‘Sci Fi Forest’ – propelling an English oak woodland to 2050

Michael Tausz and Rob MacKenzie
on behalf of the BIFoR team

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Photo credit: A. Priest Photograph

FACE – Free Air CO_2 Enrichment

- Scientific background – rising carbon dioxide in the atmosphere (CO_2)
- Mature forest FACE experiment
- The unique opportunity

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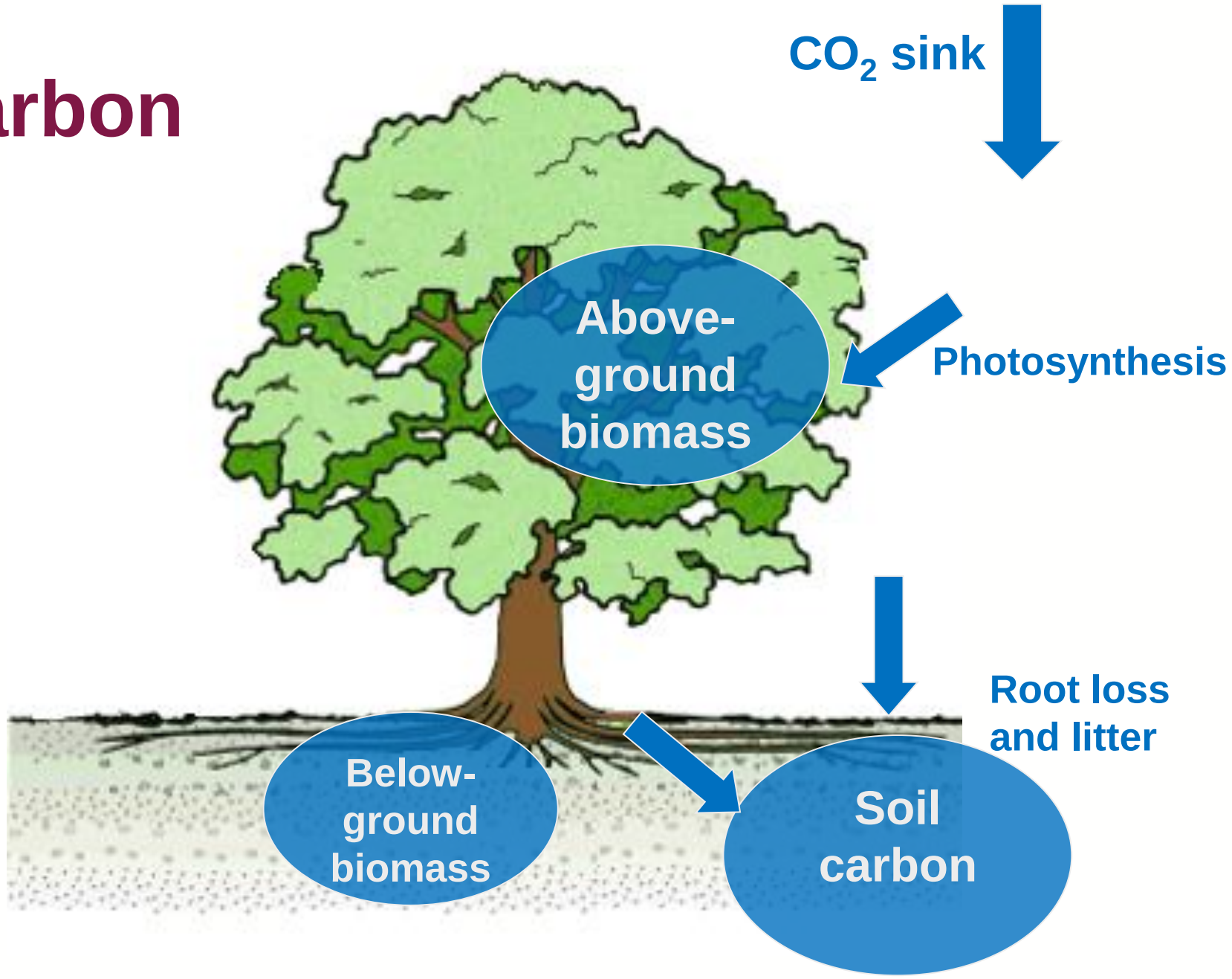
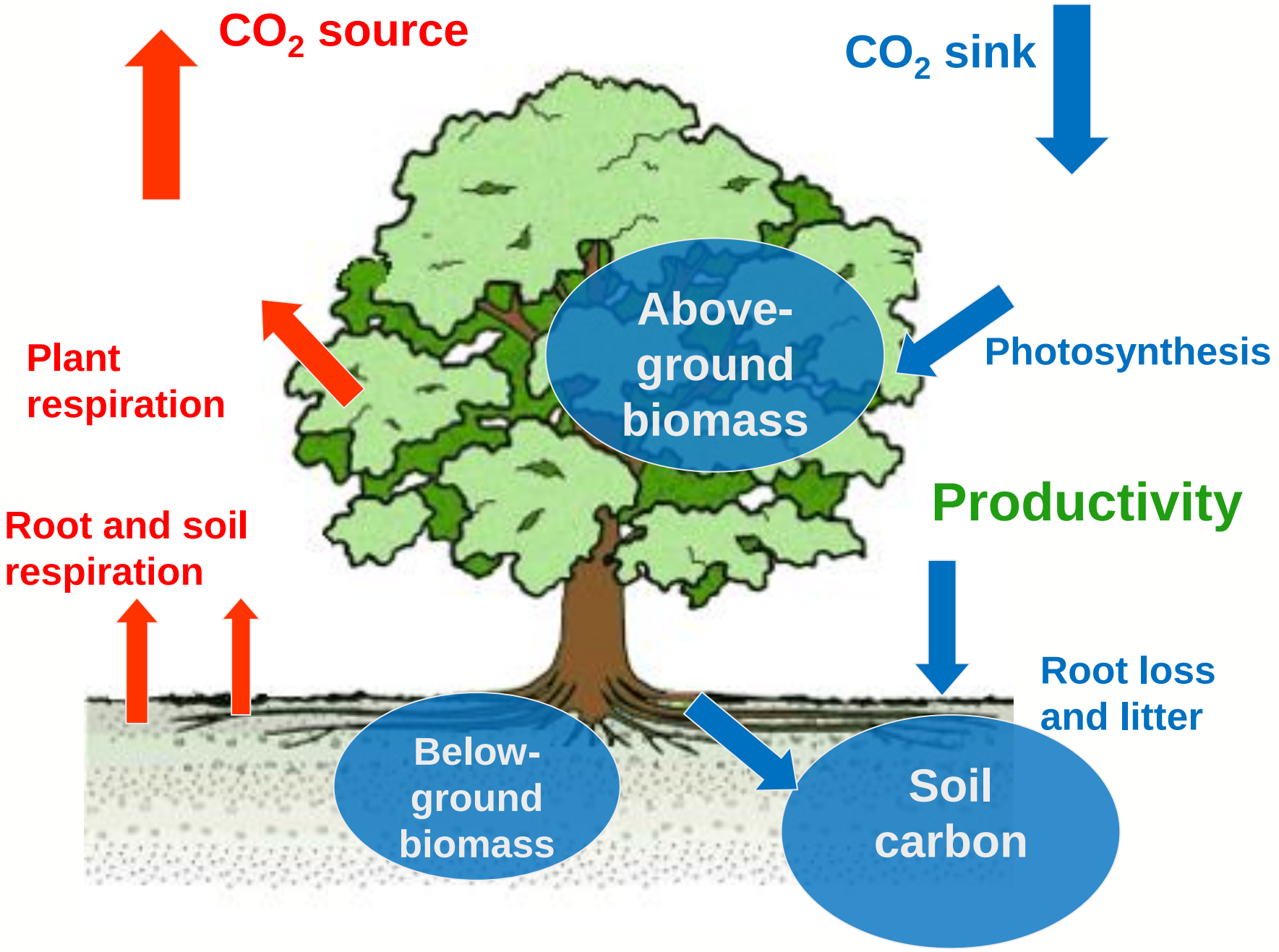
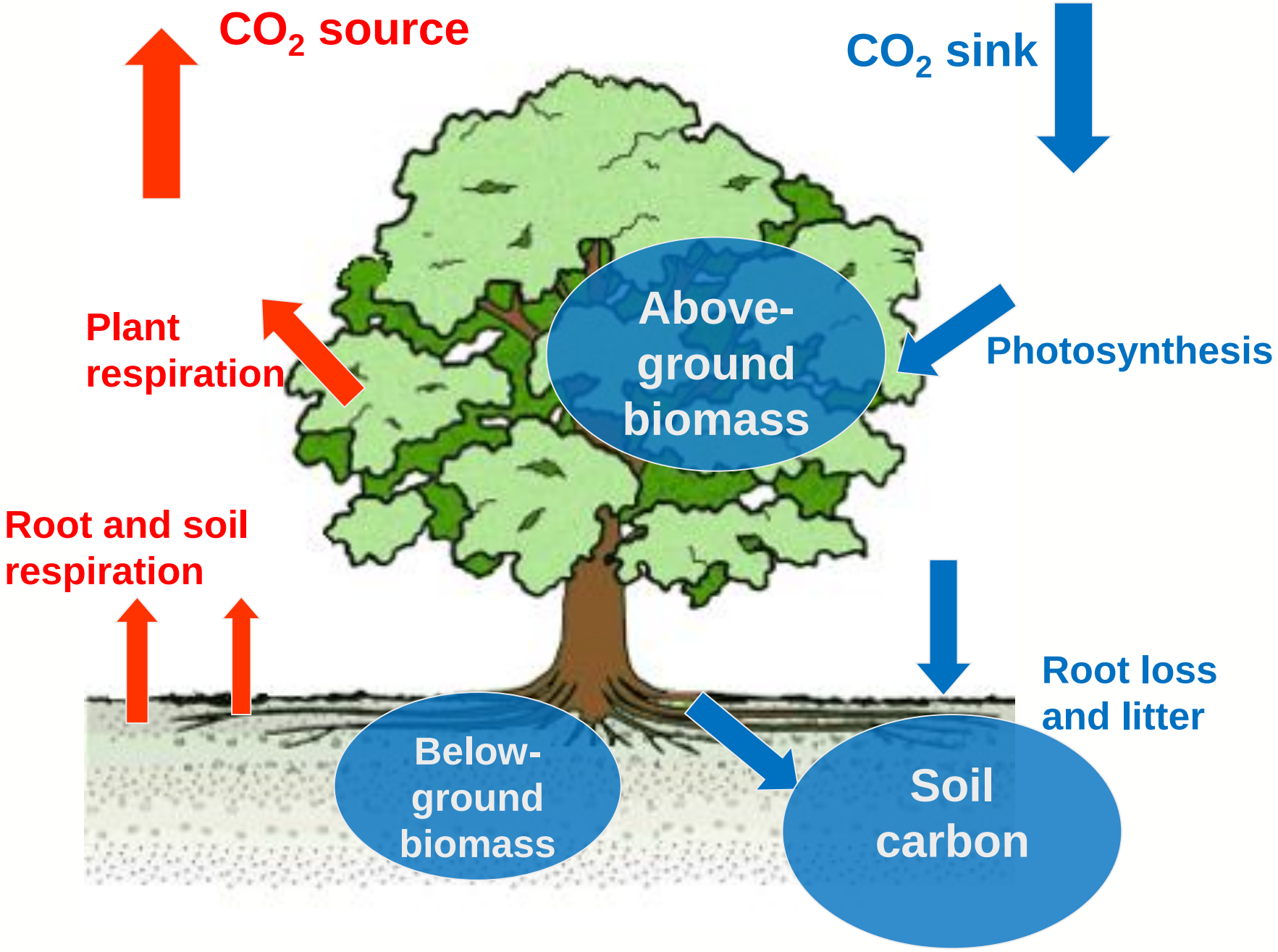
Carbon



Wilkinson M;
https://www.forestry.gov.uk/fr/straits


CO_2 source
CO_2 sink
Above-ground biomass
Plant respiration
Photosynthesis
Productivity
Root and soil respiration
Root loss and litter
Below-ground biomass
Soil carbon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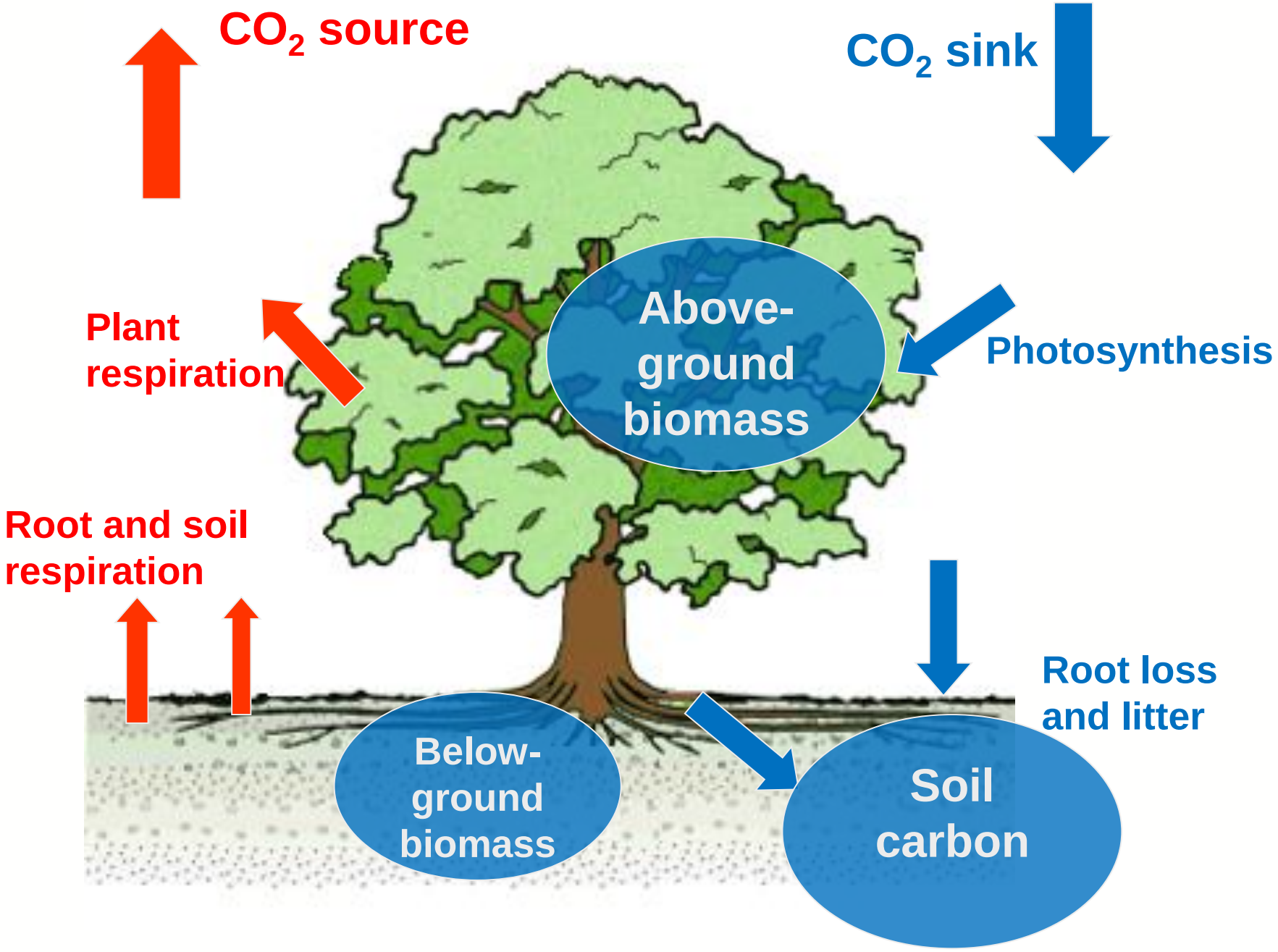
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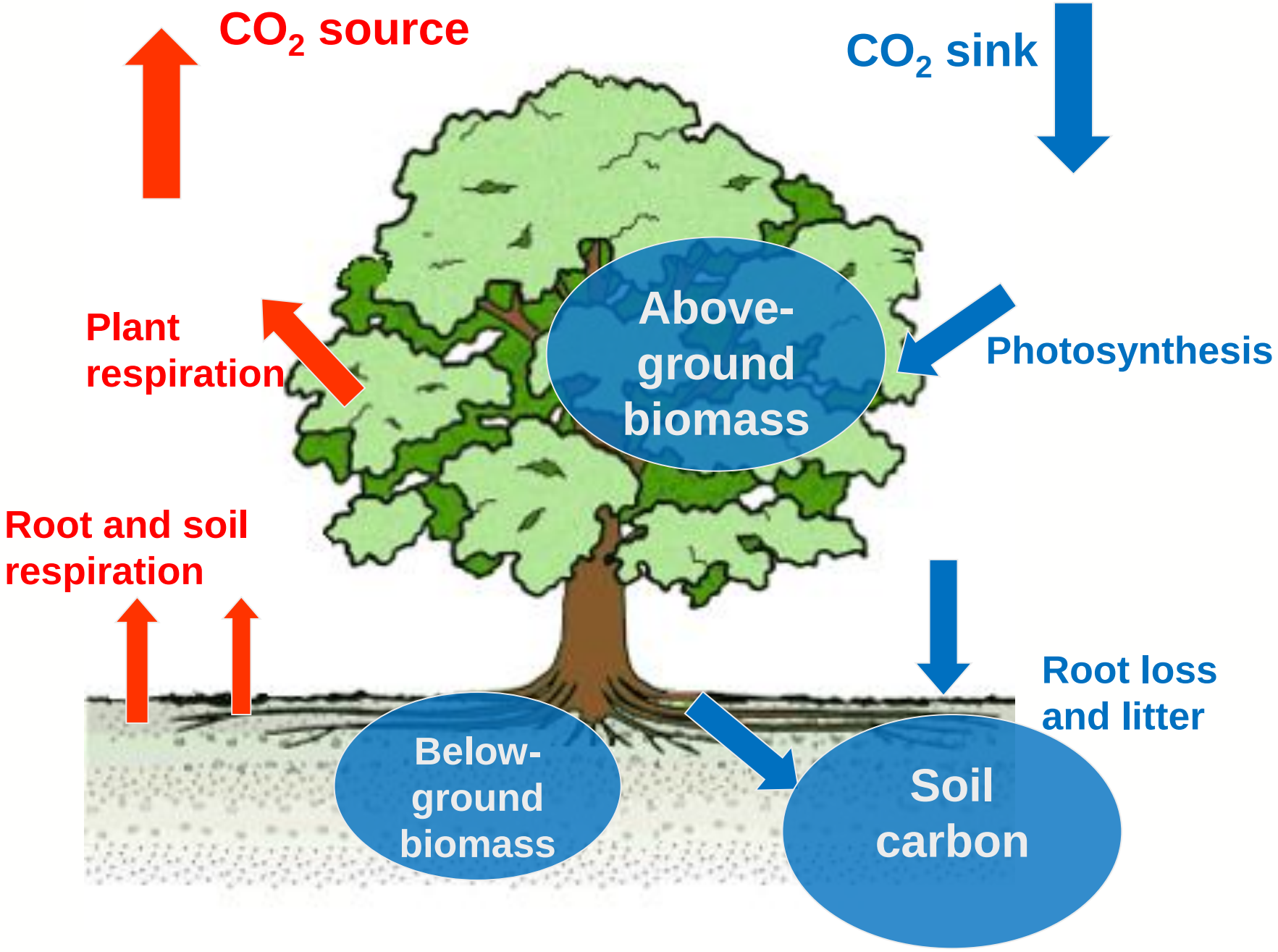
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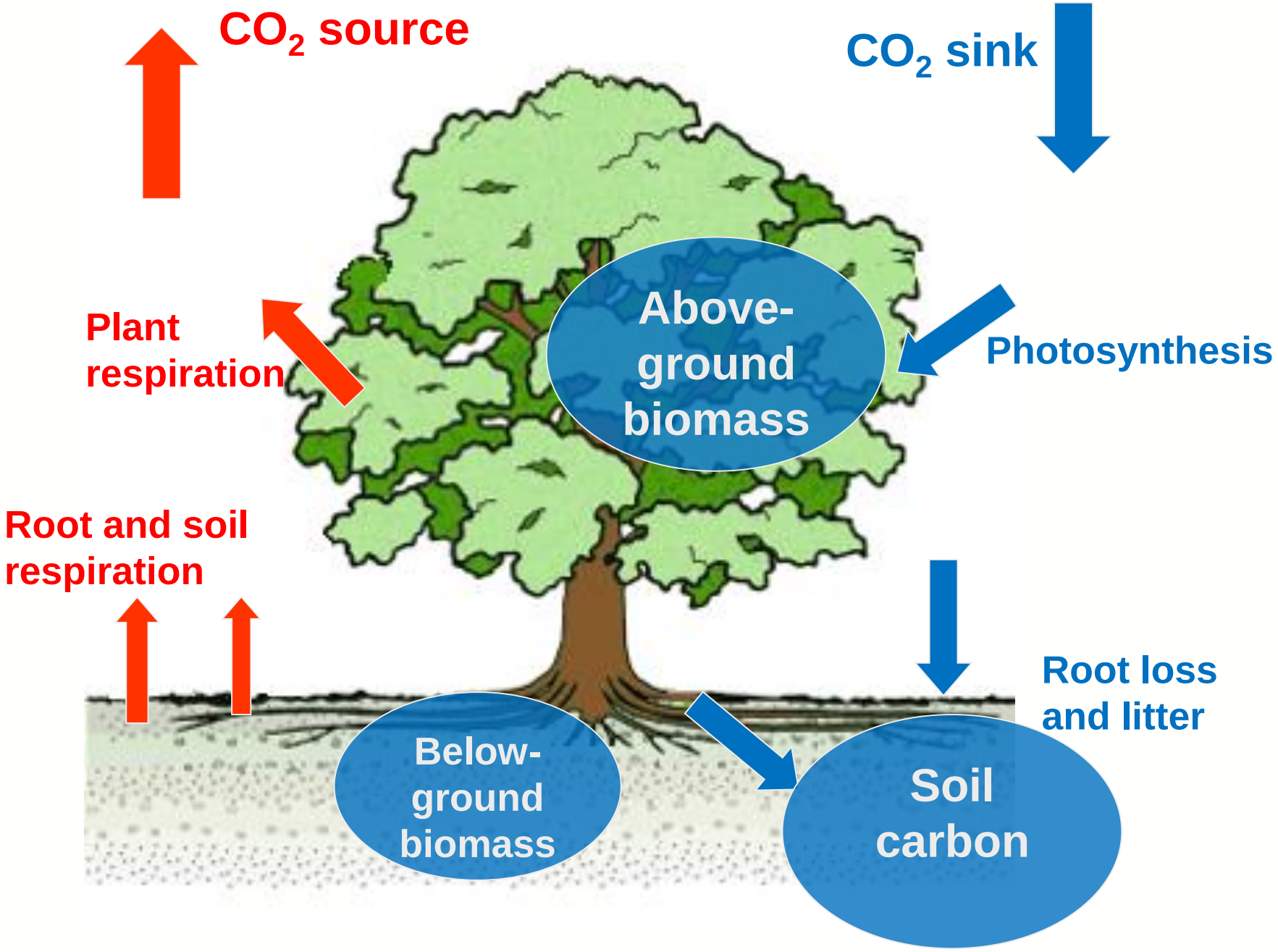
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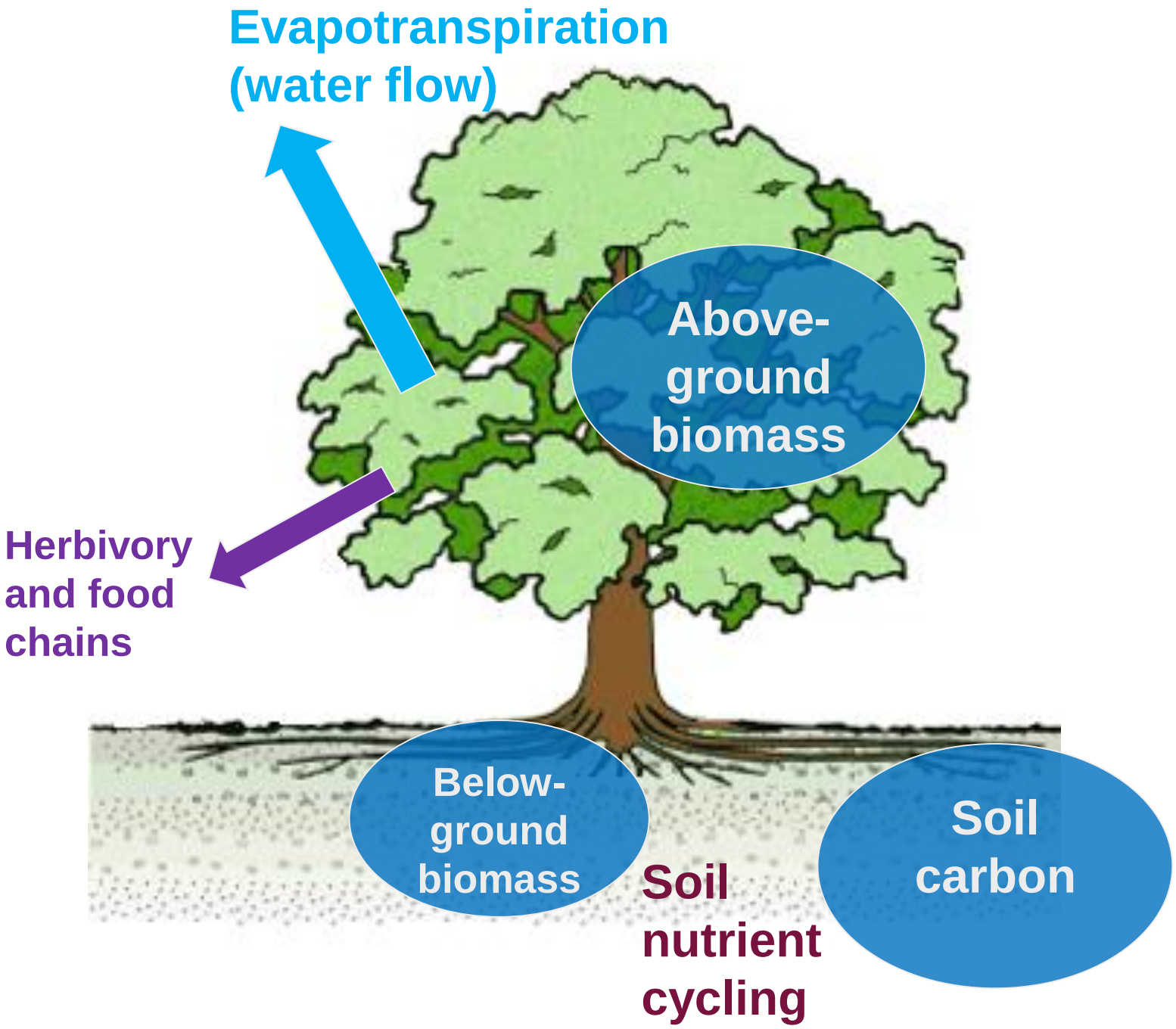
Evapotranspiration
(water flow)
Above-
ground
biomass
Herbivory
and food
chains
Below-
ground
biomass
Soil
nutrient
cycling
Soil
carbon

Big questions about land carbon

- How does elevated CO_2 change carbon flows and storage, nutrient cycles and water use?
- How does elevated CO_2 change biodiversity and ecosystem structure and function?
- How does elevated CO_2 affect susceptibility to biotic and abiotic stress?

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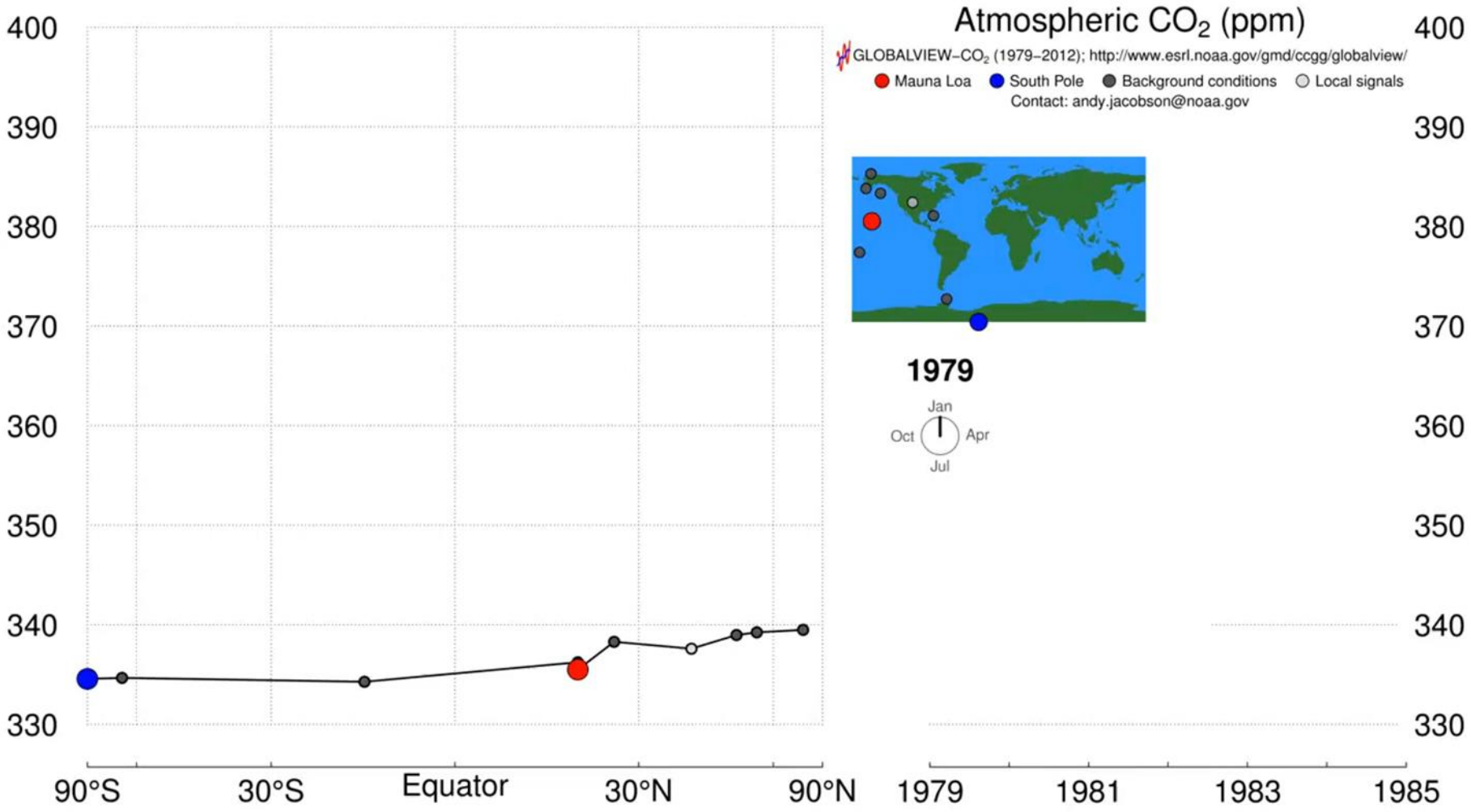
Science Background

The rise of atmospheric CO_2

Atmospheric CO_2



https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html

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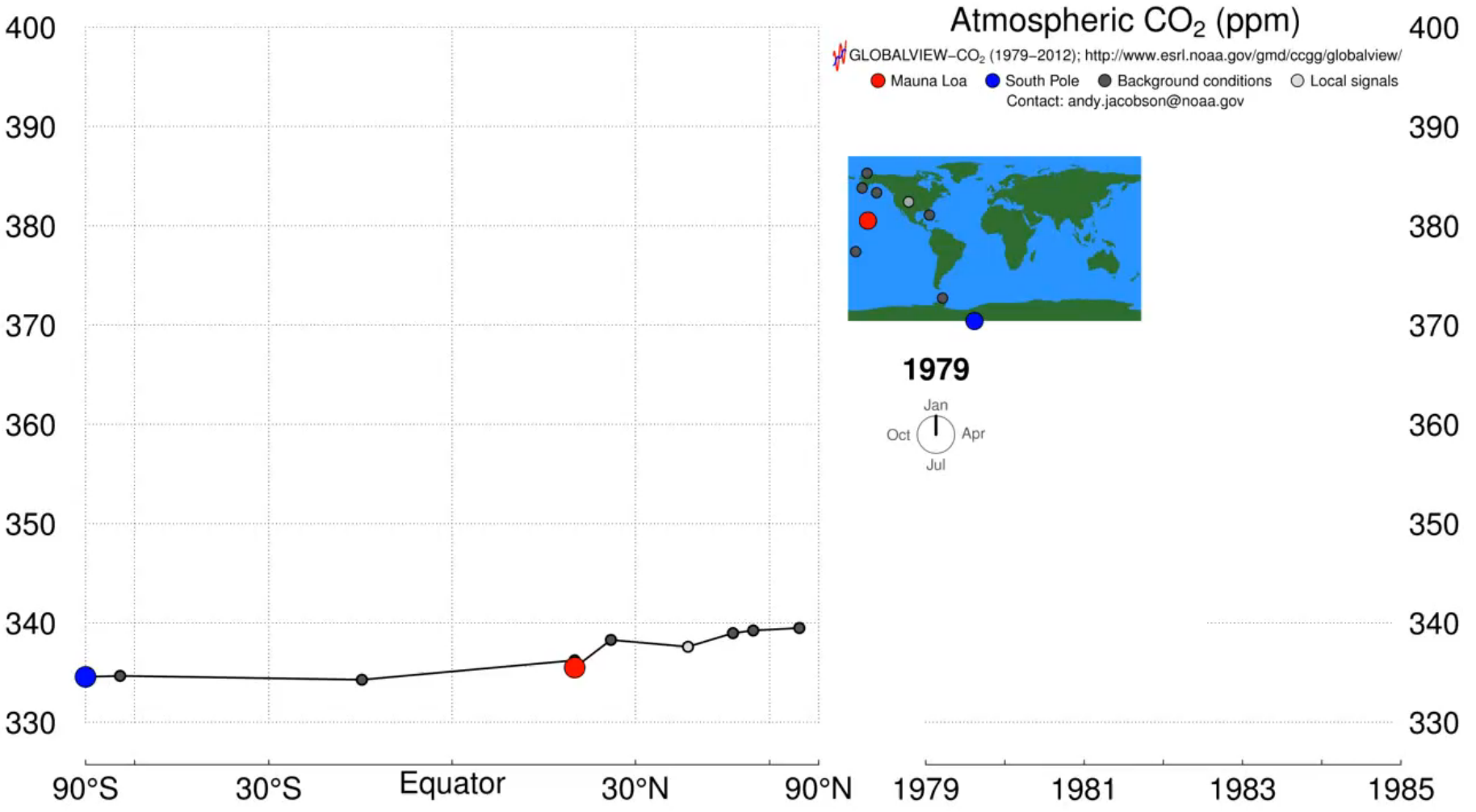
Atmospheric CO_2



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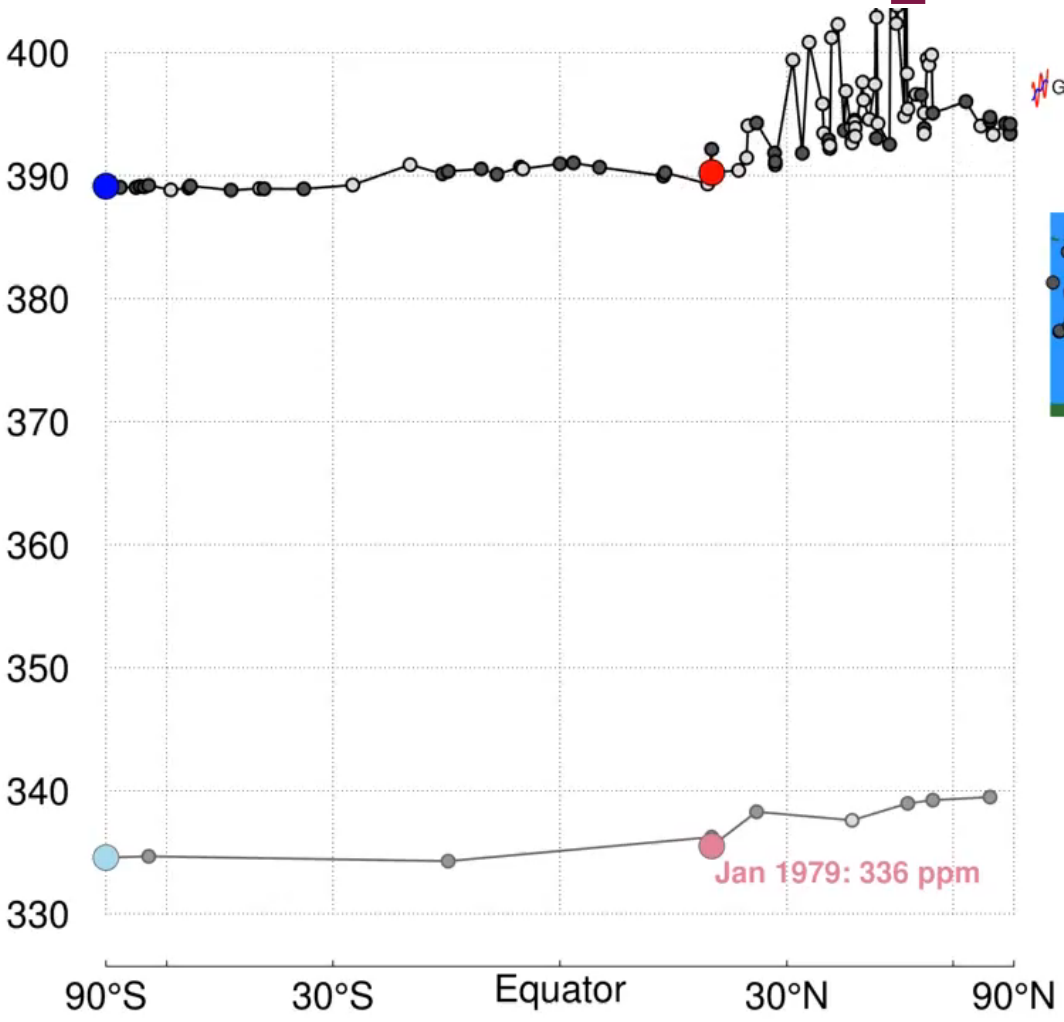
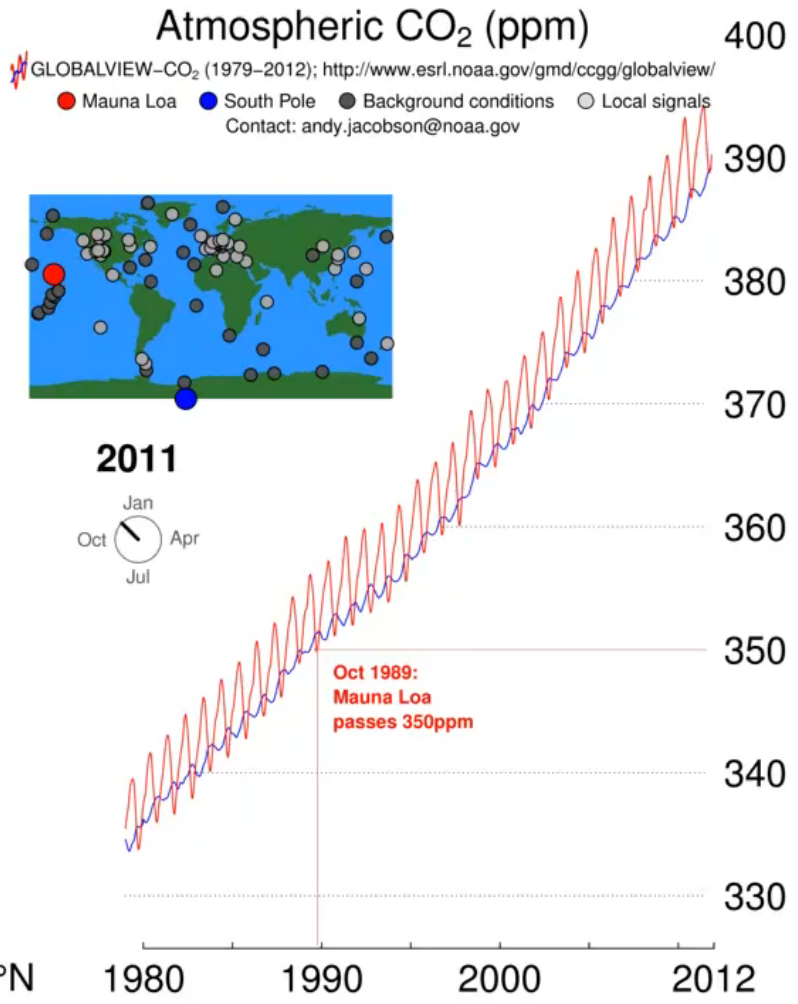
Atmospheric CO_2





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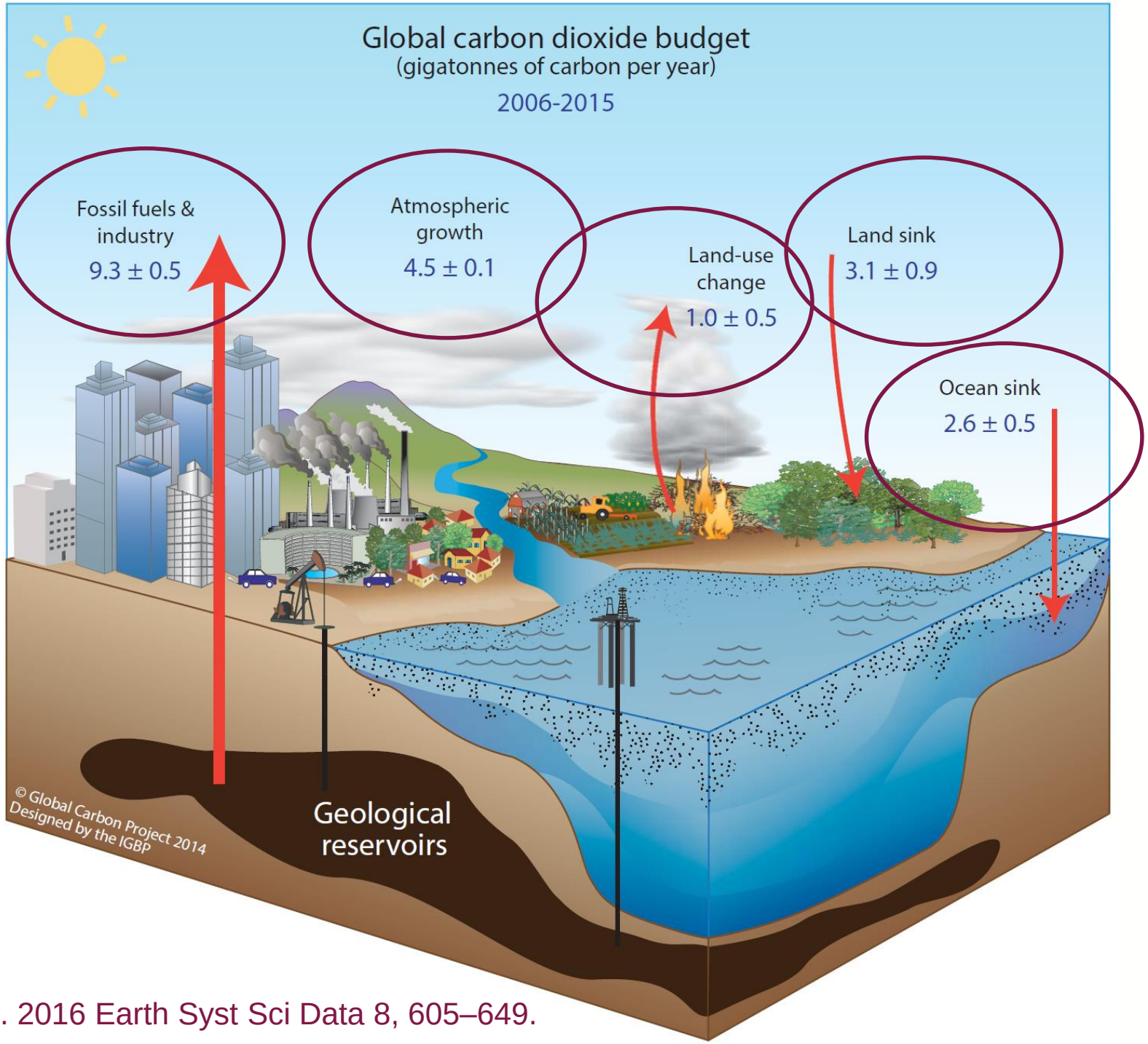
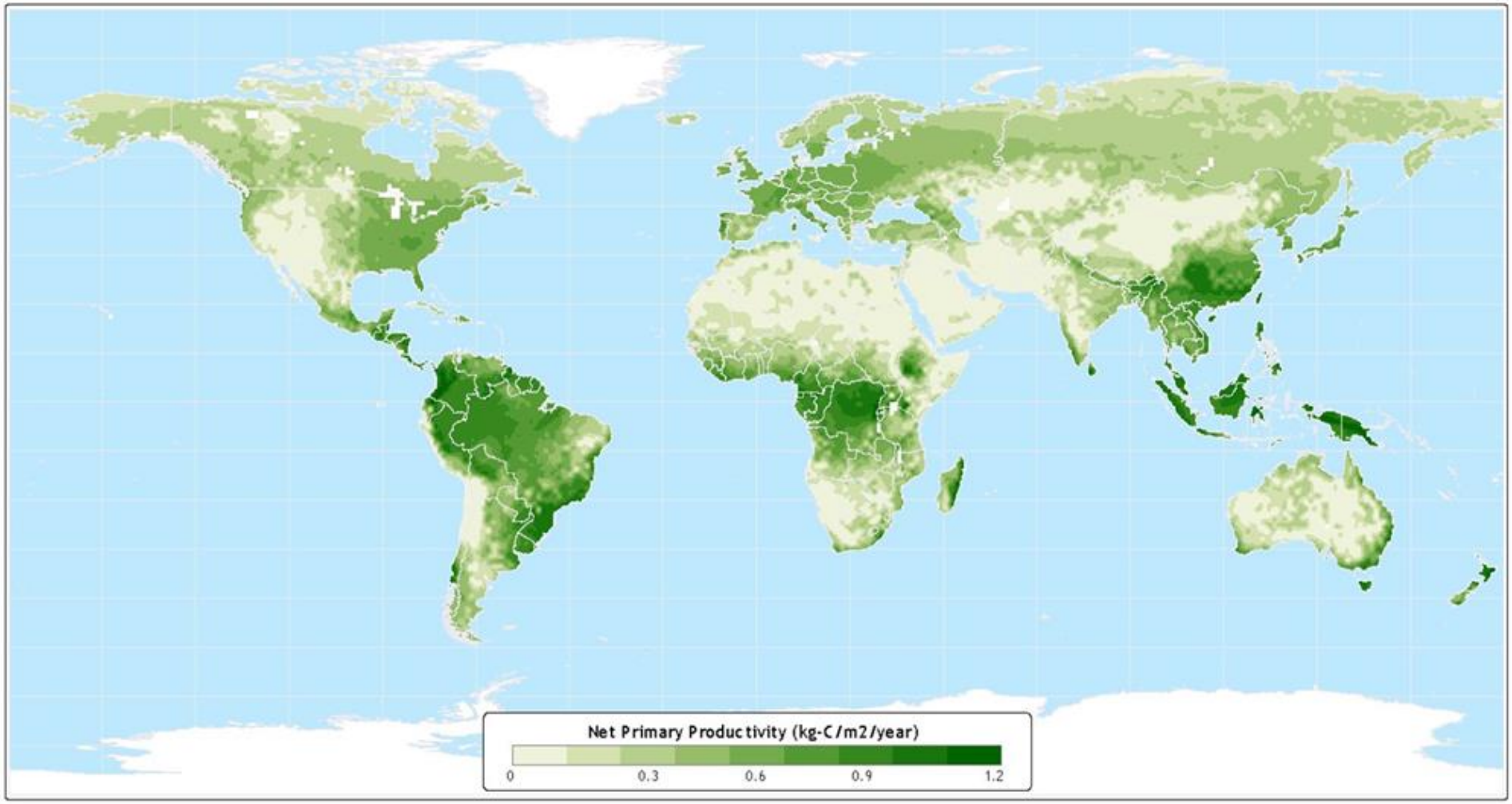


Quéré et al. 2016 Earth Syst Sci Data 8, 605–649.

Net Primary Productivity



Data taken from: IBIS Simulation
(Kucharik, et al. 2000)
(Foley, et al. 1996)

Atlas of the Biosphere

Center for Sustainability and the Global Environment
University of Wisconsin - Madison

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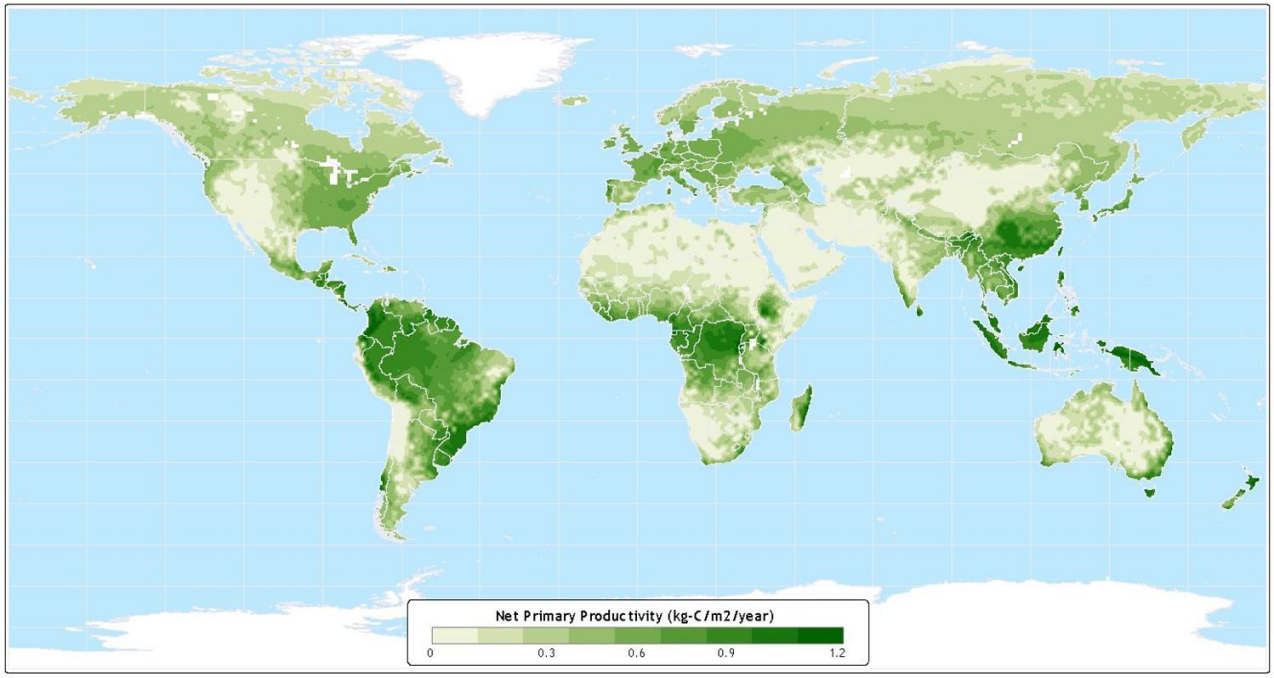

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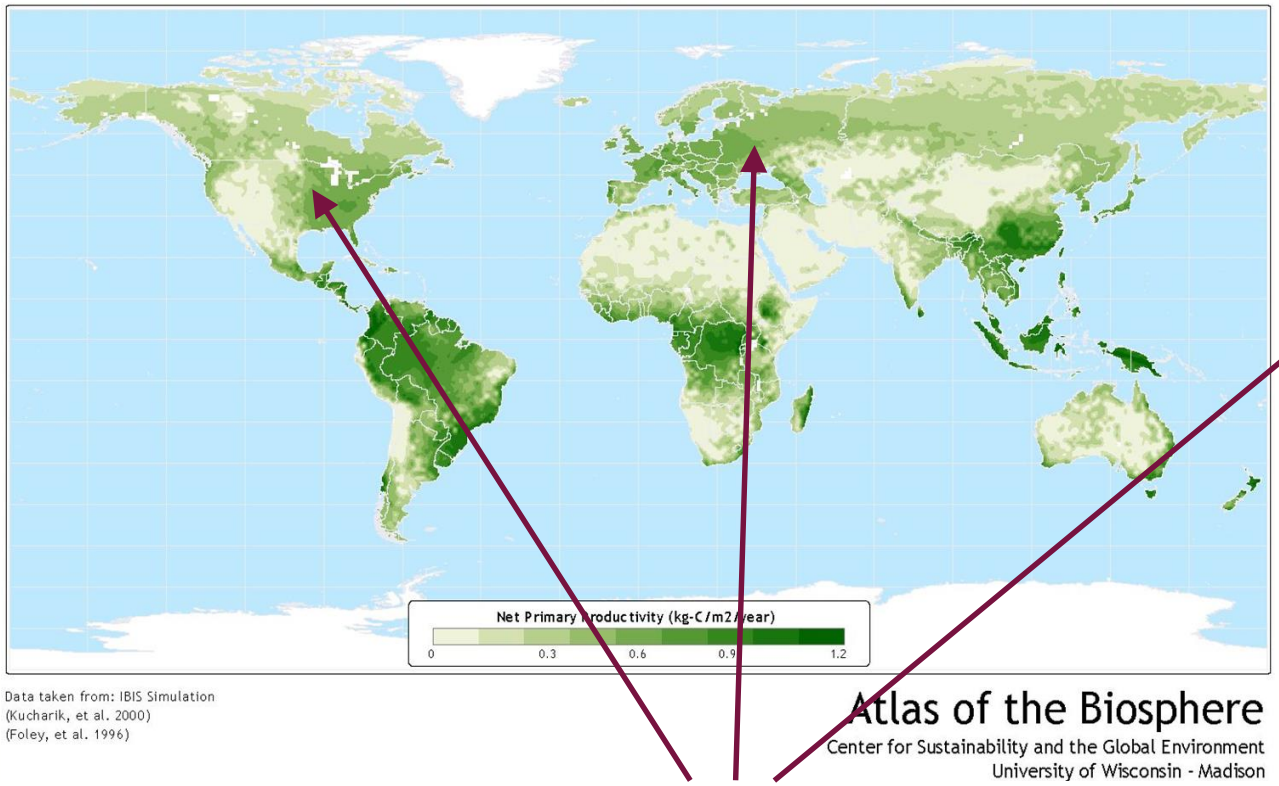
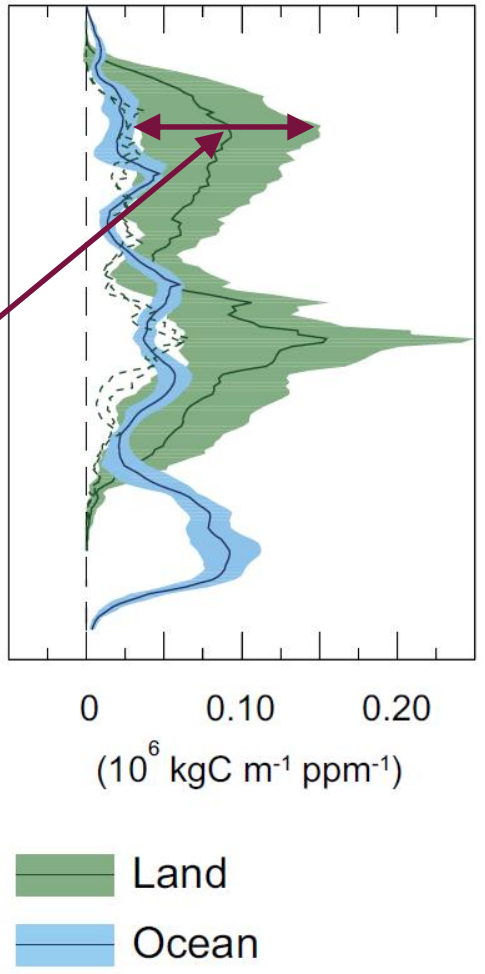
Uncertainty!





Northern Hemisphere Temperate Forests

Extra carbon per unit land area per unit increase in CO_2

Ciais et al 2013. In: Climate Change 2013. The Physical Science Basis. Cambridge Univ Press. (Fig 6.22)

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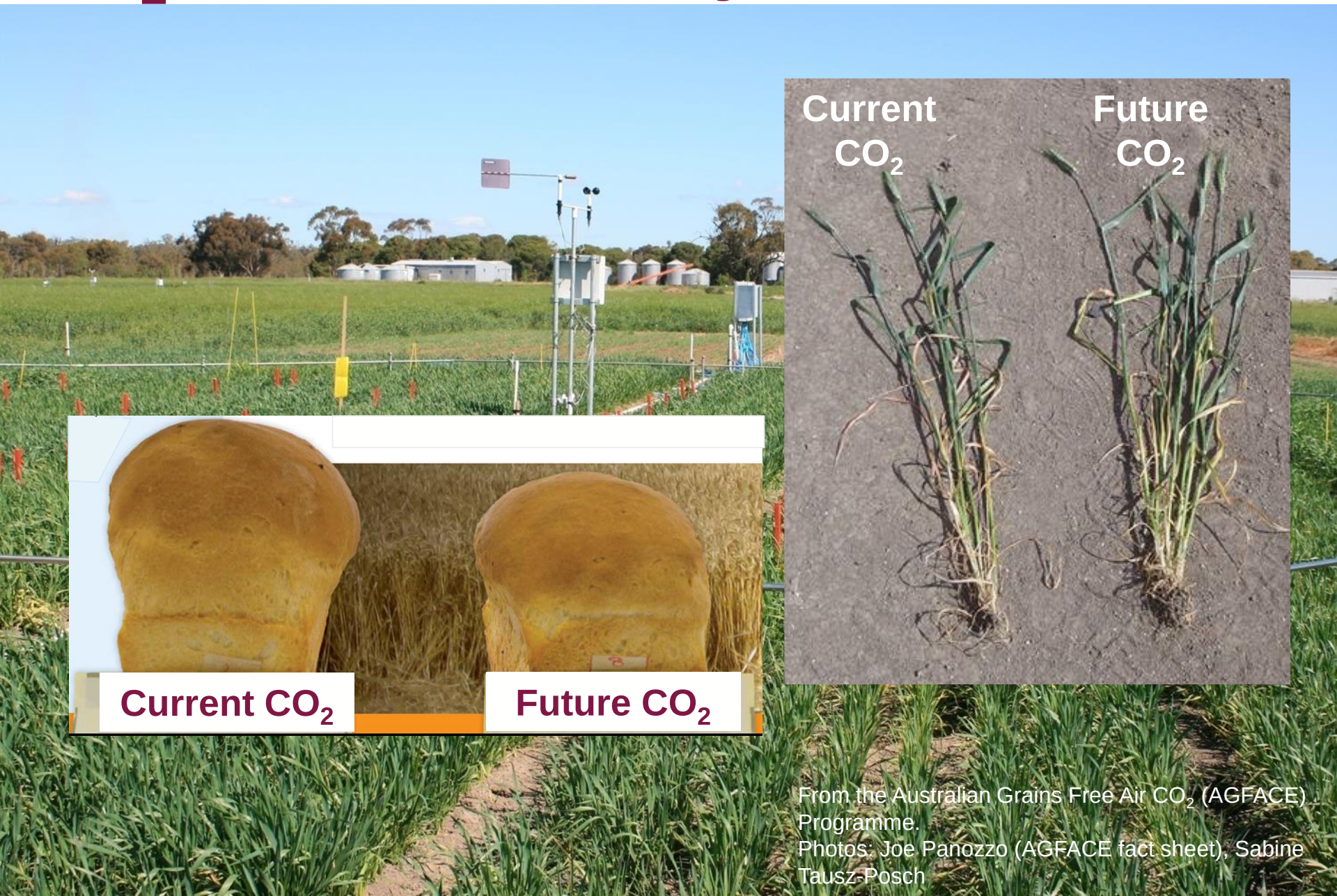
Science Background

CO_2 and plants and ecosystems

CO_2 'fertilisation' – yes, but!



From the Australian Grains Free Air CO_2 (AGFACE) Programme.
Photos: Joe Panozzo (AGFACE fact sheet), Sabine Tausz-Posch

Forest FACE experiments

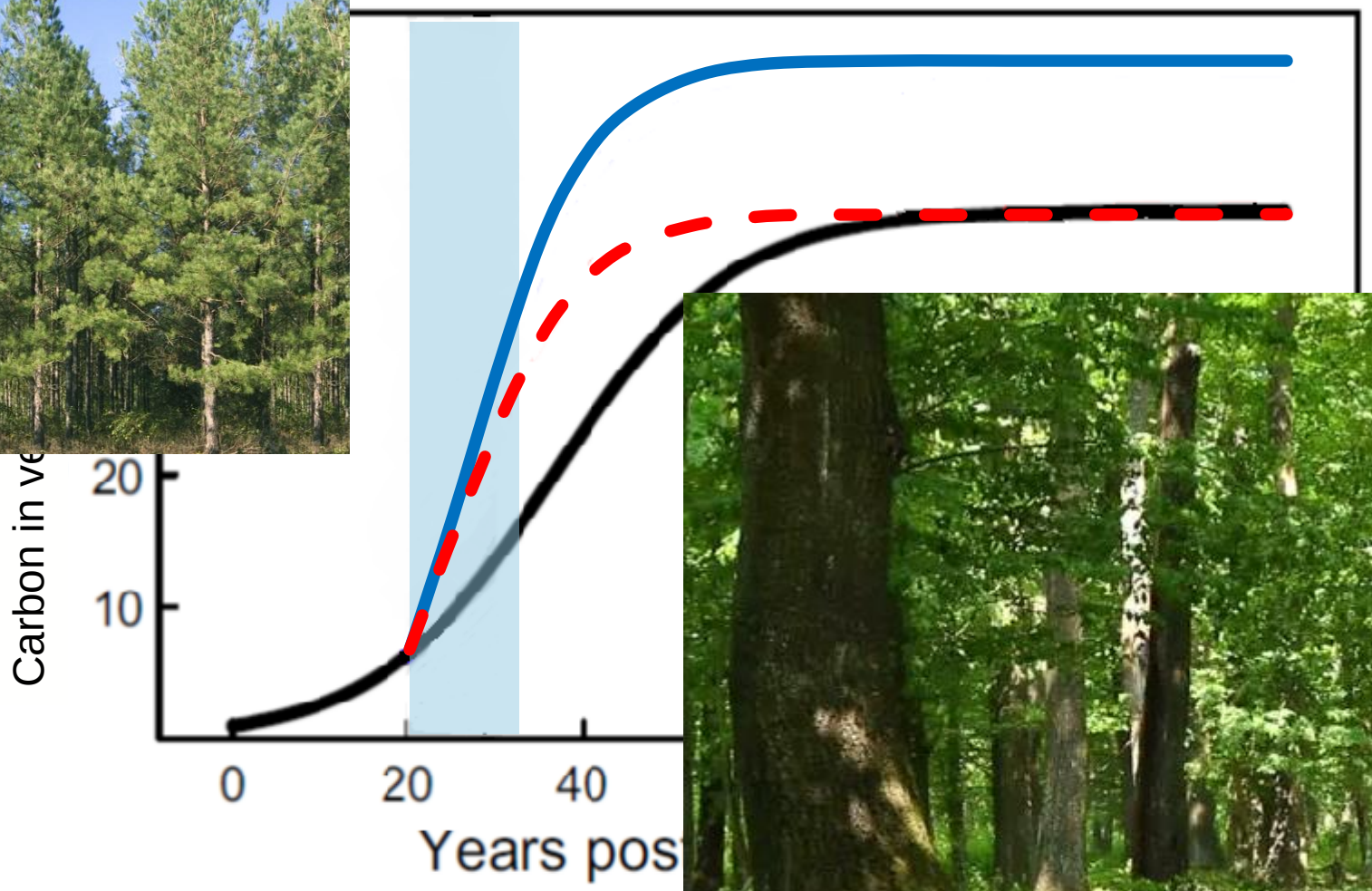
"First generation" forest FACE experiments in young, uniform, vigorously growing plantations

The closure of Duke University's FACE project could be used to fund a new generation of experiments.

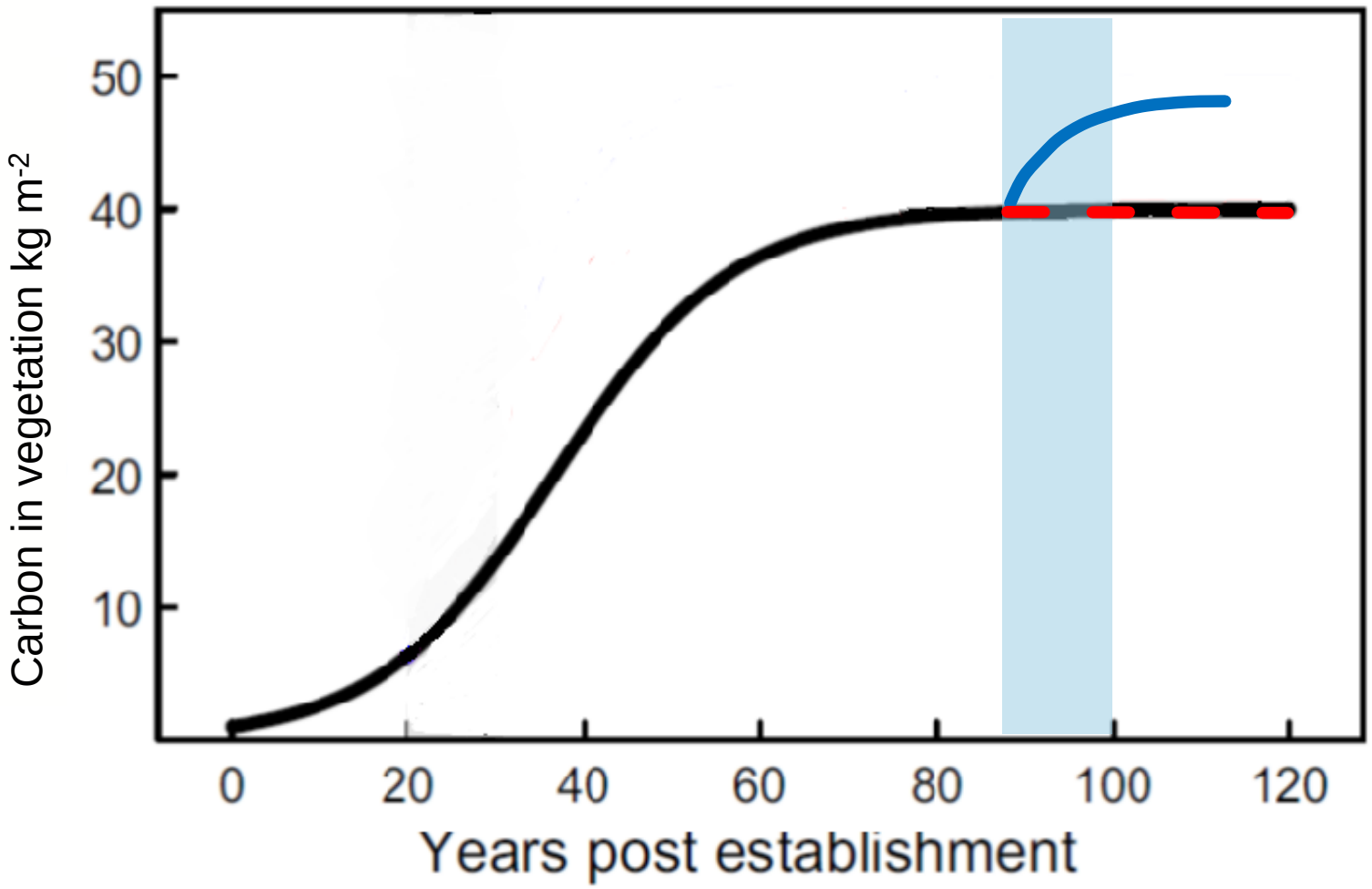
Nature News 2008. Nature 456, 289.

Aspen FACE in Rhinelander, USA (http://aspenface.mtu.edu/)

Forest FACE experiments



Forest FACE experiments



Norby et al 2015. New Phytologist

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‘BIFoR FACE’ in Mill Haft

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Mill Haft woodland

…old forest soil

Big questions on soil nitrogen and phosphorus cycling

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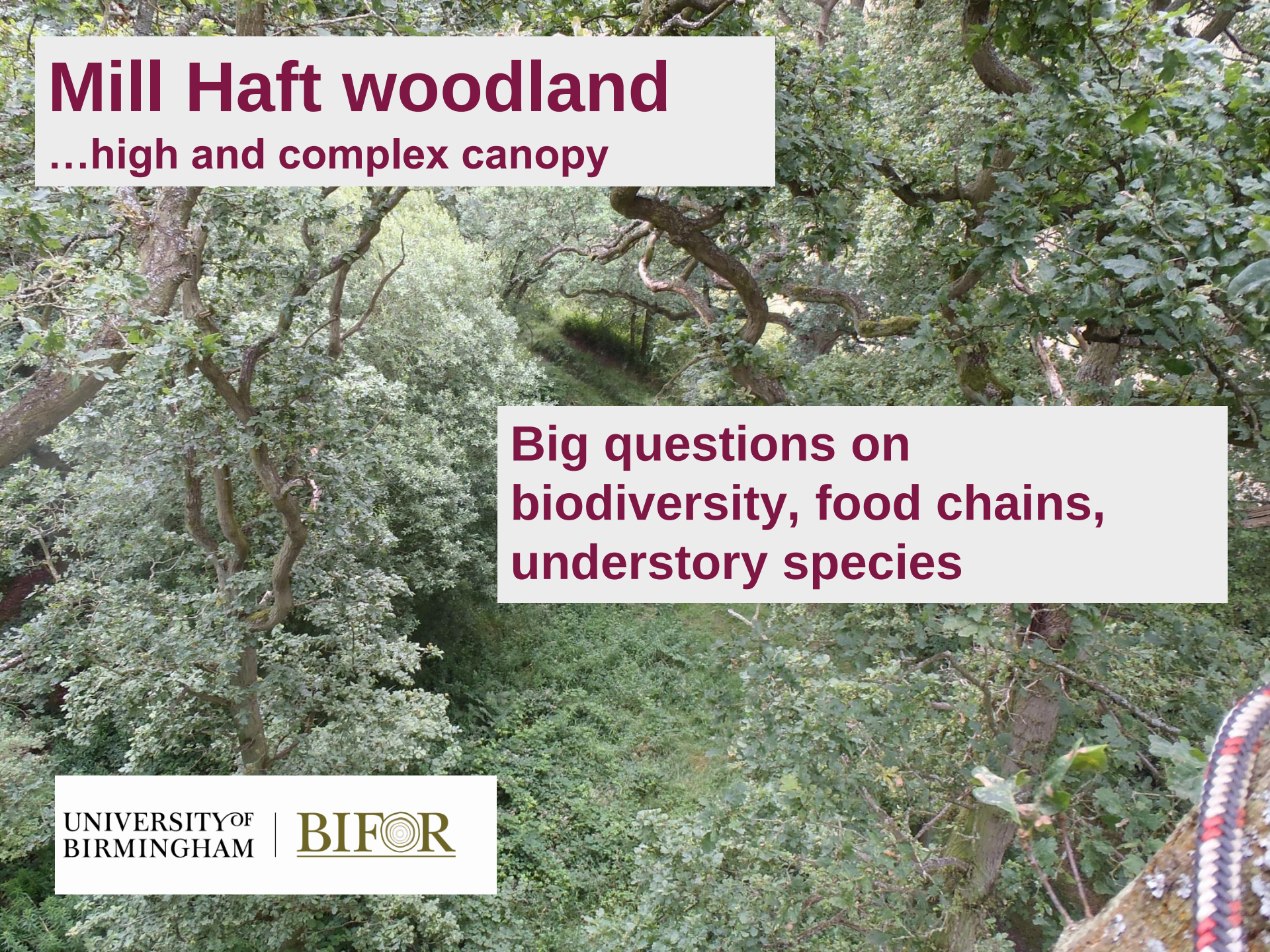

Mill Haft woodland

…high and complex canopy

Big questions on biodiversity, food chains, understory species

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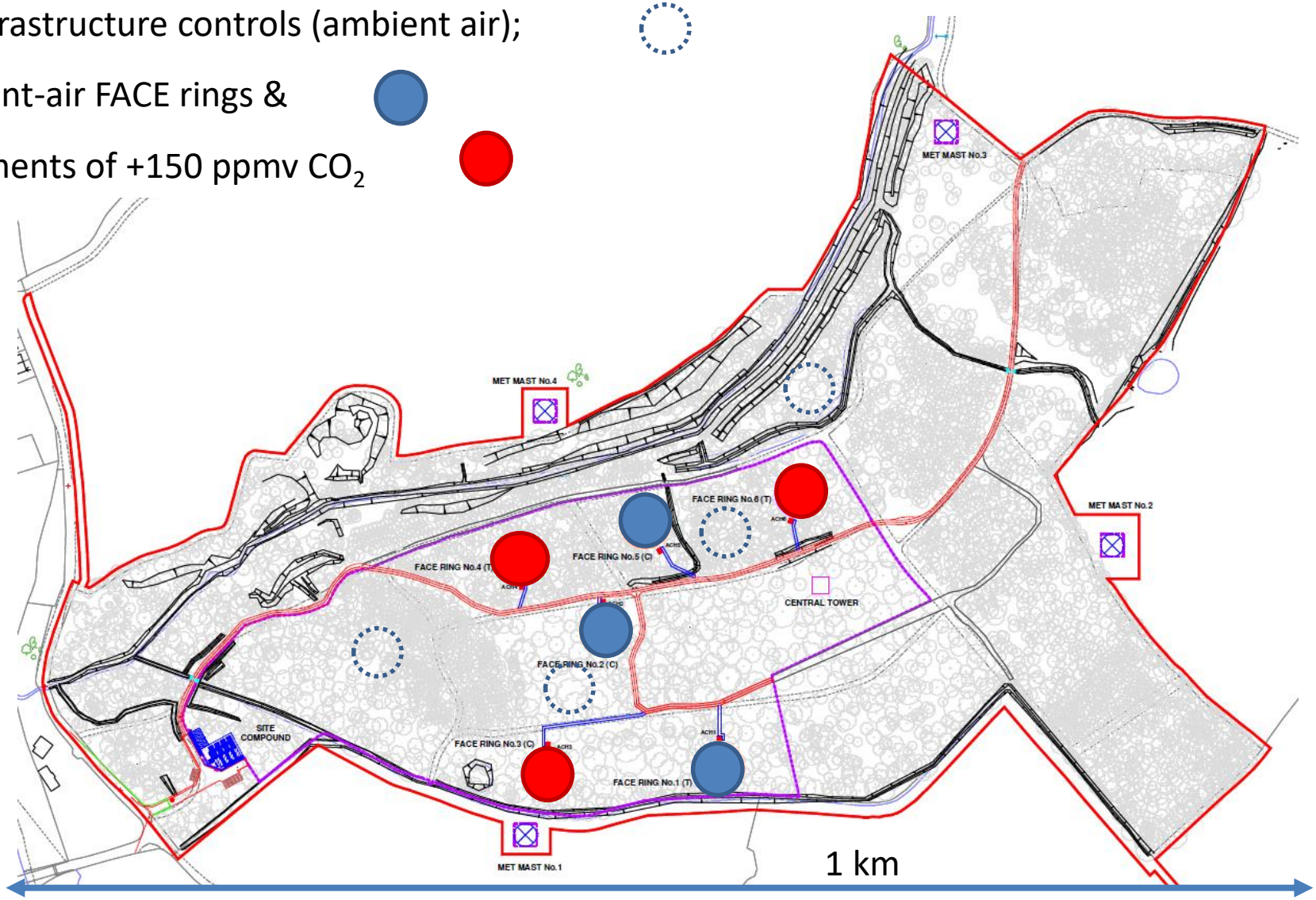
BIFoR FACE at Mill Haft

3 no-infrastructure controls (ambient air);

3 ambient-air FACE rings &

3 treatments of +150 ppmv CO_2



Mill Haft woodland

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Big moment! 3rd April 2017

BBC News

Mill Haft woodland

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FACE Plot Performance: April 4th – August 31st 2017

	ppm	±
Enrichment Target	150.0	0.2
Set Target	547.7	15.5
Average Enrichment Achieved	545.9	29.7
Above Ambient Achieved	148.2	24.6
Average Control Plot (Ambient)	397.7	15.5
Fumigation Time on Target	91.5	%

EucFACE:

88% of 5-min means within +- 37.5 ppm (512.5-587.5 ppm)
(Drake et al 2016, GCB 22, 280-290)

95% of 1-min means within 75 ppm of target (475-625 ppm)
(Ellsworth et al 2017; Nature Climate Change 7)

Operational Statistics	Hours
Leaf-On Operations	3600
Total Fumigation	2412
Fumigation Off	1188
Total Downtime	67.7
Total Operational	2344.3
Uptime	97.2%
CO_2 Consumed to date (tons)	3,815.4
CO_2 Cost to Project	£311,197

EucFACE: 95%
(Ellsworth et al 2017; Nature Climate Change 7)

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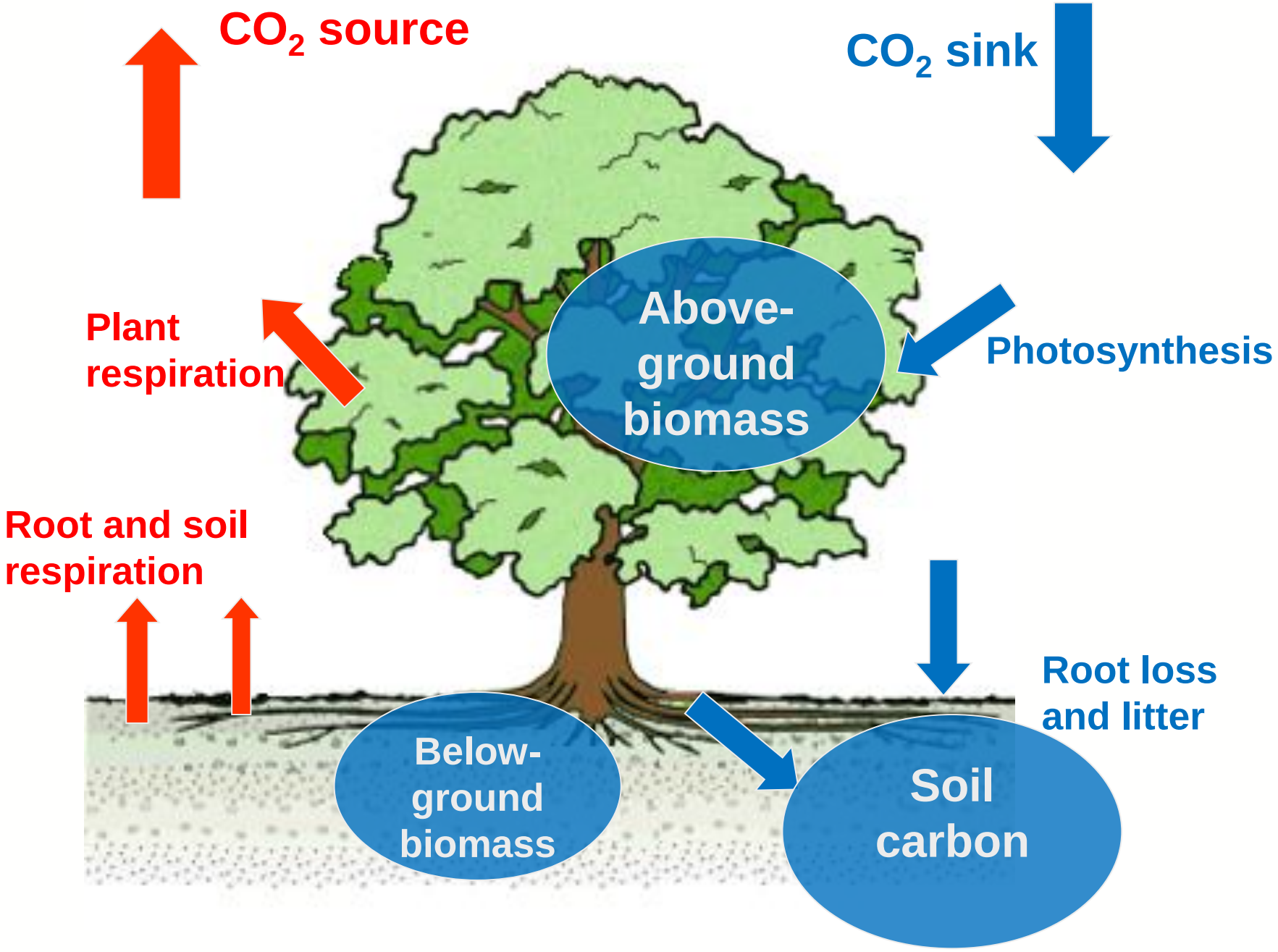
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Soil carbon

- Currently only two comparable facilities in operation worldwide
- National and International scientific facility
- Collaborations!

More Information

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