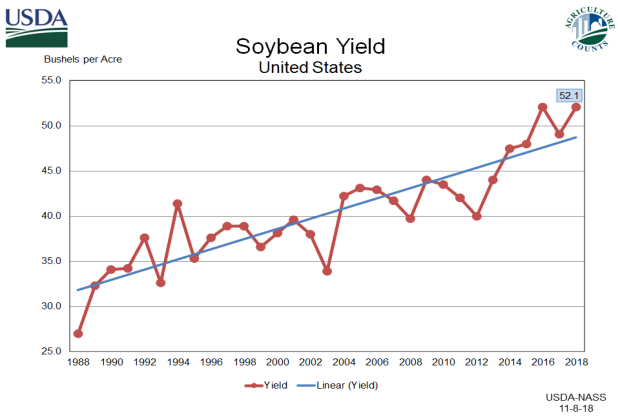
Claim: CO_2-induced climate change is threatening global food production and harming natural ecosystems

Rebuttal

The United Nations' Intergovernmental Panel on Climate Change (IPCC) claims that CO_2-induced climate change is presently stressing Earth's natural and agro-ecosystems by reducing plant growth and development. They also contend that the increases in temperature they anticipate to result from projected increases in the air's CO_2 content will be so great and occur so rapidly that many species will not be able to migrate either poleward in latitude or upward in elevation rapidly enough to avoid extinction in their attempts to find suitable (i.e., cooler) living conditions. Such claims, however, are not justified; far from being in danger, the vitality of global vegetation in both managed and unmanaged ecosystems is better off now than it was a hundred years ago, 50 years ago, or even a mere two-to-three decades ago.

With respect to managed ecosystems (primarily the agricultural enterprise), yields of nearly all important food crops have been rising for decades (i.e., the Green Revolution). Reasons for these increases are manifold, but they have mainly occurred in response to continuing advancements in agricultural technology and scientific research that have expanded the knowledge or intelligence base of farming (e.g., fertilizers, pesticides, irrigation, crop selection and breeding, computers,
machinery and other devices).



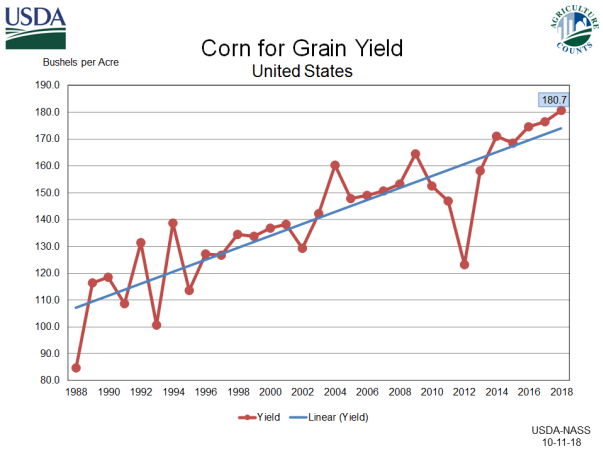


Figure 1*. Soybean and corn yields have set new records in 4 of the last 5 years in the United States.*

A significant portion of continuing crop yield increases is also due to the approximately 45% rise in atmospheric CO_2 since the Industrial Revolution. As the primary raw material of plant photosynthesis, literally *thousands* of laboratory and field experiments have conclusively demonstrated that higher levels of atmospheric CO_2 enhance crop growth and yields (see the *CO_2 Science* Plant Growth Database for thousands of examples).

With respect to unmanaged or *natural* ecosystems, they do not appear to be in danger of collapse either. Quite to the contrary, increasing temperatures and rising atmospheric CO_2 concentrations are benefitting the terrestrial biosphere. Prior to around 1940, Earth's land surfaces were a net source of CO_2-carbon to the atmosphere. From 1940 onward, however, the terrestrial biosphere has become, in the mean, an increasingly greater *sink* for CO_2-carbon. And when including data from both the land *and* ocean, it has been determined that the global carbon uptake (a measure of productivity) has actually *doubled* over the past half-century, from 2.4 to 5.0 billion tonnes per year.

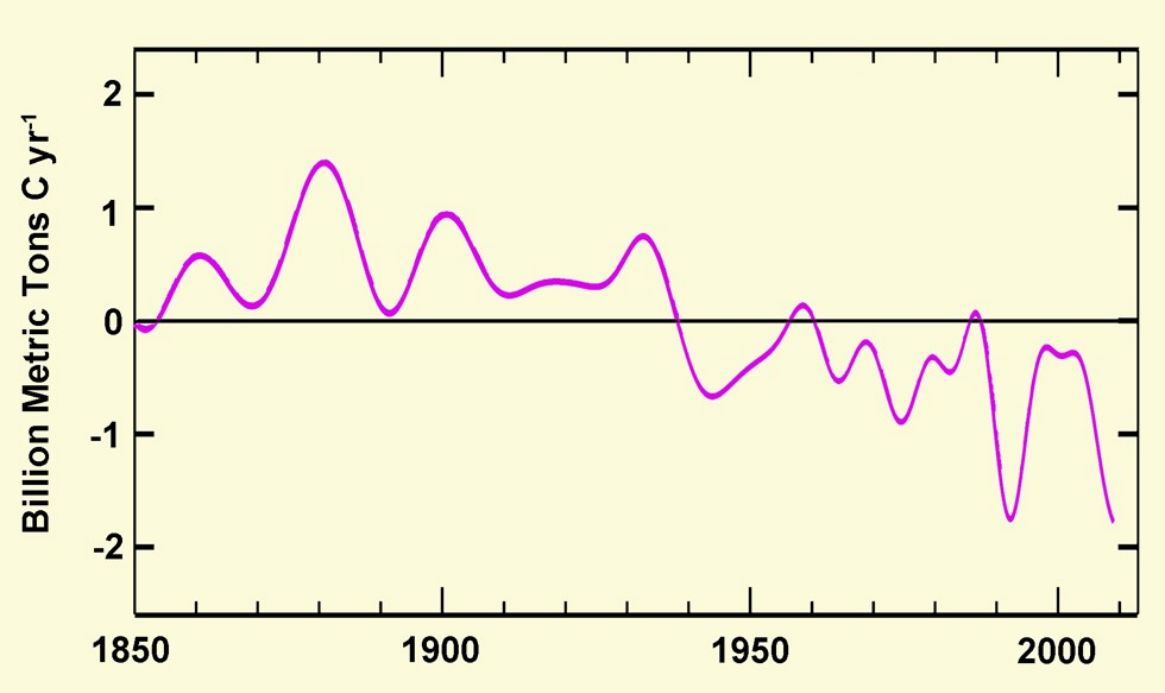


Figure 2. Five-year smoothed rates of carbon transfer from land to air (positive values) or from air to land (negative values) vs. time. Source: Tans

(2009). An accounting of the observed increase in oceanic and atmospheric CO_2 and an outlook for the future. *Oceanography* **22**: 26-35.

Additional evidence for this great *greening of the Earth*, as it is often called, is seen in satellite-derived data. But what is most surprising about these observations is the fact that they are even occurring at all—if you accept the claims of climate alarmists.

Consider, for example, their concerns that since 1980 the Earth has weathered 3 of the warmest decades in the modern instrumental temperature record, as well as a handful of intense and persistent El Niño events, large-scale deforestation, "unprecedented" forest fires, and episodes of persistent, widespread and severe drought. At the same time, the air's CO_2 content has increased by more than 16% and the human population has grown by over 55%. To global warming alarmists, the Earth has recently been in the throes of a veritable climate catastrophe. Yet instead of showing widespread decline, the terrestrial biosphere has suffered *not at all*. Increasing levels of atmospheric CO_2 have actually helped to *overpower* these and other growth-inhibiting influences in all but a few locales.

Such was the conclusion of a team of researchers (Zhu *et al*., 2016) who analyzed long-term satellite-derived *leaf area index* records, together with the output of ten global ecosystem models for the period 1982-2009. The results of their analysis revealed a persistent and widespread greening of the globe's vegetated area, evidenced by the green, blue and violet shading in Figure 3. Further analyses revealed that CO_2 fertilization effects explained 70% of the observed greening trend, followed by nitrogen deposition (9%), climate change (8%) and land cover change (4%).

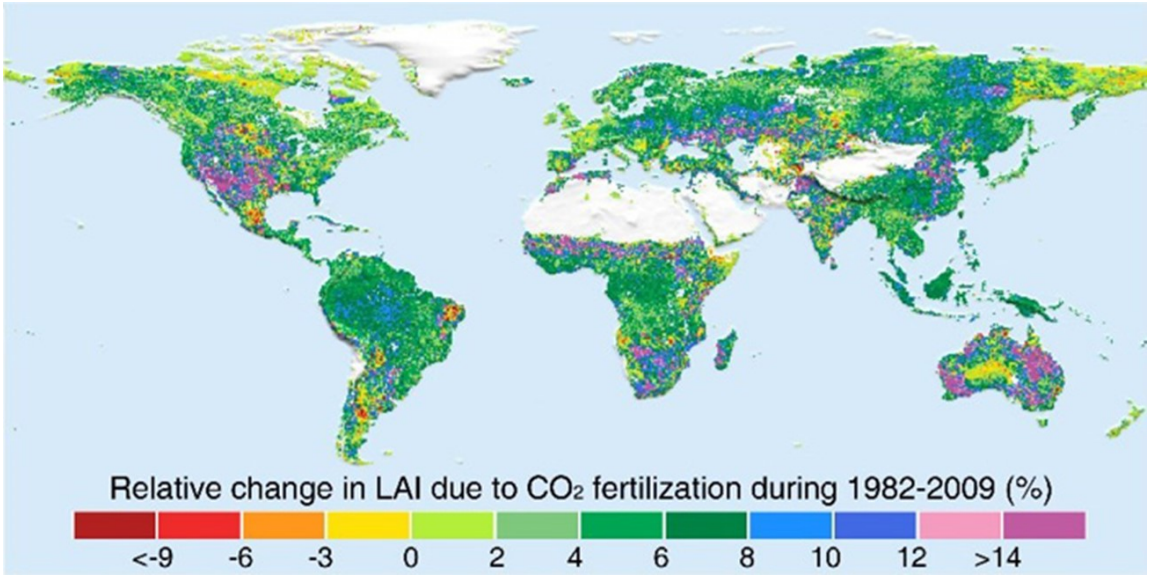


Figure 3. Spatial pattern of relative change of Leaf Area Index (LAI) greening due to CO_2 fertilization during 1982 to 2009. Source: Zhu *et al*. 2016. Greening of the Earth and its drivers. *Nature Climate Change* DOI: 10.1038/NCLIMATE3004.

Similar results were reported in 2017 by another research team (Li *et al*., 2017). Working with over 2100 globally-distributed databases, they analyzed the spatiotemporal patterns of net primary production over the past half-century, which patterns are illustrated in Figure 4. Their results indicated that, for the planet as a whole, net primary production increased significantly by 21.5 percent over the past five decades. Not surprisingly, the authors report that atmospheric CO_2 concentration was the dominant factor controlling the interannual variability and increase of global net primary production over the period of study.

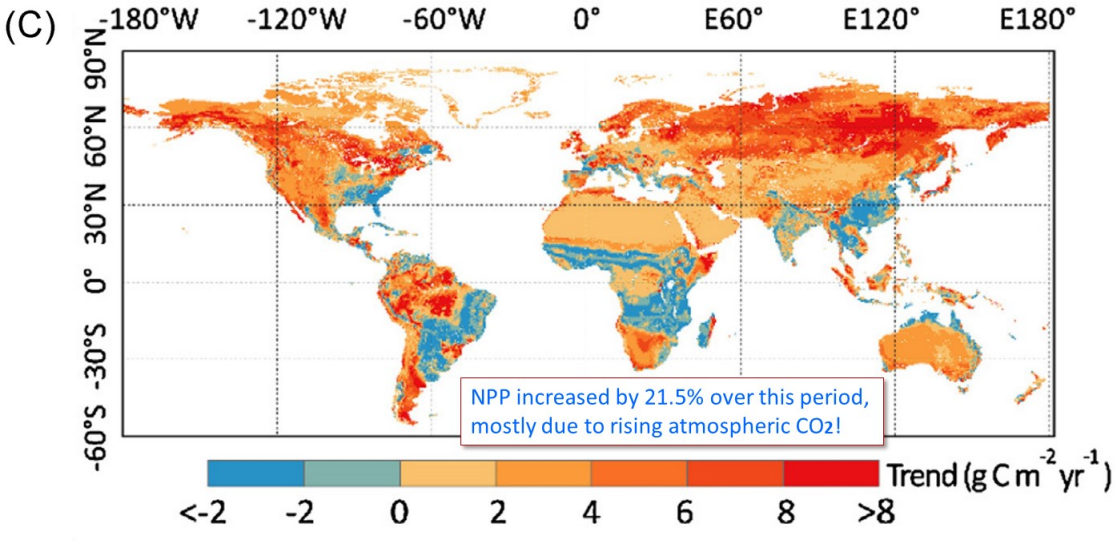


Figure 4. Spatial pattern of relative change of Net Primary Production (1961-2010). Source: Li *et al*. 2017. Quantification of the response of global terrestrial net primary production to multifactor global change. *Ecological Indicators* **76**: 245-255.

Figure 5 shows the results of a *third* independent group of scientists (Cheng *et al*., 2017), who have further documented the growth-enhancing impacts of rising atmospheric CO_2 on the biosphere. Once again, as shown by the overwhelming presence of blue shading in this figure, despite the many real (and imagined) assaults on vegetation by humanity and nature alike, the terrestrial biosphere has met and *overcome* these challenges, in this instance increasing its gross primary production by 24.9 Pg C over the past three decades. And once again, rising atmospheric CO_2 concentrations were found to be the principal cause of that increase, with the authors determining that a 10% increase in atmospheric CO_2 induces an approximate 8% increase in global gross primary production.

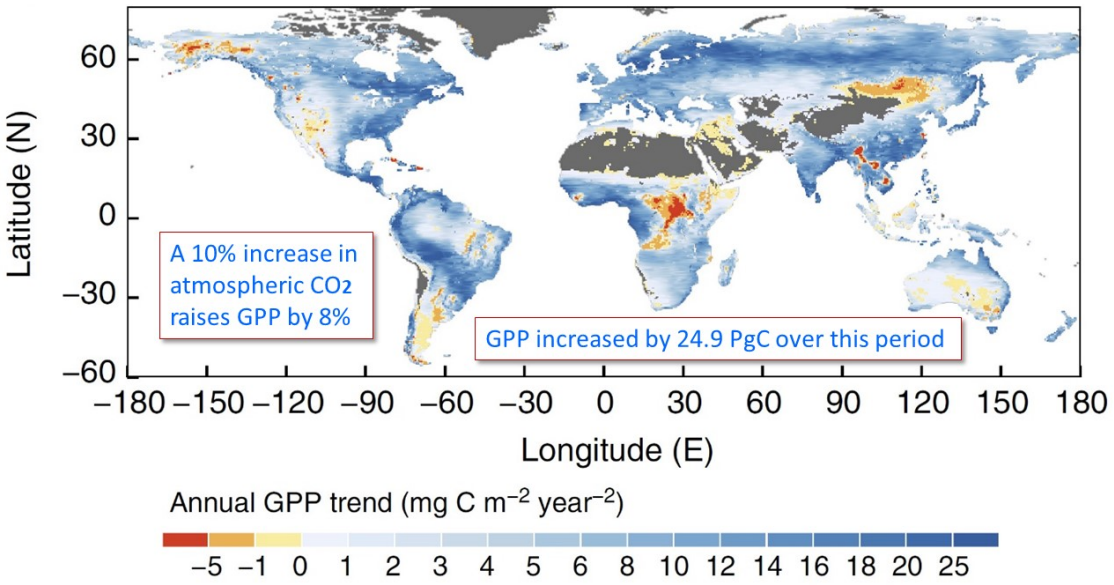


Figure 5. Spatial pattern of relative change of Gross Primary Production (1982-2011). Source: Cheng *et al*. 2017. Recent increases in terrestrial carbon uptake at little cost to the water cycle. *Nature Communications* **8**: 110, DOI:10.1038/s41467-017-00114-5.

In one final example highlighting the positive impacts of atmospheric CO_2 enrichment that are sweeping across the planet, a group of seven scientists (Sun *et al*., 2018) employed a series of global data sets just last year in an effort to estimate global monthly gross primary productivity over the period 1982-2015. Their results are highlighted in Figure 6. As indicated, the spatial distribution of the linear trends in gross primary productivity is *overwhelmingly positive*, demonstrating that a large and significant vegetative enhancement has occurred in over 75% of the land area over the past 34 years.

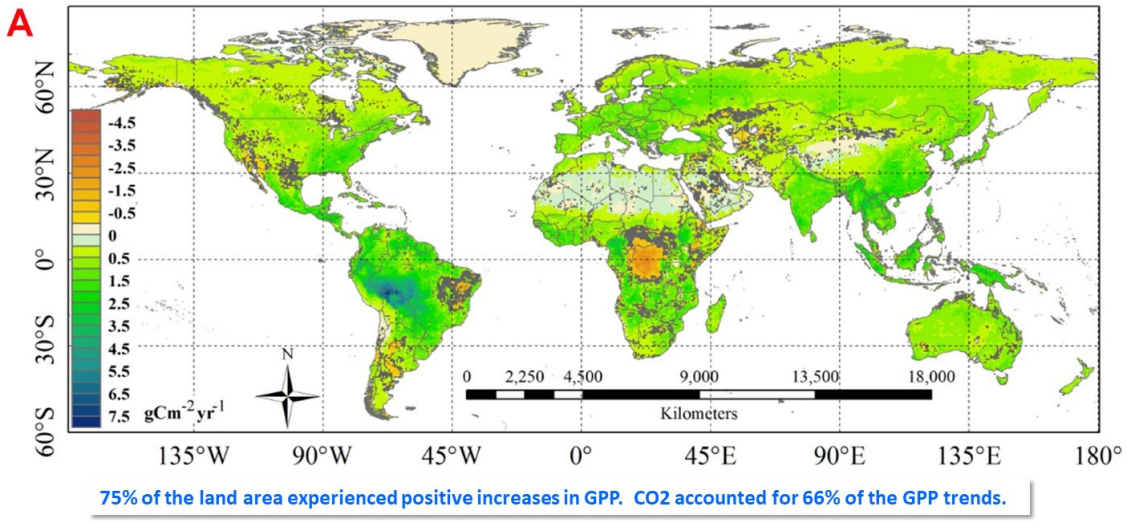


Figure 6. Spatial pattern of trends in Gross Primary Production (1982-2015). Source: Sun *et al*. 2018. Spatial pattern of GPP variations in terrestrial ecosystems and its drivers: Climatic factors, CO_2 concentration and land-cover change, 1982-2015. *Ecological Informatics* **46**: 156-165.

With respect to the factors responsible for these trends, the researchers analyzed five potential influences, including land-cover change, rising atmospheric CO_2 concentrations, and changes in solar radiation, temperature and soil water status. Their results indicated that increases in atmospheric CO_2 accounted for the largest contribution to the globally-averaged gross primary productivity trends, accounting for 65.73%, which percentage is *more than five times the value* of the next most significant contributing factor of temperature.

In considering the several empirically-based findings presented above, it is quite clear that the IPCC's model-based projections of the consequences of rising atmospheric CO_2 on agriculture and natural ecosystems are way off the mark. Pessimistic forecasts of ecosystem degradation and collapse fail to match observed trends showing widespread enhancement of planetary vegetation.

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