Risk that the terrestrial carbon sink declines in the future

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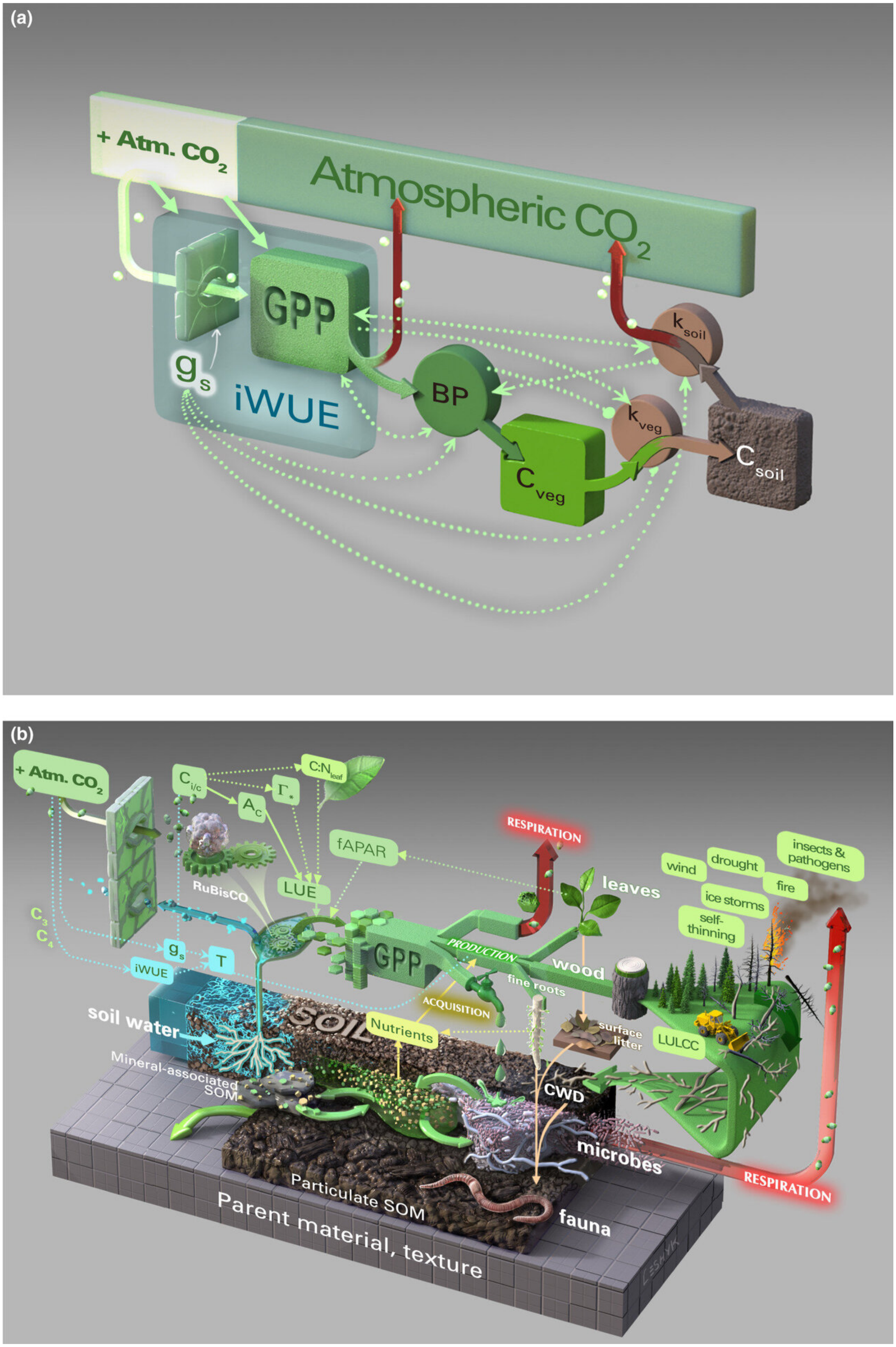
(a)
+ Atm. CO2
Atmospheric CO2
GPP
gs
iWUE
BP
Cveg
kveg
ksoil
Csoil
(b)
+ Atm. CO2
Ci/c
Ac
Γ*
C:Nleaf
RuBisCO
LUE
fAPAR
C3
C4
gs
T
iWUE
RESPIRATION
leaves
wind
drought
insects & pathogens
fire
ice storms
self-thinning
GPP
PRODUCTION
wood
fine roots
ACQUISITION
Nutrients
soil water
SOIL
surface litter
LULCC
CWD
Mineral-associated SOM
microbes
RESPIRATION
Particulate SOM
fauna
Parent material, texture

Conceptual diagrams of the terrestrial carbon cycle and the action of elevated atmospheric [CO2] (eCO2). (a) Simple pool and flux (three-dimensional (3D) shapes) diagram of the terrestrial carbon cycle showing key pools, fluxes, and processes relevant to the CO2-fertilization hypothesis as described in Box 1. Two-dimensional (2D) arrows represent direct (solid) or indirect (dashed) positive influences (triangular arrow heads), or the possibility of both positive and negative (circular) influences of eCO2. (b) Rich conceptual diagram of a landscape-scale carbon cycle and the influence of eCO2 showing more processes (see Section II) and their interconnected, multiscale nature. Solid arrows (3D and 2D) represent material (mostly carbon) flows, dotted arrows represent influence. Abbreviations not in Table 1: Ci/c, internal or chloroplastic [CO2]; Ac, carboxylation limited photosynthesis; Γ*, photorespiration; C : Nleaf, leaf carbon : nitrogen ratio; T, transpiration; LULCC, land-use and land cover change; CWD, coarse woody debris. Credit: *New Phytologist* (2020). DOI: 10.1111/nph.16866

Climate consequences can in the future become even bigger than thought, because the capacity of the land vegetation to absorb carbon dioxide is likely to decline. This is the conclusion of a large international study with contribution by Umeå University. So far the vegetation has dampened climate change by taking up a significant fraction of carbon dioxide emissions, but it is uncertain if this effect will persist.

"Plants need carbon dioxide for photosynthesis, but higher carbon dioxide concentrations in the atmosphere do not necessarily increase plant growth," says Jürgen Schleucher, professor at Umeå University.

In the study published in the scientific journal *New Phytologist*, a large international group of researchers has integrated the knowledge how increasing carbon dioxide levels affect plants. Currently, the land vegetation absorbs around one third of human carbon dioxide emissions.

The problem is that this "carbon sink" is driven by the increase in atmospheric carbon dioxide levels. But in spite of this sink, the world climate currently still follows the most dramatic climate scenario described by the International Panel on Climate Change. Without the land carbon sink, the climate crisis would be even more drastic than it is. That's why it is so important to estimate how the land carbon sink will develop.

The land carbon sink has been around 11 billion tons carbon dioxide per year, compared to emissions of 35 billion tons. That's now, but to look into the future, to predict the carbon sink decades ahead, for our greatgrandchildren, the authors had to figure out the physiological mechanisms of the sink. That concerns what fraction of the carbon sink is due to carbon dioxide fertilization of photosynthesis, and if models of photosynthesis properly describe its increase. And finally one has to gauge if the current effects will persist over coming decades.

This is where Jürgen's group has contributed with results how rising carbon dioxide has affected photosynthesis over the whole 20th century. That was a detective story, where Jürgen's group first had to develop tools to detect changes in physiology by special chemical analysis of the sugar molecules formed in photosynthesis. These tools were calibrated in experiments where the carbon dioxide concentration was varied from past to future levels. To test responses over decades, the methods were then applied to decade-old herbarium samples and historic sugar cubes.

"It is thrilling to understand a little better how the Earth system works, and rewarding to contribute to research that supports the EU's stronger climate goals," says Jürgen Schleucher.

The publication concludes that current models for photosynthesis explain only a part of the land carbon sink.

"The carbon uptake by the land vegetation has so far bought us time to deal with the climate crisis, but this uptake is likely to decline in the future, for example because rising temperatures can reduce photosynthesis. Even stronger emissions reductions will then be needed to avoid the worst consequences," says Jürgen Schleucher.

More information: Anthony P. Walker et al. Integrating the evidence for a terrestrial carbon sink caused by increasing atmospheric CO 2, *New Phytologist* (2020). DOI: 10.1111/nph.16866

Provided by Umea University