Researcher discusses new ways to calculate ecosystem impacts on climate

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For decades, scientists have relied on an established formula to measure the impact of greenhouse gas emissions on climate change.

However, these global-warming potentials (GWPs) don't tell the whole story when it comes to an ecosystem's role in climate change, according to new research by Virginia Commonwealth University's Scott Neubauer, Ph.D., assistant professor in the Department of Biology, part of the College of Humanities and Sciences.

GWPs were designed to deal with greenhouse gas emissions caused by humans, and applying them to the complexities of the natural world just doesn't make sense, Neubauer said.

In a new paper, "Moving Beyond Global-Warming Potentials to Quantify the Climatic Role of Ecosystems," Neubauer and co-author, Patrick Megonigal, Ph.D., deputy director of the Smithsonian Environmental Research Center, challenge the status quo and offer new models to determine whether ecosystems such as wetlands or forests have a warming or cooling effect on climate.

Neubauer recently discussed the new research, which was published last month in the journal *Ecosystems* and is already receiving rave reviews from fellow ecologists.

Scientists have been using GWPs for more than two decades. What did your research tell you about why this isn't the best way to measure the impact of ecosystems on climate change?

The use of GWPs is widespread as a result of political policy such as the Kyoto Protocol, which is geared toward reducing man-made emissions of carbon dioxide (CO2) and other greenhouse gases. But an economic and regulatory tool isn't always appropriate for studying the natural world, especially when you're looking at ecosystems as opposed to something like a power plant. What we found is that the GWP formula often underestimates the warming effect when an ecosystem emits a greenhouse gas like methane (CH_4) or nitrous oxide (N_2O) and, likewise, underestimates the cooling effect when an ecosystem takes up any of those gases. Ecosystems have been around forever, long before we've had recent climate change, and we're interested in getting a more accurate assessment of how these ecosystems are affecting climate.

You came up with two new metrics. How do they differ from GWPs?

Each greenhouse gas varies in how well it traps infrared radiation, or heat, and how quickly it is chemically destroyed or otherwise removed from the atmosphere. GWPs incorporate these two effects and let us compare how much warming should result from different greenhouse gases. The calculation of GWPs is based on a single pulse emission of a greenhouse gas. However, we know that ecosystems can sequester CO_2 and either add or remove CH_4 and N_2O from the atmosphere and that these fluxes persist over time. So, that points to two problems with applying GWPs to ecosystems. First, ecosystems don't emit greenhouse gases as a single pulse, and second, ecosystems can either add or remove greenhouse gases from the atmosphere.

Our new metrics—the sustained-flux global warming potential (SGWP) and the sustained-flux global cooling potential (SGCP)—take into account both of these issues. These metrics are just as easy to use as the GWP but are more appropriate for use in ecosystems. I'm not going to say that we've developed a set of perfect metrics, but we think this is a good starting point to have a real discussion about how to measure the impact of ecosystems on the climate. Basically, scientists should be using approaches that are well-suited to addressing scientific questions, rather than using metrics like GWP that were developed for policy applications.

What is the difference between a one-time pulse and continuous emissions over the same number of years?

It's easy enough to grasp the difference between a pulse emission and continuous emissions. It's driving somewhere once versus driving there every day. It's lighting a fire in your backyard fire pit once versus every day. However, it's a bit harder to intuitively grasp why that would be important.

An analogy might be if there is a nuclear facility that generates some radioactive waste that is kept in a storage facility, and this waste happens to decay at such a rate that there is no detectable radiation after 100 years. If the nuclear facility operated for only one year and then shut down (thus producing just a one-time "pulse" of radioactive waste), one could say that the storage area would no longer be radioactive after 100 years. But if the nuclear facility operated for a full century, producing waste every year, the accumulated waste in the storage facility would be a mixture of 100-year-old waste that is no longer radioactive, newly-produced waste that is highly radioactive and waste of intermediate ages with intermediate levels of radioactivity. So even though a one-time pulse of radioactive waste will be harmless after 100 years, it would be incorrect to think that the storage facility would be radiation-free after 100 years if waste was being added to it every year.

Similarly, one shouldn't expect that continuous emissions of a greenhouse gas would produce the same effects on climate as a one-time pulse.

What are the implications if an ecosystem is determined to be contributing to global warming?

Ecosystems that have been around since before the Industrial Revolution are not contributing to global warming at all because they are part of the baseline against which recent changes are being compared. If an ecosystem has changed (a wetland has been drained) or been created (a cornfield now lies where there used to be prairie), it may be contributing to recent climate changes. The SGWP and SGCP will be better than the GWP at determining how much those modified ecosystems are affecting climate.

But ecosystems are valuable in many ways. They can act as wildlife habitat, support biodiversity, improve water quality, provide food and more, so it would be oversimplistic to assess the value of any ecosystem only on the basis of its effect on climate. It would be shortsighted and foolish to do something like drain a freshwater wetland simply because the site emits some methane to the atmosphere.

Though your findings are aimed at the scientific community, what carryover might your work have on the economics of climate change?

Our work does have implications for including ecosystems in carbon credit and emissions trading plans. Emission reduction schemes like the Kyoto Protocol have tried to reduce human-caused emissions and aren't trying to regulate the natural world. But there are ways that companies can get carbon credits for doing things like planting a forest or constructing a wetland, if those projects will have a net cooling effect. You can see that using the SGWP instead of GWP would suggest that a wetland construction or restoration project should receive fewer carbon credits if that project will result in CH4 emissions. On the other hand, using the SGCP instead of GWP for a forest that takes up CH4 would suggest that such a project would deserve more carbon credits.

Now that you have these two new metrics, what's

next?

One of the things we intend to do is help answer the question of whether restored wetlands such as the one at VCU's Rice Rivers Center are having a net warming or cooling effect on the climate. Chris Gough (Ph.D., adjunct instructor and researcher in VCU's Department of Biology) and I have a new study that is getting started this year that will provide greenhouse gas flux data for the restored tidal wetland at the Rice Rivers Center. We're really excited about this new study and what it will tell us about the development of restored wetlands and how they influence climate.

More information: "Moving Beyond Global Warming Potentials to Quantify the Climatic Role of Ecosystems." *Ecosystems*. DOI: 10.1007/s10021-015-9879-4

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