The Greening of Planet Earth–*Confirmed!* Video Series

Transcript: CO_2-induced Benefits to Plant Water Use Efficiency

As the atmosphere's concentration of carbon dioxide (CO_2) continues to rise in the years and decades ahead, plants will become ever-more efficient in their use of water thanks to incredible physiological changes brought about by this important trace gas. In short, they will need less water to produce the same or an even greater amount of biomass, which transformation holds significant ramifications for future plant drought resistance and global food production.

In a previous video segment we examined how rising levels of atmospheric CO_2 enhance nature by stimulating the growth and development of plants. A *second* major benefit elevated CO_2 offers nature is the improvement of plant *water use efficiency*.

In basic terms, plant water use efficiency is the amount of biomass produced by a plant per unit of water lost via transpiration. At higher CO_2 levels plants generally do not open their leaf stomatal pores through which they give off water vapor as wide as they do at lower CO_2 concentrations. The smaller pore openings make it more difficult for water within the sub-stomatal cavities of the leaves to escape to the air. Consequently, elevated CO_2 not only enhances plant photosynthesis and growth, it also reduces plant water loss by transpiration, which combination of factors improves plant *water use efficiency*.

The magnitude of this incredible benefit varies by plant and growing conditions. Nevertheless, most plants experience water use efficiency gains on the order of 70 to 100%--*or more*—for a doubling of atmospheric CO_2.

As an example of this phenomenon, this figure shows the effects of elevated CO_2 and plant water supply on the water use efficiency of soybeans. The plants were grown in controlled-environment greenhouses for 40 days under ambient or twice ambient CO_2 concentrations and one of three water treatments: well-watered, moderate drought or severe drought. Regardless of watering treatment, the scientists who conducted this study found that a doubling of CO_2 significantly increased the water use efficiency of these plants by a whopping 217 to 247%!

Gratefully, nature does not have to wait another century or so for the air's CO_2 concentration to double before reaping benefits from enhanced water use efficiency. It has already begun to profit in this regard from the approximate 50% increase in atmospheric CO_2 that has occurred since the Industrial Revolution began.

Evidence of this fact is frequently noted in scientific studies utilizing dendrochronological methods and stable isotope analyses on long-lived tree species from all across the globe. This image, for example, depicts the change in atmospheric CO_2 and water use efficiency for an evergreen coniferous species in China. Since 1880, the rise in atmospheric CO_2 has helped boost the water use efficiency of these trees by an incredible 60%.

Similar-magnitude increases in water use efficiency have also been noted in Douglas fir and Ponderosa pine from the United State, in Norway spruce in Italy and Germany, cypress trees in southern Chile, Juniper, Acacia and Aleppo Pines in northern Africa, as well as a host of other trees from numerous other locations. But perhaps the best evidence of a modern increase in water use efficiency due to rising levels of atmospheric CO_2 comes from a key study published in the scientific journal *Nature Communications*.

Using a combination of ground-based and remotely sensed land and atmospheric observations, the authors of this seminal work performed a series of calculations to estimate changes in global water use efficiency over the period 1982 to 2011.

Results of their work, as shown in this figure, reveal that global water use efficiency increased at a mean rate of 13.7 milligrams of carbon per millimeter of water per year, experiencing a phenomenal 21.6% enhancement over this three-decade-long period, almost all of which was attributed to rising atmospheric CO_2. What is more, the authors report that this increase did ***not*** come at a cost of enhanced global terrestrial water use. Instead, rising atmospheric CO_2 improved the global carbon uptake per unit of water used, meaning that plants today are larger and produce significantly more biomass than 30 years ago without needing any more water to do so, which finding holds extremely important ramifications for the future growth and survival of both plant and animal species.

This final figure presents a spatial view of the global water use efficiency trends reported in the *Nature Communications* study. As is clearly evident by the various degrees of green shading, a full 90 percent of the global vegetated land area show *positive*, increasing trends in water use efficiency, which finding is actually quite impressive considering there were large-scale disturbances such as heat waves and droughts over the study period that should have adversely impacted water use efficiency in many regions. So why didn't they?

The reason, as you might have already guessed, is because of CO_2. Thanks to rising levels of this key atmospheric trace gas, the world's vegetation has met and largely overcome a host of debilitating influences that should have reduced plant water use efficiency in more locations than shown on the preceding map. And as CO_2 emissions from fossil fuel use *continue* to increase in the years and decades ahead, the observed positive enhancements to plant water use efficiency will increase even more, as the authors of our *Nature Communications* study further report a 10% increase in atmospheric CO_2 induces a 14% increase in global water use efficiency.

So it is that nature truly benefits from rising levels of atmospheric carbon dioxide. Far from being a pollutant, atmospheric CO_2 is necessary for enhancing life.

Note: this video was posted on 2 December 2019