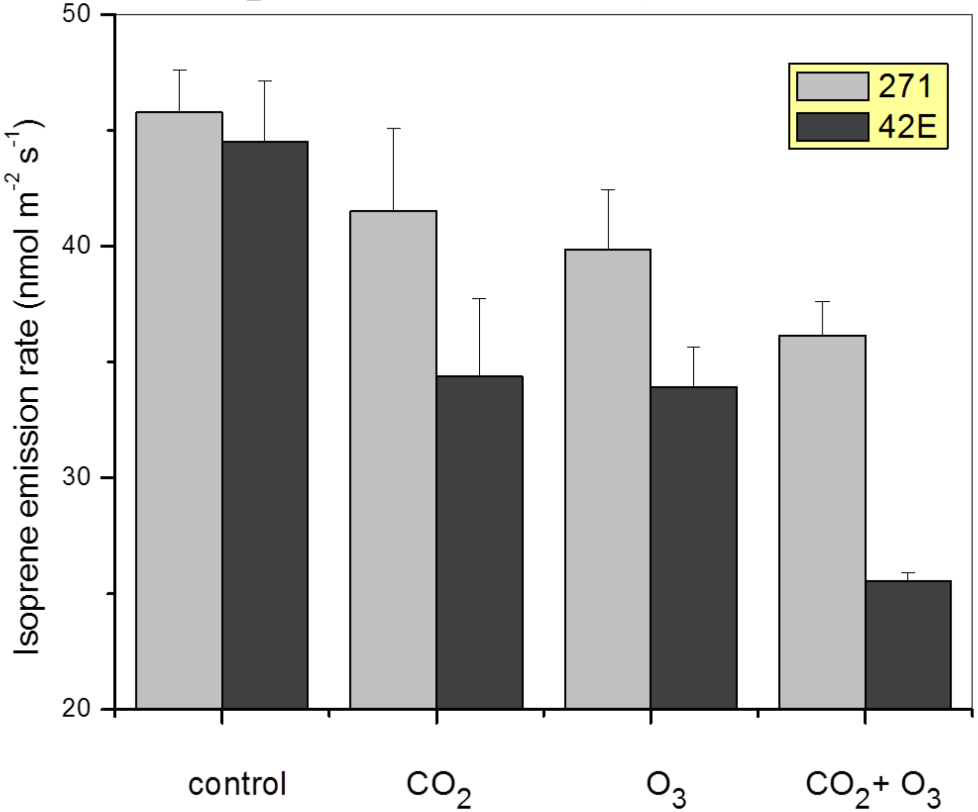
CO_2 effect: Conclusions

- recently agreement on a reduced emission under elevated CO_2
- reason: reduction of dymethylallyl diphosphate (DMAPP) - substrate for isoprene synthesis
- production of DMAPP is also linked to the availability of phosphoenolpyruvate (PEP)
- under elevated CO_2 leaf respiration in the light is usually reduced --- > increased conversion of PEP to pyruvate substracting that from DMAPP synthesis pathway
- there should be a competition between respiration in the light and isoprene emission and differences occurring under elevated CO_2 should highlight this link

Interactions of CO_2 and O_3

Effect of CO2 and O3

Calfapietra et al. (2008)



271= O3 tolerant
42E=O3 sensitive

Control
Elevated CO2 = 550 ppm
Elevated O3 = 1.5 x ambient O3
Elevated CO2 + Elevated O3

Aspen Clones with different O3 sensitivity

	overall	271	42E
CO_2	*	ns	*
O_3	**	ns ($P = 0.052$)	**
CO_2 x O_3	ns	ns	ns

Indirect effects on BVOCs emission

- LAI: ↑CO_2 ↓ozone
- Leaf longevity: ↑CO_2 ↓ozone
- Pests & insects: ? CO_2 ↑ozone

Perspectives

- We are now able to clone the isoprene synthase gene from many species
- If the protective benefits of isoprene for the plants are large, then it might be better to engineer those plants who don’t emit isoprene to make it
- If the protective benefits are small, then it might be better to engineer those plants that do make isoprene to no longer make it

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