Global vegetation's CO_2 uptake

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Ecosystem ecology: Global vegetation's CO_2 uptake

Sara Vicca

Centre of Excellence PLECO (Plants and Ecosystems), Biology Department, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium

Multiple lines of evidence reveal that annual maximum photosynthesis across the world has been increasing over the past 30 years, adding crucial new information on the processes influencing the land carbon sink, and of vegetation's key role in mitigating climate change.

Globally, terrestrial ecosystems have been absorbing roughly 30% of anthropogenic carbon dioxide (CO_2) emissions, hence retarding climate change[1]. This land carbon sink reflects the balance between CO_2 uptake by vegetation during photosynthesis, and CO_2 losses from vegetation and soils through respiration (Fig. 1a). Changes to the photosynthetic rate or to the length of the photosynthetic period will affect the potential for vegetation to absorb CO_2, and thus the carbon cycle feedback to climate. Understanding these processes is critical for reliably projecting the impact of different greenhouse gas emission trajectories. Writing in *Nature Ecology and Evolution*, Huang et al.[6] provide the first global study on changes in peak vegetation growth and photosynthesis, and the underlying drivers.

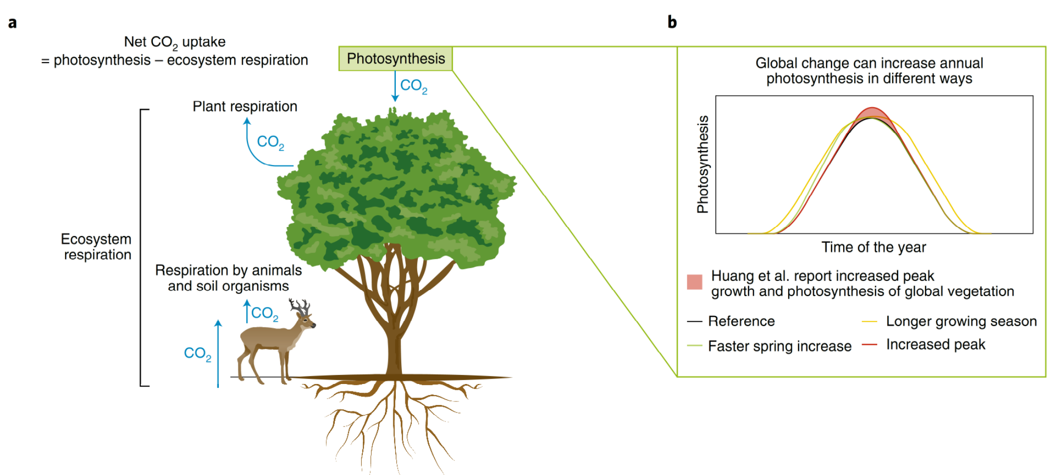

*Figure 1: **Changes in photosynthesis can alter the land carbon sink**. a) The land carbon sink is primarily determined by the balance between CO_2 uptake during photosynthesis and CO_2 losses during respiration. Increases in photosynthesis, if not followed by increases in respiration, can increase the land carbon sink strength. **b**, Annual photosynthesis can increase due to lengthening of the growing season (yellow line), by increased uptake rates early in the season (green line), and/or by increased maximum photosynthesis rates (red line).Huang et al.[6] report that annual maximum photosynthesis by global vegetation has increased linearly over the past 30 years.*

Previous work has suggested that the positive effect of increasing CO_2 concentrations on annual photosynthesis and plant growth is the primary reason for the increased C sequestration on land in recent decades[2,3]. Increases in the annual CO_2 uptake by the vegetation can follow from three mechanisms: 1) lengthening of the growing season, which allows a longer photosynthetic period; (2) a faster increase towards peak photosynthesis, increasing uptake rates early in the season; (3) an increase in the maximum photosynthetic rate reached, or a combination of these factors (Fig. 1b). While lengthening of the growing season has been observed repeatedly[4,5], changes in the peak of vegetation growth had so far received less attention. By analysing satellite-derived vegetation indices as well as global photosynthesis estimates from ground-based measurements, and satellite and meteorological observations[7], Huang et al[6] demonstrate that both the annual maximum greenness of vegetation and the annual maximum photosynthesis rates increased linearly over the last three decades. They attribute these increases to roughly equal contributions from increasing atmospheric CO_2 concentrations, increasing nitrogen deposition, and expansion of croplands.

The positive effects of increased CO_2 concentrations and nitrogen deposition on peak vegetation growth and maximum photosynthesis add to the evidence on their key role in explaining the increases in plant growth and plant carbon sequestration over the past few decades[3,5]. The positive effect of cropland expansion, and especially its magnitude (explaining more than 30% of the increase in global maximum photosynthesis) is more surprising. Previous work has hinted towards a positive effect of cropland expansion[3], and as stated by Huang et al.[6], the increase in maximum vegetation growth and photosynthesis following cropland expansion likely reflects positive effects of management practices such as irrigation and fertilization. By including a meta-analysis on leaf-level photosynthesis measurements that indicates a higher photosynthetic capacity for crop species compared to trees and grasses, these findings give strong support for the higher capacity of croplands to take up CO_2 from the atmosphere.

This higher CO_2 uptake by croplands may seem counter-intuitive at first sight. Conversion into cropland has contributed greatly to increasing atmospheric CO_2 concentrations because of large emissions from vegetation and soil when lands are cleared or deforested for agricultural use[1]. Moreover, the higher photosynthesis rate of crop species does not necessarily translate into increased carbon sequestration of a cropland ecosystem. On the contrary, croplands are losing substantial amounts of carbon from the soil[8] and improving agricultural practices to reduce and reverse these losses remains a major challenge[9].

The study by Huang et al.[6] indicates the increasing capacity of vegetation on land to absorb CO_2 from the atmosphere. However, these past patterns give no guarantee for continued increases in photosynthesis and plant growth in future. Land ecosystems are increasingly under pressure from human activities and environmental change and there are some indications now that the net CO_2 uptake by land vegetation is already starting to decline[5]. Increasing frequency and intensity of extreme weather events[10,11] and limited availability of important nutrients such as phosphorus[12] are among the factors likely to limit enhancements of photosynthesis, plant growth and the land carbon sink in future. Huge uncertainties still exist regarding the future of the land carbon sink, but it is becoming ever more clear that limiting climate warming and preserving our natural ecosystems is essential for safeguarding the climate change mitigation capacity of land ecosystems and avoid them from becoming a net source of CO_2 to the atmosphere.

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