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Teaching Issues and Experiments in Ecology - Volume 19, December 2023

Tropical Forests and Data Availability

The primary learning objectives of this module are for students to be able to:

- Understand that the unequal distribution of resources is one of the reasons behind the non-uniform distribution of measurement networks.
- Explain how underrepresentation in data collection can lead to systematic biases in forecasting, but also to lack of career opportunities for researchers in developing countries that are already in a disadvantaged position.
- Discuss the implications of biased forecasting for climate change mitigation policies for already vulnerable communities.

Assigned reading

Before class, please read these short and accessible articles on underrepresentation of measurement networks and meaningful international collaborations:

- Wheeling, K. 2021. The gaps in environmental networks across Latin America, Eos 102, https://doi.org/10.1029/2021EO156506
- Adame, F. 2021. Meaningful collaborations can end 'helicopter research', Nature https://doi.org/10.1038/d41586-021-01795-1

Further (optional) reading on inequities in data coverage and career prospects for researchers:

- Dwivedi, D., A. L. D. Santos, M. A. Barnard, T. M. Crimmins, A. Malhotra, K. A. Rod, K. S. Aho, S. M. Bell, B. Bomfim, F.Q. Brearley, and H. Cadillo-Quiroz. 2022. Biogeosciences perspectives on Integrated, Coordinated, Open, Networked (ICON) science. Earth and Space Science 9:e2021EA002119. https://doi.org/10.1029/2021EA002119
- Villarreal, S. and R. Vargas. 2021. Representativeness of FLUXNET sites across Latin America. Journal of Geophysical Research: Biogeosciences 126:e2020JG006090. https://doi.org/10.1029/2020JG006090

Case study

Data are essential for conservation

Tropical forests are complex ecological systems and hotspots of biodiversity (Figure 1; e.g., ter Steege et al. 2013) and are key in regulating the global and local flows of carbon and water (e.g., Staal et al. 2023). Tropical forests are resilient ecosystems but facing increasingly large pressures from climate change and deforestation (Boulton et al. 2022). Better understanding, monitoring, and forecasting of this ecological system will require high-quality observational data.

Discuss with a neighbor (1)

- Tropical forests are of global significance. Is the conservation of these forests solely a task for the national governments that harbor these forests? If not, what other organizations or entities are responsible?
- What can or should the international community do to support conservation of tropical forests?
- What are potential unintended consequences to be aware of when working in another country?

TIEE

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Figure 1: Tropical forests are complex ecosystems and hotspots of biodiversity, including tree species (top photo, from the Amazon rainforest; source: Conscious Design on unsplash), amphibians (bottom left photo, from India; source: Sonika Agarwal on unsplash) and birds (bottom right photo, from Costa Rica; source: Kenny Goossen on unsplash). All photos are licensed for reuse under the Unsplash license.

How we see the world

Observations underpin how we see and understand the world around us. Observational networks are not uniformly distributed, and in many cases determined by the availability of economic resources in the region. Figure 2 shows the distribution of measurement sites across the globe for the PhenoCam Network and the FLUXNET carbon and energy flux measurement sites. Clearly, there is a large discrepancy in the observational coverage over tropical ecosystems and those in moderate climate zones (Villarreal and Vargas 2021, Wheeling 2021).

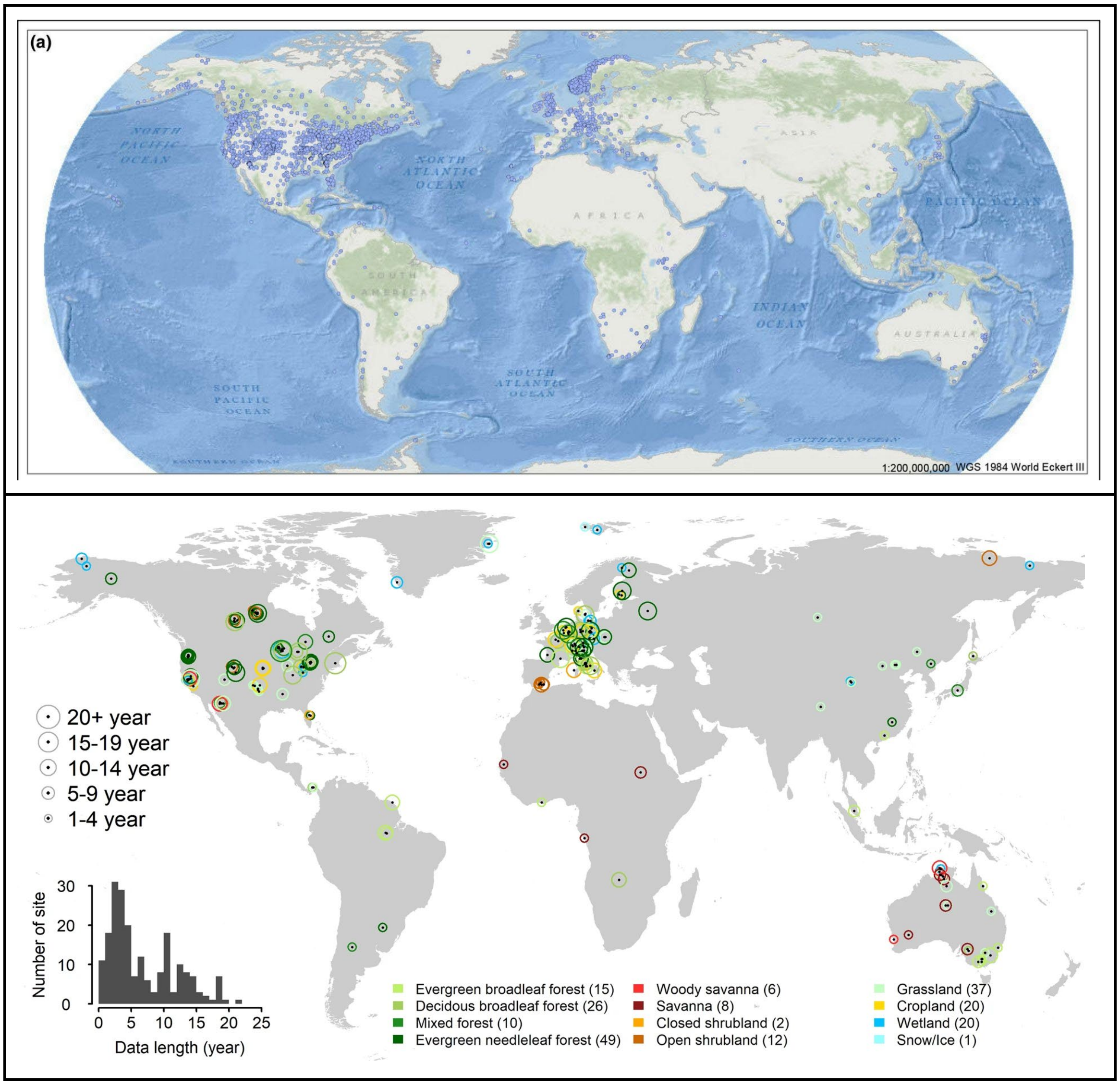

Figure 2: Ecological measurement sites are often biased towards North America and western Europe. Top: spatial distribution of vegetation phenology monitoring sites in the PhenoCam Network (blue dots are the sites); reproduced from Pastorello et al. (2020) with permission from the publisher. Bottom: spatial distribution of sites that monitor water and carbon exchange as part of the FLUXNET network. Here, the size of the marker indicates the length of the records and the color refers to the different vegetation types. Reproduced from Brown et al. (2016); licensed under CC BY 4.0.

It is not always summer in the tropics

When data is not available from the region of interest, researchers tend to look for other data that is available, which can lead to biased forecasts. This can also happen when machine learning models are trained on large datasets and are projecting relations derived in temperate climate zones onto tropical climate zones. For instance, biased models might predict typical spring or summer behavior or phenological development, as displayed in temperate climate zones, for vegetation in warm tropical conditions. Availability of sufficient high quality in situ data remains essential for different models (Adiku et al. 2021, van Schaik et al. 2018, Smallman et al. 2021).

Satellites to the rescue?

In recent years, monitoring capabilities of satellites have improved substantially and new missions with superior sensory equipment are being developed. This results in better monitoring capacity for remote areas, including tropical forests (e.g., Deblauwe et al. 2016, Naus et al. 2022). Unfortunately, this does not resolve the data problem, as validation with local data (e.g., Donnelly et al. 2022) remains an essential step in the development of the satellite retrieval algorithms that translate the measured irradiance into a more meaningful ecological property. High quality measurement sites in tropical regions are thus still an indispensable resource for validation of satellite observations (e.g., Koren et al. 2018, Mengistu et al. 2021).

Discuss with a neighbor (2)

- Satellites provide an opportunity to observe remote regions without needing access to a region. Could this have negative consequences for local researchers?
- Improved monitoring capacity results also in increasingly large datasets, which in turn requires stable internet and reliable computing infrastructure. How would this influence researchers in under-resourced environments?

Capacity building

There exist initiatives where funds from developed countries can flow to underrepresented regions to support the development of measurement networks. In these projects, it is essential that there is not only financial support for equipment, but also for local capacity building, such that local researchers can sustain the operation of measurement networks (the practice of short-term funds without any long-term commitment or vision is sometimes referred to as ‘helicopter science’). Capacity building should not be limited to practical execution of tasks but should be directed at advancing independent scientific research careers, including publication of scientific papers led by local researchers.

Below is an excerpt from Adame (2021), who shared her experience with ‘helicopter’ science:

> *“I was born in Mexico, and my first postdoctoral position was at Cinvestav in Yucatan, part of the National Polytechnic Institute. For many years, I read papers on the rainforest and freshwater sinkholes of Yucatan, the mangroves of the Mexican Caribbean and the Maya ruins of southern Mexico. Most of those papers do not include Mexican authors or agencies, and they often lack an acknowledgement to the Maya people who live in the region. I saw foreign scientists come to our laboratory carrying high-tech instruments that we didn’t have access to. We took the scientists to our field sites and taught them about the unique ecology of the mangroves. Sometimes they used our small laboratory to store or analyse their samples. Neither I nor anyone else on the team was ever asked to contribute to the papers that were published.”*

Reflect and conceptualize

- Based on the Adame (2021) article, what are the most important factors for meaningful and long-term collaborations? Try to summarize the most important concepts and their relations in a visual diagram.
- Compare your drawing with the schematic diagram in Figure 3 (provided as a separate handout). Reflect on the differences and similarities and update your drawing if you feel you missed something.

TIEE

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