# Study finds biodiversity impacts of agricultural deforestation have inherent and predictable geographical differences

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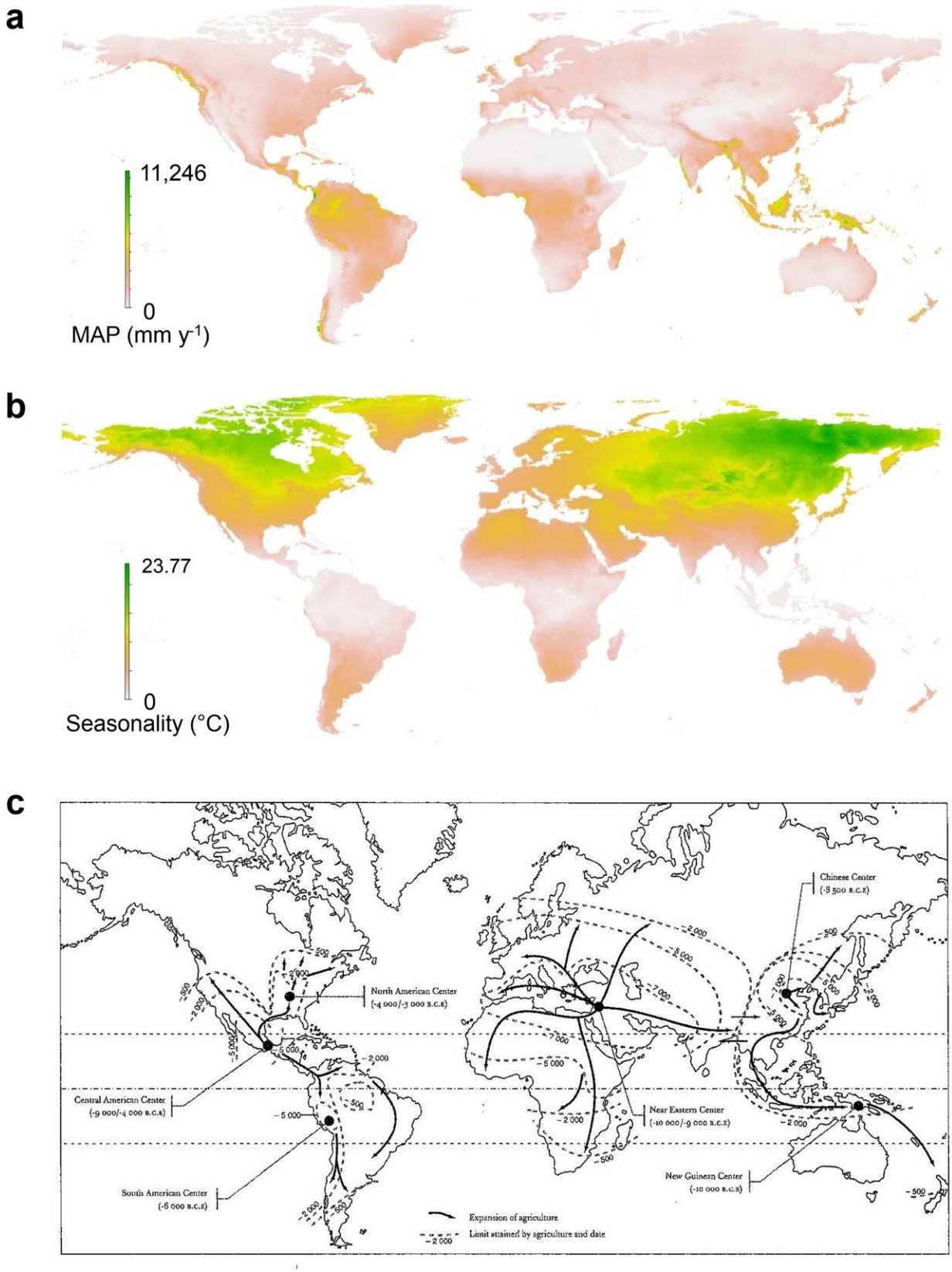
a
11,246
0
MAP (mm y-1)
b
23.77
0
Seasonality (°C)
c
North American Center
(-4 000/-3 000 B.C.E)
Central American Center
(-9 000/-4 000 B.C.E)
South American Center
(-6 000 B.C.E)
Chinese Center
(-8 500 B.C.E)
Near Eastern Center
(-10 000/-9 000 B.C.E)
New Guinean Center
(-10 000 B.C.E)
Expansion of agriculture
Limit attained by agriculture and date

Geographical patterns of three filtering factors across the world. Credit: *Nature Ecology & Evolution* (2024). DOI: 10.1038/s41559-023-02280-w

Agriculture is the foundation of human civilization and a prime example of our impact on Earth. Almost 40% of our planet's ice-free land surface, most of which was previously forested, is now dedicated to agriculture. As our demand for food increases, so does agricultural deforestation, which is widely viewed as one of the greatest threats to global biodiversity.

Yet, the magnitude of agriculture's impact on biodiversity varies widely across the world. Take birds, for example. While many species in the Ecuadorian Amazon are highly sensitive to deforestation, most birds in Costa Rican agricultural landscapes seem more tolerant.

Research from the Indian Himalayas has reported some bird species even benefit from agriculture at certain times of the year. So far, this variation has mostly been explained by how 'natural' the agricultural landscapes are, for instance, how much forest cover remains, or how frequently synthetic fertilizers are used. But this reasoning does not adequately explain the full story.

A new study led by Peking University and involving 49 institutions from around the world reports that, beyond the 'naturalness' of agricultural landscapes, regions differ inherently and predictably in how sensitive their bird communities are to agricultural deforestation.

The global-scale synthesis, recently published in *Nature Ecology & Evolution* suggests that regions with more variable natural environments and longer agricultural histories tend to support bird communities that are more tolerant of deforestation. The study is titled "Ecological

filtering shapes the impacts of agricultural deforestation on biodiversity."

"What we found is that natural environmental conditions and past human influences have essentially served as filters to determine what kinds of species—in terms of tolerance to agricultural deforestation—are present in a region's bird community today," said Fangyuan Hua, assistant professor at Peking University's Institute of Ecology and co-lead author of the new study.

The 'filtering effect' by agricultural history makes perfect sense when we think back to the well-documented extinction of North American megafauna, which is unequivocally linked to the arrival of prehistoric humans. Similarly, past deforestation events by humans may have caused certain species to go extinct or otherwise adapt to deforestation, meaning that species that survived should be more tolerant of current-day deforestation.

"This was indeed our initial motivation to do this study, to test if, in simple terms, bird communities in regions with thousands of years of agricultural histories—for instance, those found in East Asia—are more tolerant of agricultural deforestation than those in regions more recently exposed to agriculture, such as the Amazon," said Weiyi Wang, co-lead author and former research assistant in Hua's research group.

Wang is currently pursuing her Ph.D. at the University of Tasmania and adds, "To us, this was simply a fascinating question to ask."

But the team also expected the environment of the natural forest in a region, specifically the presence of non-forested elements resembling deforested habitat, to influence the sensitivity of birds to deforestation. For example, birds that live in seasonal forests, which periodically lose their leaves and are thus exposed to more non-forest-like conditions

should be more adapted to deforestation.

The authors refer to this as a second filter related to 'natural environmental variability,' whereby species in more variable environments are pre-disposed to a wider range of conditions and should be more adapted to them. This prediction is linked to a classic concept in ecology known as 'environmental filtering,' which theorizes that environmental conditions strongly influence the kinds of species that occur in a region or habitat.

"Scientists have recognized the importance of filtering by environmental conditions and past human influences to understanding species' responses to environmental change, but these critical explanatory factors have been entirely left out of previous attempts to understand the apparent global variation in species' responses to agricultural deforestation," said Paul Elsen, Climate Adaptation Scientist from the Wildlife Conservation Society and last author of the study.

Thanks to a global collaboration, the authors developed a database of 71 regional bird communities and 2,647 bird species which enabled them to test, for the first time, whether environmental conditions and agricultural history could explain the global variation in how severely agricultural deforestation impacts biodiversity.

"This would not have been possible without the active participation of all the original study authors, and their arduous fieldwork that generated these data in the first place," noted Wang, who coordinated the author team.

Beyond testing for a simple signal of environmental and human filtering, the study took the next step to understand how certain species are filtered out. The researchers found that bird species tend to be filtered based on 'functional' traits—such as body size, habitat preference, and

diet—that influence how tolerant a species may be to deforestation.

For example, the research team found that deforestation-tolerant species tended to be smaller and migratory, less dependent on mature natural forests, and less picky with food resources than birds that were highly sensitive to deforestation. These features were also more common in birds found in regions with more variable natural environments and longer agricultural histories.

"These findings brought this story of filtering full-circle," Hua said. "Which, in sum, highlights the inherent and predictable geographical differences in how sensitive the world's bird communities are to agricultural deforestation, beyond the 'naturalness' of agricultural landscapes per se. This also means that biodiversity in some regions is more inherently threatened by agricultural deforestation than in others."

It is concerning that many predicted hotspots for future agricultural deforestation are in such 'high impact' regions, notably tropical areas with short agricultural histories and less variable environmental conditions. This foreshadows severe biodiversity consequences of future agricultural expansions, and underscores the need to proactively plan agricultural land use to reduce deforestation in these regions.

"Our results also underscore the importance of conserving existing intact forests, the Earth's rapidly disappearing strongholds of complete species assemblages," added Elsen. "Otherwise, the inevitable filtering and loss of sensitive species will only further erode the diversity of Earth's life forms."

**More information:** Fangyuan Hua et al, Ecological filtering shapes the impacts of agricultural deforestation on biodiversity, *Nature Ecology & Evolution* (2024). DOI: 10.1038/s41559-023-02280-w

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