Study restores consensus after controversial 2014 paper questioned direct effects of climate change

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An international research team led by UCLA life scientists has, for the first time, quantified the direct influence of climate on the growth of

ecosystems around the globe.

The paper also restores scientific consensus to the fact that record-breaking temperatures and droughts directly affect ecosystems—which was called into question by a 2014 University of Arizona paper in the journal *Nature*.

The new study, which was funded by the National Science Foundation, was published this week in the journal *Global Change Biology*.

The growth of whole ecosystems—the accumulation of new growth in a forest, shrub land or grass land—is referred to by scientists as net primary productivity. NPP is greater in the tropics than in the arctic because productivity responds directly to climate in much the same way that individual plants do. This means that the growth of ecosystems would respond rapidly to climate change. And because forests take up carbon dioxide from the atmosphere, even as their growth responds to climate, they play a role in determining ongoing climate change.

In challenging that point of view, the Arizona researchers found no correlation between NPP and climate, after accounting for the influence of forest mass and age. They concluded that the correlation of NPP with climate was a coincidence or an illusion that arose simply because larger forests tend to be located in warmer, moister climates, and because larger forests have faster growth.

But the UCLA-led study found definitively that NPP responds strongly and directly to climate. The implication of the new research is that climate change will have strong and immediate effects on forest productivity because climate strongly affects NPP, independent of the mass of the forest and its age.

"Our analysis shows that the direct influence of climate on NPP globally

is undeniable and enormous," said Lawren Sack, a UCLA professor of ecology and evolutionary biology in the UCLA College and senior author of the research. "Our models can explain at least half of the global variation in NPP, with a major proportion attributable to climate, independently of biomass."

Sack said the fact that so much of ecosystems' productivity is tied to climate makes it clearer than ever that new and stronger policies to mitigate climate change are needed.

The researchers found major statistical flaws in the Arizona paper. For example, the UCLA-led team demonstrated that, because NPP is a measure of ecosystem growth, the Arizona researchers created a circular model by inputting the biomass and age of the ecosystems together in their model.

"In a statistical model, it's very important to ensure that there are no circularities—that the model doesn't use terms that automatically explain the variable we want to predict," said UCLA graduate student Megan Bartlett, a co-author of the new study. "If there are circularities, you lose the power to find the real influential variables. In this case, when we removed the circular influence of biomass and age, we could see the enormous influence of climate."

The UCLA-led team used multiple approaches to re-analyze the data from the Nature paper, with a focus on isolating the influence of climate from biomass in influencing NPP. They found that climate-related effects explained at least as much of the variation in NPP across forests worldwide as forest biomass.

"Everyone who has grown a plant understands how sensitive growth is to temperature and rainfall, but whether whole ecosystem growth responds in the same way had become controversial," Sack said. "It's obvious that

ecosystems with more biomass have higher NPPs, in the same way that larger organisms grow faster than smaller organisms. Also, older ecosystems tend to grow slower than younger ones."

Yet Sack said the UCLA team was skeptical of the claims that the biomass and age of forests could explain global variation in NPP without accounting for climate, or that plants and ecosystems could compensate for different climates and maximize growth globally, as the Nature paper suggested.

"If that were true, the implication would be that climate change would have slower, or minimal, impacts on ecosystem growth worldwide," he said. "But this turns out not to be correct."

Sack said more research is needed to understand how each species and ecosystem responds to climate change, to learn more about the influence of other variables, such as soil fertility, and to make better predictions about the influence of climate on ecosystems.

"Our analyses have to keep improving if we are to have a chance to contribute to policies to anticipate, avert or mitigate the effects of changing climates and to guarantee a future not only for our species, but for entire ecosystems around our planet," Sack said. "Collaborations across scientific fields and among nations are becoming ever more critical."

More information: "Chengjin Chu et al. Does climate directly influence NPP globally?," *Global Change Biology* (2015). DOI: 10.1111/gcb.13079

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