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Vegetation Growth Carryover, a new parameter to consider in prediction models of vegetation cover change

How does the current scenario of global warming affect the development of plants? Are the parameters of the current models for predicting the change in vegetation cover sufficient? A study published in the journal Nature Communications has evaluated the Legacy of Vegetation Growth, defined as the effect of the current state of the vegetation on its subsequent growth, in the different growth phases and on an annual scale in the vegetation of the northern hemisphere. The results indicate that not taking this parameter into account leads to underestimating the level of CO_2 sequestration.

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The life-cycle continuity of plant growth implies that present states of vegetation growth may intrinsically affect subsequent growths, which is a type of biological memory, and can be referred to as vegetation-growth carryover (VGC). Thus, the state of ecosystems is influenced strongly by their past and describing this carryover effect is important to accurately forecast their future behaviors. However, the processes involved in the lagged vegetation responses to precedent climate, soil, and growth conditions are highly complex and often non-linear. It should also be noted that the strength and persistence of this carryover effect on ecosystem dynamics in comparison to that of simultaneous environmental drivers are still poorly understood.

In a new study published in the journal Nature Communications we hypothesize that the VGC has played a critical role in regulating the seasonal-to-interannual trajectory of vegetation growth. Our study quantifies the impact of VGC on North Hemisphere (NH) vegetation growth with a large set of measurements, including satellite, eddy covariance (EC), and tree-ring chronologies, and compare the size of this effect against that of immediate and lagged impacts of climate change.

This work provides quantitative evidence that peak-to-late season vegetation productivity and greenness are primarily determined by a successful start of the growing season (via the interseasonal VGC effect), rather than by a transient or lagged response to climate. This carryover of seasonal vegetation productivity exerts strong positive impacts on seasonal vegetation growth over the Northern Hemisphere. In particular, this VGC of early growing-season vegetation growth is even stronger than past and co-occurring climate on determining peak-to-late season vegetation growth, and is the primary contributor to the recently observed annual greening trend.

In order to examine whether this VGC effect operates at longer time scales of multiple years, we performed lagged partial autocorrelations with interannual anomalies of satellite-observed NDVI and 2739 standardized tree-ring width (TRW) records. For a time lag of 1 year, a positive interannual VGC was present across northern lands, with 75.6% of vegetated areas (for NDVI) and 82.9% of the tree-ring samples (for TRW) showing positive lagged correlations. This positive interannual VGC indicates that a greener year is often followed by another greener year. When we extended the time lags to 2 years, the positive correlation between current year NDVI (or TRW) and that of 2 years earlier was significant for only 14% of tree-ring samples or 5% of the total vegetated area (for NDVI). If time lags of 3 years were considered, the lagged correlation was found to be close to zero. Based on these results we conclude that the effect of seasonal VGC persists into the subsequent year but not further.

In the study we also discussed process-based ecosystem models, a useful tool for predicting vegetation growth and examining the associated complex mechanisms. To better simulate biological processes related to this carryover, we highlighted the importance not only of using satellite and ground measurements to refine existing parameterizations, but also using leaf-level measurements to understand the physiological mechanisms controlling VGC patterns and to incorporate new process representation in model components.

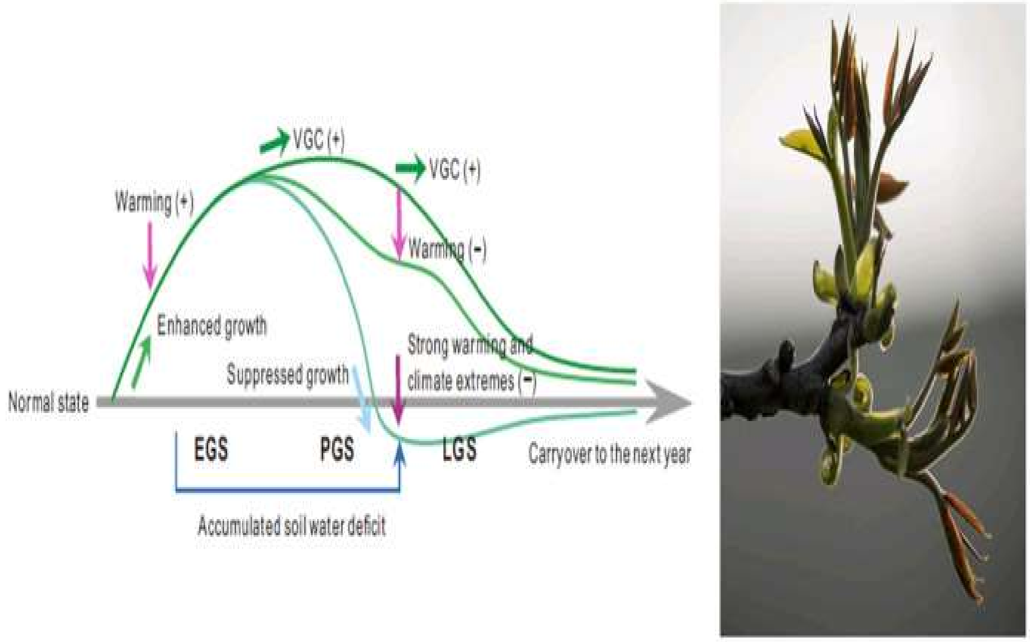

***Figure**: Biological cycles of a plant include many successional growth periods in which the past and the present are tightly connected. Figure shows schematic representation of the vegetation growth carryover (Source: Lian et al Nat Comm 2021; image: Pixabay).*

Our analyses provide new insights into how vegetation changes under global warming. The VGC effect represents a key yet often underappreciated pathway through which warmer early growing season and associated earlier plant phenology subsequently enhance plant productivity in the mid-to late growing season, which can further persist into the following year.

The results of our study highlight the need for improved representation of the intrinsic VGC effect in dynamic vegetation models to avoid that they greatly underestimate the VGC effect, and may therefore underestimate the CO_2 sequestration potential of northern vegetation under future warming.

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