

Scientific Life

Making ecology really global

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Ecology must flourish globally, especially in a period of unprecedented anthropogenic global change. However, some regions dominate the ecological literature. Multiple barriers prevent global production and exchange of ecological knowledge. The first step towards solutions is acknowledging and diagnosing this inequality and embracing our geographical and cultural diversity.

The science of ecology

The term ‘ecology,’ or *oekologie*, was coined in Europe in the 19th century. However, it is fair to assume that all societies independently developed some level of ecological knowledge. For instance, evidence from different parts of the globe has shown us that indigenous communities had sufficient biological and ecological knowledge to domesticate plants and to manage animals and fire, among other environmental practices [1]. Thus, although modern ecological science started in Europe and matured as a discipline in Europe and North America [2], ecological knowledge has been developed all over the globe in many different forms and by many different societies. Furthermore, in the past two decades, ecology has grown substantially in many countries, such as Brazil, where the number of graduate ecology programs doubled between 2008 and 2020 (<https://appliedecologistsblog.com/2019/11/29/brazil-ecology-the-editors-perspective/>).

It is important for ecological science to flourish in many parts of the planet because a deep understanding of global

phenomena requires global research [3,4], especially in a time of unprecedented anthropogenic global threats. However, some wealthy countries and regions dominate the geography and the paradigms of ecological literature [5–7] (Figure 1).

Why should ecology be a global endeavor?

Ecology is context dependent, and patterns and processes vary across regions and ecosystems and over time [8]. Far from being problematic, these differences are fundamental to our understanding of nature. For example, differences in species diversity between tropical and temperate regions have underpinned much ecological theory [9]. Despite this, most ecology publications come from very few countries [5,6] (Figure 1). This restriction limits the use of theory and also limits the possibilities for researchers from under-represented areas to share their findings. There is a growing demand to make ecology a more global endeavor, which can be achieved with the help of the international scientific community, including journals and scientists from all regions of the world. Ecology needs to capture the plethora of different phenomena in all parts of the globe.

Because of the global imbalance in scientific production and visibility, it is common to see global analyses or synthesis papers that include studies from only a limited range of regions and with most authors being from high-income countries, rendering global generalizations suspect [5]. Recent work has shown that global meta-analyses that do not include research in multiple languages fail to capture all available knowledge; therefore, the results they report are often biased [10]. This type of bias might not be easily perceived by ecologists from dominant regions, because the results tend to fit their expectations based on knowledge gathered predominantly in systems they are familiar with. However, for ecologists working on neglected or poorly studied systems, this bias can generate certain expectations

of ecological patterns and processes, ultimately hindering scientific advance. Such phenomena are especially important when they pervade ecological textbooks and thus heavily influence the knowledge base and training of young ecologists [11]. If textbooks do not accurately reflect the diversity of global ecological knowledge, the dubious notion that we can learn global ecological principles from studying a few ecosystems will persist.

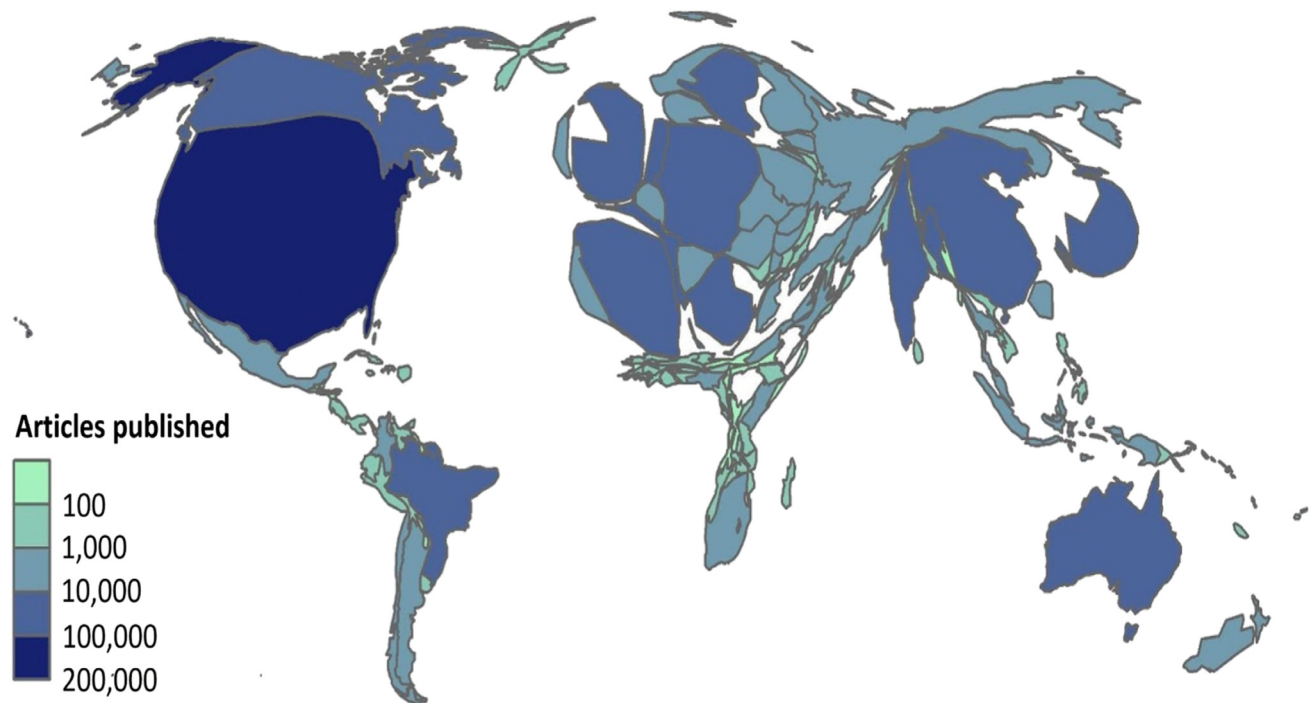
Another important reason for adopting a global approach to ecology is that only rarely is a single ecologist or a small group of ecologists capable of studying a topic in all relevant regions. In this context, international collaborations increase geographical representation [4] and reduce the bias of heavily studied field sites [5]. Unfortunately, the geography of international scientific collaboration is still concentrated in certain countries, usually those with higher income and more robust scientific and education systems [3].

How to make ecology global?

We understand that requesting similar levels of contributions from all parts of the world is unrealistic, but we believe there are steps that will help generate a deeper global understanding of ecological phenomena and solutions. We need bold, coordinated action across multiple fronts. Here, we identify five barriers and propose a series of actions to help make ecology a more global endeavor (Figure 2). This is our own assessment, and other barriers and actions may be noted by colleagues across the globe.

Language

A common language in science is important for global exchange of ideas and knowledge. However, there is tremendous global heterogeneity in access to English caused by differences in education systems, history, and geography, among other factors. In fact, most scientists who speak English speak it as a second language. Proper grammar and clear writing must be



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Figure 1. Ecological science, in terms of papers published, is disproportionately skewed to some countries and regions, while other regions and countries are almost absent from ecological publications. Source: Scientific articles in 391 journals in the field ecology published per country between 1996 and 2019, from Scimago Journal and Country Rank. Note: some authors have used the terms 'Global North' versus 'Global South' to describe this pattern, but north and south do not accurately describe this pattern (e.g., Australia is part of the Global North). Nor do economic variables describe this pattern, because some very wealthy countries do not publish much, and some less wealthy countries contribute substantially. Furthermore, there are also important gaps and inequalities within countries. Clearly, deeper multifactorial analyses are needed to understand the underlying factors behind the pattern.

expected in scientific papers. However, expectations from reviewers and editors that all ecologists should or will communicate with the proficiency of a native English speaker is a form of prejudice that acts as a barrier to the publication of important work and the overall participation of ecologists in international groups (i.e., meetings, networks). Many researchers depend on professional translation and editing services, which are often costly, to be able to publish their papers and are unable to present their work at conferences because of limited English proficiency. It is important to acknowledge that not all science is produced in English and that a significant and sometimes fundamental portion of it is not written in English.

Solutions for the language barrier include journals supporting researchers

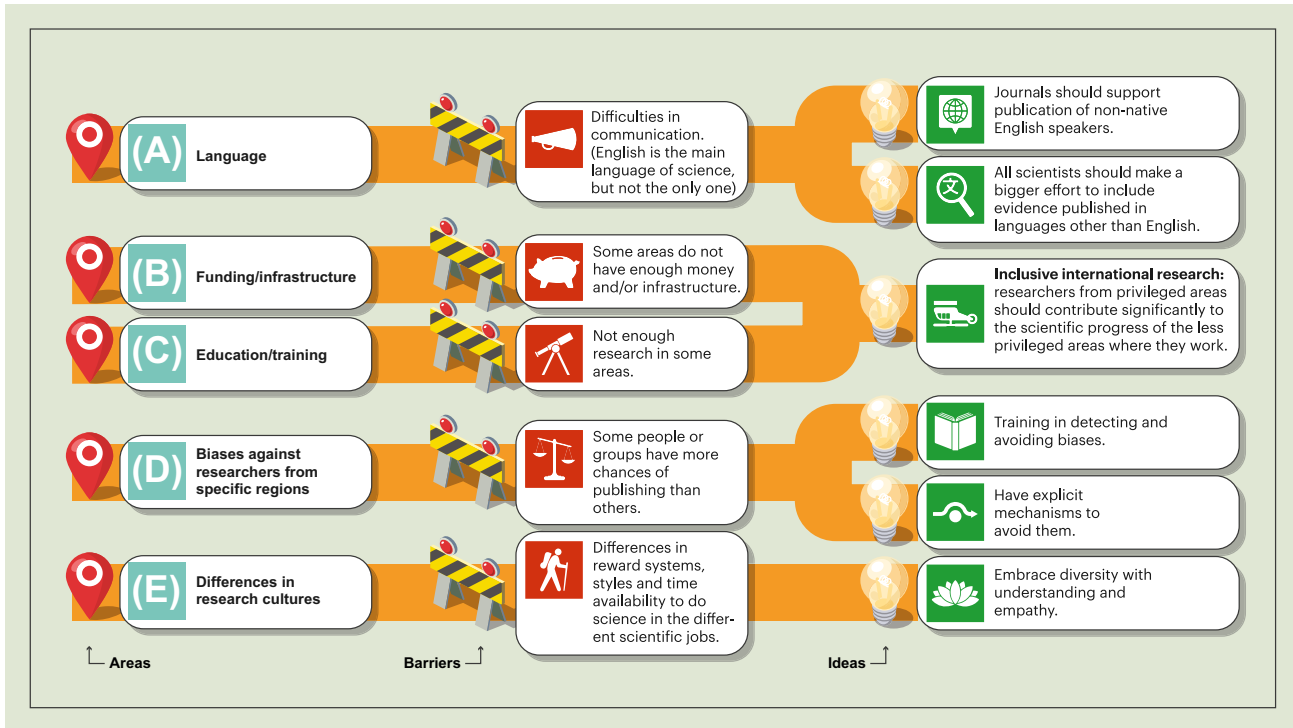
from countries where English is not spoken as a main language (e.g., by providing services such as language editing). As for ignoring science not written in English, researchers should go beyond English when searching for literature and references, because non-English documents can contain unique, important knowledge [10,12]. Some of these solutions are at the individual level, and we all can try to do a better job in these areas.

Funding/infrastructure

Funding for ecological research is uneven across the world, and so is access to state-of-the-art or even minimally adequate infrastructure. The inequality in funding and infrastructure exists within and among countries and creates a large barrier to producing knowledge in many parts of the planet. Historically, many well-funded

and well-equipped research teams have travelled to less privileged regions to collect data with limited involvement from local researchers or the consent of local communities. This has been described as 'helicopter science' and is a form of neocolonialism [13]. Unfortunately, funding differences create strong asymmetries among world researchers, still allowing this type of behavior to occur.

We propose 'inclusive international research.' Instead of just studying other regions of the world, scientists from privileged regions should establish strong collaborations with local researchers and interact with local communities. For large and well-funded projects that need data and insight from researchers based in regions with limited resources and infrastructure, finding ways to share not only



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Figure 2. Five proposed barriers that create problems and potential ideas on how to solve them. This is not an exhaustive list of the problems but includes some of the main ones we have identified whose solution might need the help of governments, ecological societies, nongovernmental organizations (NGOs), funding agencies, scientific journals, and individuals pushing for and making the needed changes. It is not the goal of this text to offer a final solution to such a complex problem, but rather to contribute to a global debate with suggestions in mind to contribute to making ecology the global discipline it needs to be.

authorship of papers but also project leadership can yield important impacts in the long run. The overarching solution for the strong inequalities in science requires profound changes in how societies and countries operate, and thus they will probably not disappear soon, but we as scientists can act to minimize their negative consequences on producing and disseminating scientific knowledge.

Education/training

A dearth of scientists or students can greatly impede the development of ecology in some regions. This barrier may be difficult to overcome, but promoting inclusive international research and collaborations can be fundamental. Educators must show that ecological knowledge results from collaborative efforts across many regions and systems. Courses in ecology should use

examples and studies from a variety of authors, systems, and regions whenever possible and appropriate. Illustrating how diverse ecology is and how ecological patterns and processes vary across biological systems will help future ecologists to develop respect and interests beyond their fields of specialty and regions of study.

We need to encourage research from poorly studied areas, ideally by local researchers who may have insights into the local ecosystems but also by promoting working collaborations rather than only invitations to collect samples or contribute data. Latin America offers a good example of how research has grown in the past decades, due in part to successful international collaborations [14]. Also, researchers need to read the literature from poorly studied areas and cite it if appropriate.

Some publications will be in local languages or the grey literature. Empowerment of scientists from less privileged areas should be encouraged.

Biases against researchers and research from less privileged regions

We all have biases, either conscious or unconscious, and we must be aware of them, even though we can never be certain of the exact biases we have or how strong they are. These biases and our own limited views of the world can affect the value we place on science coming from certain regions or groups. For publication purposes, we must increase awareness and training of journal editors to help them recognize and avoid biases of reviewers and themselves in judging the scientific quality of manuscripts [15]. Opportunities for such training for editors

and reviewers should be an objective. Avoiding such biases will promote a truly global, inclusive ecology.

Differences in research cultures

As researchers, we may have the same overall goals of understanding nature, but we do not all follow the same rules. Some countries demand research productivity as evidenced by an ever-increasing number of publications per year, while other countries do not expect their researchers to publish more than one paper annually. Also, we do not all work at the same pace. For some, papers are produced rapidly, whereas for others, writing is a much slower process. This may be particularly true for women, who tend to be burdened with more family responsibilities than men [16]. As an author, do not expect all collaborators to work and respond at the same pace or to communicate in the same way. We need to embrace each other's differences in order to allow people to do their best.

Reducing power asymmetries, broadening ecology, and increasing diversity

Reducing the asymmetric production of scientific knowledge should be a priority for ecology. The first step is diagnosing and acknowledging the problem, as some journals and scientific organizations are doing (e.g., [17]). For example, in global analyses, we should describe the data gaps and be explicit about what regions are poorly represented. In international networks, we should adopt inclusion criteria that address regional and cultural

diversity, such as those used by the Inter-governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), in selecting experts globally.

Asymmetry emerges when barriers hinder publication and knowledge production from some regions or groups and no solutions are in place to overcome them. Currently privileged positions are overwhelmingly based in a small subset of countries. By increasing all types of diversity (e.g., geographical, ethnic, gender) in producing and sharing ecological knowledge, we can help make ecological understanding more global. Calls to decolonize science are numerous and are based on solid ethical grounds [7], but it is also important to remember that making ecology a really global enterprise is fundamental for our understanding of nature and how to address the existential global environmental crisis.

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Declaration of interests

The authors have no interests to declare.

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