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The North 'Helicoptering' into the South: A Meta-Analysis of Parachute Science in Ecological Field Studies

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Abstract

Science is increasingly collaborative, but scientists from the Global North (GN) often fail to collaborate with local scientists or to build local scientific capacity when conducting research in the Global South (GS). This practice is known as "parachute science" or "helicopter science". In addition to ethical concerns, this practice is problematic in the field of ecology because it may reduce the likelihood that the research will inform local resource management and science policy. I hypothesized that, because research has become increasingly collaborative, there would be a decline in parachute science over time. In addition, I hypothesized that papers that included local authors would be more likely to be cited and to be published as open access. I tested these hypotheses using bibliographic data collected from the top 25 journals in the field of ecology. Despite increased interest in and strides towards decolonizing science, parachute science remains an issue in this field, with fewer scientists from the GS (0.43 ± 0.39) included in ecological research focused on their countries than those in the GN (0.73 ± 0.32). The less economically developed a country is (based on the Human Development Index), the less likely that country is to have local authors involved in ecological research on that country ($b = 0.98$, $r2 = 0.16$, $p < 0.0001$). There is some reason to be optimistic, as the proportion of papers that included local scientists was significantly higher in the 2010s than in previous decades ($H = 20.51$, $p > 0.05$). In contrast to my hypothesis, I found that GN scientists are more likely than GS scientists to have their work published open access and that involving local scientists does not make it more likely that a paper will be cited. In addition to discussing these results, I will provide recommendations on how ecologists and other scientists can avoid practicing parachute science and pursue more equitable research.

Keywords

parachute science, field ecology, helicopter science, bibliometrix, science collaboration

Disciplines

Ecology and Evolutionary Biology | Inequality and Stratification | Race, Ethnicity and Post-Colonial Studies

Comments

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by

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A thesis submitted in partial fulfillment of the requirements for the Degree of Bachelor of Arts in Environmental Studies.

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I affirm that I have upheld the highest principle of honesty and integrity in my academic work and have not witnessed a violation of the Honor Code.

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May 2022

Abstract

Science is increasingly collaborative, but scientists from the Global North (GN) often fail to collaborate with local scientists or to build local scientific capacity when conducting research in the Global South (GS). This practice is known as "parachute science" or "helicopter science". In addition to ethical concerns, this practice is problematic in the field of ecology because it may reduce the likelihood that the research will inform local resource management and science policy. I hypothesized that, because research has become increasingly collaborative, there would be a decline in parachute science over time. In addition, I hypothesized that papers that included local authors would be more likely to be cited and to be published as open access. I tested these hypotheses using bibliographic data collected from the top 25 journals in the field of ecology. Despite increased interest in and strides towards decolonizing science, parachute science remains an issue in this field, with fewer scientists from the GS (0.43 ± 0.39) included in ecological research focused on their countries than those in the GN (0.73 ± 0.32). The less economically developed a country is (based on the Human Development Index), the less likely that country is to have local authors involved in ecological research on that country ($b = 0.98$, $r^2 = 0.16$, $p < 0.0001$). There is some reason to be optimistic, as the proportion of papers that included local scientists was significantly higher in the 2010s than in previous decades ($H = 20.51$, $p > 0.05$). In contrast to my hypothesis, I found that GN scientists are more likely than GS scientists to have their work published open access and that involving local scientists does not make it more likely that a paper will be cited. In addition to discussing these results, I will provide recommendations on how ecologists and other scientists can avoid practicing parachute science and pursue more equitable research.

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Introduction

Science is increasingly collaborative, and globalization and technological advances in travel and communication have made it easier for more of these collaborations to be international (Barlow et al. 2018; Stefanoudis et al. 2021). Despite growing opportunities to collaborate with local researchers, scientists from the Global North often ignore collaboration with local scientists when conducting research in the Global South (Barber 2014; Scerri et al. 2020). This practice, known as “parachute science” or “helicopter science”, occurs when international scientists conduct scientific research/collect samples or data without involving or crediting local scientists and collaborators.

Parachute science undermines efforts to promote diversity, equity, and inclusion in the sciences and the science itself. It can lead to mistrust between international and local scientists, barriers to the development of scientific research within Global South countries, and a loss of important information and local perspectives (Thornton and Scheer 2012; Barber 2014; Hart et al. 2020; North et al. 2020; Scerri et al. 2020; Pettorelli et al 2020; Nuñez et al. 2021). A lack of representation in published research is also likely to impact other scientific measures of success; for example, one recent study found that 67% of editors across 24 environmental biology journals were from the United States or the United Kingdom (Espin et al. 2017). As a result of these concerns and the lack of progress on this issue, there has been a call to “decolonize” field courses and research through steps like involving and training local researchers, ensuring that research results (data, publications) are freely available, and obtaining all necessary local permits (Hart et al. 2020). It is important to note that the process of ‘decolonizing” field courses and research does not only include stakeholders such as the researchers (both local and international), but it also includes institutions that provide funding for research, academic journals, and educators in the field of ecology (Pettorelli et al. 2020).

Over the past several years, regional studies have highlighted the magnitude and pervasiveness of parachute science. According to Perez and Hogan (2017), almost half of tropical biology papers are led by authors from four countries: the United States (26%), Brazil (12%), Mexico (7%), and Germany (6%). Only 37% of the published tropical biology authors were from tropical countries. Most of the authors from tropical countries were from Brazil and Mexico, which are wealthier in comparison to other tropical countries (Perez and Hogan 2017). There has been increased collaboration between tropical and extratropical scientists, but rates have only increased by 10% in the past 40 years. Additionally, Perez and Hogan (2017) found that the likelihood of collaboration between tropical and extratropical scientists was not correlated with the number of authors on the paper. Therefore, unfortunately, a movement towards more collaborative science does not necessarily equate with a reduction in parachute science.

Stocks et al. (2008) conducted a similar study to Perez and Hogan (2017) but focused on the papers published in *Biotropica* and the *Journal of Tropical Ecology*. According to Stocks et al. (2008), only 38% of papers had lead authors from the country in which the research was conducted. Additionally, cross-country collaboration only accounted for 28% of studies (Stocks et al. 2008). These findings demonstrate that the tropics are not only primarily studied by extratropical researchers, but that research was not spread evenly throughout the tropics, as most studies (62%) were conducted in a subset of ten countries.

Another study focusing on Geoscience research within Africa (North et al. 2020) demonstrated similar results to those seen across tropical countries. North et al. (2020) broke down the top 25 high-impact journals in the Geosciences and found the top 525 most cited articles from those journals. They found that only 10 of the articles were focused on Africa and only four of the 10 had a scientist from Africa as the lead author, two of which were from South Africa (North et al. 2020).

Most recently, Stefanoudis et al. (2021) focused on marine science, using coral reef biodiversity research as a proxy for this broader field. They showed that, out of the top 10 countries with the most publications in this specific field, only two countries were not classified as high-income nations (Stefanoudis et al. 2021). Additionally, two of the countries within the top ten, Germany and Canada, do not contain any warm-water tropical coral-reef habitats, and only three of the countries (Australia, Indonesia, and France) are among those with the highest coral reef coverage (Stefanoudis et al. 2021). Seeing that Canada and Germany have more publications pertaining to warm-water tropical coral-reef habitats than most countries with these types of ecosystems is alarming for the reasons outlined above (e.g., Adams et al. 2014). Additionally, the inclusion of local scientists in this research could improve the chances that the resulting findings are integrated into local management, a key consideration for coral reefs given their rapid, global declines.

Based on the above studies, parachute science and a lack of local involvement continue to be an issue in the sciences. However, these patterns have yet to be examined on a global scale for the broad field of ecology. Here, I aim to examine parachute science at a global scale within ecological studies involving fieldwork. Many ecological studies have implications for local conservation and resource management, so excluding local researchers in these studies may reduce the effectiveness of science-based management.

Objectives

In this study, I quantify patterns in parachute science using bibliometric data from the top 25 journals in the field of ecology. I chose to focus on journals and publications that relied on ecological fieldwork because fieldwork requires travel to the region of interest. Therefore, it provides abundant opportunities for collaboration with local scientists. By analyzing these data, I hope to inform scientists, specifically those within ecology-related fields, about the need for more inclusive collaboration as well as the potential benefits of increased collaboration with local scientists. Involving local scientists, the focus of this study, is different from integrating traditional knowledge into research, though there is likely to be an interaction between these two pressing needs.

I used the data collected to test the following predictions:

> Hypothesis 1: Over time, due to an increasing number of international collaborations (Dusdal and Powell 2021), an awareness of the need to decolonize science, and requirements from funding agencies, I predict that the proportion of studies that include local scientists as co-authors will have increased from 1970 to 2020.

> Hypothesis 2: Because scientists from the Global North are more likely to publish overall (Maas et al. 2021), I predict that the likelihood of local authors being included as co-authors on research conducted in their affiliated country will increase if they are from

a country that is more economically and socially developed (i.e. Human Development Index ranking, Global North and Global South distinctions)

Hypothesis 3: Because collaborative papers are more likely to be cited and international collaborations should reach broader audiences, I predict that papers that include local scientists are more likely to be cited.

Hypothesis 4: I predict that, if involving local scientists indicates a greater awareness of issues of equity in research, the resulting papers are more likely to be published open access than those that do not include local researchers.

Methods

My methodological approach included both close and distant reading methods, as it included both manual reading of abstracts and papers and automated data mining processes in the statistical program R using the packages litsearchr (Grames et al. 2019) and bibiliometrix (Aria and Cuccurullo 2017). The first step in this process was looking through abstracts from the journal *Ecology* to find terms that were associated with ecological fieldwork. Terms were also crowdsourced using the social media platform Twitter. On Twitter, people suggested terms relating to the methods of ecological fieldwork (e.g., 'transect', 'plot'). This input helped with my approach and I decided that using method-based terms would also help prevent picking up terms that relate to more meta-analysis or lab-based research studies. For example, a more general term like "tree height" may be commonly used in field studies but also in studies based on pre-existing datasets.

Another initial step was to determine which journals I would collect information from. Using the website Scimago (https://www.scimagojr.com/), I downloaded data on journals in the field of ecology and ranked these journals by averaging the following three values in the statistical program R: the journal's h-index of authors published, the SCImago Journal Rank (SJR), and the average number of citations for each article in that journal, as done in previous studies (North et al. 2021). From this list, I went through the top 50 journals to exclude journals that were: too discipline-specific (e.g., *Reviews in Aquaculture*); focused on computational studies (e.g., *PLoS Computational Biology*); or not directly related enough to the ecology field (e.g., *Landscape and Urban Planning*). The top 25 remaining journals are the journals that I used in my study.

After choosing the 25 journals, I performed a search in Scopus for these journals for the years 1970, 1980, 1990, 2000, 2010, and 2020. Based on the workflow described above, the "naive" search terms used in this initial search were:

> *"quadrat" OR "transect" OR "fieldwork" OR "plot" OR "point count" OR "surveyed" OR "mark-recapture" AND NOT "theoretical" AND NOT "empirical" AND NOT "meta-analysis" AND NOT "laboratory" AND NOT "historic records" AND NOT "database"*

This search resulted in 1,205 articles for the six years included in the search.

I then used the package 'litsearchr' to search through the resulting abstracts, titles, and keywords from these 1,205 articles to find the single words and two-word phrases with the highest frequency. The purpose of this step was to ensure that there weren't any keywords that I missed during the "naive keyword" phase of my study (Grames et al. 2019). I decided not to add any of the resulting terms to my search because many of the most commonly used words were not specific to field studies or were already included in my search terms. For example, the most common single-word phrases were ‘species’, ‘result’, ‘plots’, and the most common two-word phrases were ‘species richness’, ‘ecological society’, and ‘plant species’

My final search for articles to include in the study was::

(TITLE-ABS-KEY ("quadrat" OR "transect" OR "fieldwork" OR "plot" OR "point count" OR "surveyed" OR "mark-recapture" AND NOT "theoretical" AND NOT "empirical" AND NOT "meta-analysis" AND NOT "laboratory" AND NOT "historic records" AND NOT "database")) AND (LIMIT-TO (EXACTSRCTITLE , "Global Change Biology") OR LIMIT-TO (EXACTSRCTITLE , "Global Environmental Change") OR LIMIT-TO (EXACTSRCTITLE , "Frontiers In Ecology And The Environment") OR LIMIT-TO (EXACTSRCTITLE , "Ecology") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Applied Ecology") OR LIMIT-TO (EXACTSRCTITLE , "Conservation Biology") OR LIMIT-TO (EXACTSRCTITLE , "Global Ecology And Biogeography") OR LIMIT-TO (EXACTSRCTITLE , "Ecological Applications") OR LIMIT-TO (EXACTSRCTITLE , "Ecosystems") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Biogeography") OR LIMIT-TO (EXACTSRCTITLE , "Conservation Letters") OR LIMIT-TO (EXACTSRCTITLE , "Ecology And Society") OR LIMIT-TO (EXACTSRCTITLE , "Landscape Ecology") OR LIMIT-TO (EXACTSRCTITLE , "Ecological Indicators") OR LIMIT-TO (EXACTSRCTITLE , "Ecosystem Services") OR LIMIT-TO (EXACTSRCTITLE , "Nature Ecology And Evolution") OR LIMIT-TO (EXACTSRCTITLE , "ICES Journal Of Marine Science") OR LIMIT-TO (EXACTSRCTITLE , "Applied Soil Ecology") OR LIMIT-TO (EXACTSRCTITLE , "Journal Of Vegetation Science") OR LIMIT-TO (EXACTSRCTITLE , "Biological Invasions") OR LIMIT-TO (EXACTSRCTITLE , "Marine Ecology Progress Series") OR LIMIT-TO (EXACTSRCTITLE , "Animal Conservation") OR LIMIT-TO (EXACTSRCTITLE , "Biodiversity And Conservation") OR LIMIT-TO (EXACTSRCTITLE , "Restoration Ecology") OR LIMIT-TO (EXACTSRCTITLE , "Ecosphere")) AND (EXCLUDE (PUBYEAR , 2022) OR EXCLUDE (PUBYEAR , 2021) OR EXCLUDE (PUBYEAR , 2020) OR EXCLUDE (PUBYEAR , 1979) OR EXCLUDE (PUBYEAR , 1978) OR EXCLUDE (PUBYEAR , 1977) OR EXCLUDE (PUBYEAR , 1976) OR EXCLUDE (PUBYEAR , 1975) OR EXCLUDE (PUBYEAR , 1974) OR EXCLUDE (PUBYEAR , 1973) OR EXCLUDE (PUBYEAR , 1972) OR EXCLUDE (PUBYEAR , 1969) OR EXCLUDE (PUBYEAR , 1957))

When downloading the data, I collected the citation information, bibliographical information, abstracts, and keywords in the form of a .csv file. The data had to be downloaded as subsets of 2,000 articles. The number of articles from 1980 to 2019 was 8,919.

I based the country of the authors on the country of their affiliation institution. Obtaining affiliation data is automated using the bibliometrix package for R, which I will also use to collect other bibliometric data including the number of citations and the open access status. I created a vector of one-word identifiers for each country (e.g. “Zealand” for “New Zealand”) and created a loop that looked through each abstract to see which, if any, country names were mentioned in that abstract. Similarly, I created a loop that searched through the author affiliations listed for each paper to see which, if any, country names were mentioned in the author affiliations list. This process involved preliminary research (reading through abstracts) to collect information on the different ways that countries are referred to in these abstracts. Additionally, some abstracts contained organization names that had country names (i.e. Springer International Publishing Switzerland), which had to be manually removed from the final dataset.

Once these data were collected, I used functions from the *Tidyverse* package to count the number of papers that included that country in the abstract, the affiliations, or both for each year of the study period. For each country, the 'setdiff' function was used to compile a list of 1) papers with abstracts mentioning that country that did not include an affiliate of that country as a coauthor (abstract only), 2) papers with coauthors affiliated with that country but without mention of the country in the abstract (addresses only), and the 'intersect' function was used to find papers where that country was in both the abstract and affiliation list (both).

I used these data to calculate a ratio that showed the proportion of papers conducted in each country that included at least one scientist from that country as a co-author using the equation (both)/(abstract only + both). A low ratio suggests the presence of parachute science; i.e., very few papers published about that country include authors from that country. Our ratio data did not fit the assumptions of parametric tests given that they were non-normal and non-independent (e.g., multiple countries from the same continent) so I used non-parametric Wilcoxon signed-rank and Kruskal-Wallis tests to test for relationships between country characteristics and parachute science.

To test the third and fourth hypotheses, I also downloaded the citation and open-access information from Scopus. For the third hypothesis, I used a Kruskal-Wallis test followed by a Wilcoxon test to test whether the number of citations varied among articles of type “address only”, “abstract only” (suggesting parachute science), and “both”. For the fourth hypothesis, I used Pearson’s Chi-squared test to see if the ratio of open access to non-open access varied between “address only”, “abstract only” and “both” articles.

In addition to unique identifiers, I collected other pertinent information regarding each country, including their GN-GS status, G20 members (which is comprised of the 20 countries with the largest economies at the time of its creation in 1999), Continent, and HDI, which is based on a number of social and economic indicators (e.g., life expectancy, literacy rate, GDP per capita) and was used as an indicator of development in this study. I used Kruskal-Wallis and Wilcoxon tests to examine differences among groups and regression tests to test for relationships among continuous variables.

Results

Hypothesis 1

Based on the ratio I developed, the mean proportion of papers including local scientists increased over the decades, suggesting that the prevalence of parachute science has decreased over time (Table 1). The increase in the proportion of papers including local scientists is most evident in recent years. The Wilcoxon test showed that only 1980 and 2010 ($z = 1577$, $p = 0.044$), 1990-2010 ($z = 10632.5$, $p = 0.012$), and 2000-2010 ($z = 27844.5$, $p = 0.004$) were statistically significant from each other in terms of the proportion of papers including local scientists (Table 2).

Across all years, countries in the GN had a greater average ratio of papers involving local scientists (0.73 ± 0.32 Mean ± SD) compared to countries in the GS (0.43 ± 0.39). This difference was significant ($H = 20.51$, $df = 3$, $p < 0.0001$). Similarly, within each decade, countries in the GN had a significantly greater average proportion of papers involving local scientists than did countries in the GS (Table 3; Figures 1 & 2). There were very few papers about a country in the GN that did not include an author from that country (Figure 1).

Hypothesis 2

Continents varied in how many of their papers were considered parachute science (i.e., in the proportion of papers involving local scientists) (Table 4; Figure 3). Additionally, while there are more studies being conducted in non-G20 countries (1149 in non-G20 countries vs. 534 in G20 countries), the majority of authors are affiliated with G20 countries (3042 in non-G20 countries vs. 7400 in G20 countries) (Figure 4). As with the GN/GS distinction, studies conducted in G20 countries were more likely to involve scientists from that country than those in non-G20 countries (Table 1 & 5).

There was a significant positive correlation between HDI and the proportion of papers including local scientists ($b = 0.98$, $r^2 = 0.1598$, $p < 0.0001$) (Figure 5). This relationship suggests the lower the country's HDI is, the less likely that country is to have local authors involved in research on that country.

Hypothesis 3

The number of citations differed significantly among the three article types: "address only", "abstract only" and "both" ($H = 331.06$, $p > 0.05$), and a post-hoc Wilcoxon test showed that all pairwise comparisons were significant ($p > 0.05$) (Table 6). Articles that were "address only" had the highest number of citations on average (50.23 ± 69.76) and "both" had the lowest (42.45 ± 59.63) (Table 7).

Hypothesis 4

A total of 28.4% of articles (5,528 articles) where the country is in both the abstract and addresses were open access, 39.2% of articles (24,228 articles) where the country is only on the address were open access, and 28.2% of articles (2,523 articles) where the country is only in the abstract were open access. These differences were significant ($X^2 = 1003.1$, $p < 0.0001$). Additionally, all continents had more papers that were not open access than papers that were open access (Figure 7).

Discussion

In 2015, the United Nations outlined 17 goals attempting to advance environmental, social, and economic development (the United Nations Sustainable Development Goals, SDGs). SDG17 aims to "Strengthen the means of implementation and revitalize the global partnership for sustainable development." (United Nations Department of Economic and Social Affairs 2022). In addition to strengthening partnerships, SDGs also stress the importance of science and technology capacity development and multi-stakeholder approaches. In their words, we need "all hands on deck" (United Nations Department of Economic and Social Affairs 2022).

Parachute science undermines the goal of SDG17, as international scientists are less likely to actually contribute their work and research to better local communities compated to local scientists (Stöfen-O'Brien et al. 2022). This phenomenon can weaken a country's progress toward the SDGs. It can also harm science policy and development, since data and information can help policymakers come up with sustainable science policy, including environmental and public health policies. The scientific community needs to acknowledge and address parachute science if we want to address complex, global issues such as climate change, COVID-19, and biodiversity loss. The UNSDG focuses on encouraging Global North-South and South-South partnerships, which can be helpful in addressing parachute science (United Nations Department of Economic and Social Affairs 2022). These efforts also have to be made at the level of the individual scientist and at the level of institutions, funding agencies, international bodies, and scientific journals.

The reason why it is important for approaching the parachute science issue from a multilateral approach is that studies have shown that the scientific outcomes from research that is deemed either 'parachute' or 'helicopter' science actually decrease in quality. Important information, such as the historical ecology and location of species, is left out due to the fact that external researchers have a limited understanding of the study area (or region) (Adams et al. 2014; Barber et al. 2014; Mwampamba et al. 2021). Ignoring the local knowledge can also cause even more issues, as it prevents the opportunity for the most important stakeholders (the individuals who actually live in the study area or region) to collaborate with international scientists to come up with sustainable management practices (Adams et al. 2014; Barber et al. 2014).

Here, I aimed to quantify trends in parachute science in ecological field studies and recommend solutions to scientists to help prevent unethical practices, which can obstruct the sustainable development process. I also examined connections between parachute science, citation impact, and open access.

Trends in Parachute Science

Using data from 8,919 scientific articles in the field of ecology across four decades, I demonstrated that, despite increased interest in and strides towards decolonizing science, parachute science remains an issue. In support of my first hypothesis, fewer scientists from the GS were included in ecological research focused on their countries than those in the GN (Figure 2). This pattern was true in all decades, including the most recent decade (2010). There is some reason to be optimistic, as the proportion of papers that included local scientists were higher in the 2010s than in previous decades (Table 1; Figure 2). The results from the first hypothesis potentially demonstrate that countries, journals, and scientists are being more mindful of collaborating with local scientists and researchers. This trend may be due to the rising demand for diversity, equity, and inclusion in the sciences and in academia as a whole. Trends of increasing collaboration could also indicate a rising science and technology capacity in GS countries, an indication of development.

Despite this progress, there is still a divide between the GN and GS, as the countries with the lower ratios tend to belong to the GS. One potential reason for this is the fact that many countries within the GS experience a "brain drain", which can negatively impact a country due to the loss of skilled scientists (Mwampamba et al. 2021). There are many reasons why a scientist might go abroad, such as political conflicts and a lack of infrastructure regarding scientific research and development (Powell et al. 2020).

I used several approaches beyond the GN/GS distinction to examine trends in parachute science. In support of my second hypothesis, I also found that countries with higher HDIs are more likely to have a local author involved in research on their country (as indicated by a higher ratio). I found similar patterns when comparing more and less-developed continents (Figure 3) and G20 and non-G20 countries (Figure 4). All of these results (Figures 1, 3, 4, 5) demonstrate the same thing - countries that are deemed ‘less economically developed’ are less likely to have a local scientist work on research conducted within that country, compared to scientists from more ‘developed’ countries.

Current Roadblocks to Better Collaboration

In general, the history of science has led to mistrust of researchers by local communities especially if they have dealt with unethical practices like parachute science in the past (Mwampamba et al. 2021). Some countries consider those that have left for work or schooling reasons as “mzungufied”, which indicates that the local researchers that stayed home might no longer see *you* as a *local* (Mwampamba et al. 2021). This response might seem uncooperative to international researchers, but the reality for many individuals from the GS is that the legacies of colonization and racism are still seen throughout their systems of governance and social hierarchies (Watson 2021). Historical legacies, such as colonization, can potentially make it harder for someone from the GN to find a collaborator in GS. Trust is a necessary and time–consuming the first step. While building trust is key for long-term collaboration, it is important to start with reliance, as it sets the relationship to focus on minimizing risks and maximizing benefits (Kerasidou 2018). Starting with reliance can also help distribute the rights to the partners involved, as collaborations with GN and GS researchers can be asymmetrical - whether intentional or not (Kerasidou 2018). Slowly building a relationship with reliance can lead to trust, but starting with trust could lead to asymmetrical collaboration where a GS researcher depends on a GN collaborator rather than setting a level playing field between all stakeholders involved in the research (Kerasidou 2018).

In many North-South collaborations, a more economically developed state supports a state that isn't as developed (e.g. Norway utilizing green funds for sustainable development initiatives in Global South countries) (Stöfen-O'Brien et al. 2021). This aid can come in the form of funds or other resources, such as technological exchanges (Stofen-O'Brien et al. 2021). There are some controversies with North-South cooperation, as it often prioritizes the needs and approaches of the GN (Stöfen-O'Brien et al. 2021). North-South cooperation could potentially lead to more parachute science, and not having local scientists take part in the key early stages of the research process, such as the goal-setting stage (Stöfen-O'Brien et al. 2021). More local participation at all stages of the scientific process, from brainstorming to publishing, can potentially lead to results that better inform local and global science policy (Thorton and Sheer 2021; Stofen-O'Brien et al. 2021).

Another issue with North-South cooperation is that many of the "cooperations" that do exist between countries and regions are not evenly distributed, ignoring some countries and regions that need help in regard to scientific capacity building (Blicharska et al. 2021). Stefan-O'Brien (2022), for example, points out how the Wider Caribbean Region gets ignored in environmentally-focused international cooperation. Stefan-O'Brien et al. (2022) support the results from the Blicharska et al. (2021) meta-analysis of international cooperation for the UN Sustainable Development Goals, as low-income countries were least likely to be a part of partnerships when compared to other income groups.

Parachute Science and Research Visibility and Accessibility

Though previous research has found that collaborative research is more likely to be cited (Pan et al. 2012), I did not find support for my hypothesis that involving local researchers in a paper would lead to a greater number of citations. In fact, I saw the opposite trend, demonstrating that papers including local authors are less likely to be cited.

Maas et al. (2021) performed a similar analysis, focusing on conservation, and found that women and individuals from GS countries account for a minority of authors with high publishing rates, which can impact the citation impact rates of researchers. Similar to our findings on a reduction in parachute science in recent decades, Maas et al. (2021) only found a significant increase in women and GS authors in the most recent decade examined (1990-2004). Despite these improvements, authors from the United States, United Kingdom, and Australia make up over two-thirds of authors with the highest publishing rates (Maas et al. 2021). One of the main similarities between the three countries is that they are: 1) a majority English-speaking countries, 2) higher income per capita compared to countries with lower GDP per capita, and 3) most scientific journals are based in these three countries (e.g. *Ecology* (United States) and *Journal of Applied Ecology* (United Kingdom)). Having English as a first language (or as the main language of instruction) puts researchers ahead of others, and this can result in a loss of local ecological knowledge and historical ecology (Thorton and Sheer 2012). Additionally, bias plays a large role in approving an article for publishing (Mammides et al. 2016; Maas et al. 2020; Nuñez et al. 2021). Bias can be seen not only in terms of geographic representation but also in regard to the gender distribution of high-impact (or high publishing) authors (Maas et al. 2021).

The results from our studies (as well as the other studies mentioned) also align with the results of Mammides et al. (2016), which found that the mean acceptance rates were different across levels of income. Non-high income countries (NHIs) have a mean acceptance rate of approximately half that of their high-income counterparts (HIs) (Mammides et al. 2016).

Indicators such as GDP per capita, population size, and the quality of governance impact publishing rates across regions; more populous countries, for example, have more research institutions and scientists, which can result in a higher frequency of published research (Meijaard et al. 2015). Due to these factors, the GN has a much higher science capacity and stronger funding mechanisms, which is likely to impact how likely papers from a country are to be cited (Table 6 & 7; Meijaard et al. 2015).

Another important aspect to take into consideration is open access publishing, as this can lead to greater citation rates of a paper (Lawrence 2001, Eysenbach 2006, Evans and Reimer 2009). Additionally, it's incredibly important for scientists and citizens from a country to be able to access research about ecological issues in their country, and those from the GS are disproportionately reliant on citing open access articles in their own research (Evans and Reimer 2009).

In contrast to my hypothesis that including local authors suggests more inclusive research and would lead to higher rates of open access, we found that papers that excluded local authors were more likely to be published OA than those that did not (Figure 6). Previous studies have similarly found that GS scientists are actually less likely to have their work published as OA. Reasons for this include negative perceptions regarding OA journals, employers requiring or incentivizing authors to publish their work in higher impact journals, and high publishing fees (Powell et al. 2020; Entradas et al. 2020; Kwon 2021).

Powell et al. (2020) discussed the different levels of OA, and how popular each model is for GS scientists. For example, the most commonly used OA model is the Gold Article Publication Charge (commonly referred to as Gold APC), which accounts for 18% of articles published, and requires the author to pay a fee in order for their work to be published as OA (Powell et al. 2020). This model is problematic, as OA articles are meant to allow for the free distribution of scholarly articles, and adding fees actually prevents the GS perspectives (and research) from being brought to light (Powell et al. 2020; Entradas et al. 2020; Kwon 2021).It's worth noting that APC charges can be waived by journals, as researchers from the GS are less likely to have institutional support for the APC charges (Iyandemye and Thomas 2019). However, the ability to waive fees is only available to the lowest income countries and authors may not always be aware of this option (Newton 2020).

An important consideration for my results is that this research focused only on the top 25 journals in the field, which may not be where scientists from the GS choose to or are able to publish. One of the reasons surrounding this actually connects with the *Times of Higher Education* (THE) World Rankings, and how research and publications are weighted for 60% of the rankings until 2019 (Irfanullah 2021). For example, many Bangladeshi universities invest only 1% of their resources towards research, hence causing Bangladeshi universities to have a lower ranking compared to institutions in other countries (Irfanullah 2021). *THE* introduced a new Impact Rankings system that equally distributed the weight of indicators within the rankings to focus more on publications indexed by Scopus, which disqualifies any Bangladeshi journal and focuses on an institution's contribution to the 17 SDGs (Irfanullah 2021). Many of the OA journals that fit the Scopus-index requirement mostly utilize the Gold APC model, which as we know, requires money to publish articles (Powell et al. 2020). According to Irfanullah (2021), without any subsidization, it costs $9,900 to publish in Elsevier's *Cell*. For context regarding the barriers to publishing in OA, the average monthly salary for a professor in the United States is $6,054, which is a GN country (Jaschik 2012). Currently, 75% of GS authors had their works published in paywalled journals, and the rest were OA (Irfanullah 2021). This issue is not unique to Bangladeshi, as authors from many GS countries have expressed frustration at the barriers placed upon them in regard to publishing their research (Kwon 2022).

One of the main reasons why there needs to be more action toward establishing an equitable approach to publishing in an OA journal is the fact that GS authors are more likely to cite OA articles compared to their GN counterparts (Evans and Reimer 2009). In addition, the English language requirements for journals also bring in a new barrier, which can be seen in OA journals, as 88% of OA articles are written in English (Evans and Reimer 2009). Future research should focus on the solutions to inequities in publishing, OA or otherwise, among GS and GN countries. To make OA more equitable, journals should work on making the grants and waiving fee process more transparent, and easy to understand for scientists who might not be able to afford the APC or might not be fluent in English..

Recommendations for an Equitable Science

Nuñez et al. (2021) highlight several issues that perpetuate parachute science, such as language barriers, inequality in funding and infrastructure within and among countries, discrepancies in education and training, and biases against researchers and research from less privileged areas. The four issues that Nuñez et al. (2021) bring up demonstrate the complexity of the issue, as they cannot be solved unless there is a change in the ways we approach ecology and other fields of research. Pettorelli et al. (2020) also bring up similar issues about the way we practice ecology, and how these practices are mainly shaped by "...white European and North American values and ways of approaching problems". This approach creates biases in the hypotheses that are being proposed, the language which most research is used to communicate, and how (and where) the research is being conducted (in addition to who is conducting the research) (Pettorelli et al. 2020). The barriers mentioned tie in with the issue of ignoring conscience when formulating research, especially when the perspectives of locals do not fit the Western approach to science (as mentioned above).

When conducting research, it is imperative that researchers from the GN (or from more developed nations) have to take the necessary steps that true collaboration is taking place. This includes ensuring that scientists are not tokenizing local collaborators on projects, which ruins the entire concept of collaboration, as international scientists are not taking the perspectives and ideas of their collaborators seriously. Local collaborators should be involved from the beginning of the scientific process, and this partnership needs to emphasize building trust between all participants (Bennet and Gadlin 2012). An example of proper collaboration would be consistent communication, and also the ability to relinquish one's control over the scientific research process. It might not be an easy step, but current distrust between scientific communities - especially in field ecology - negatively impacts the future of scientific research.

The practice of parachute science and other neo-colonialistic practices have hurt collaboration, especially between GN and GS researchers. One of the best ways to approach building trust is having all participants take part in all aspects of the scientific research process - meaning that they should be involved from the get-go (Bennett and Gadlin 2012). Trust between collaborators allows for the scientific research to reach a wider audience, and even play a role in science policy for a specific nation or region. In addition, there needs to be a bigger push for scientific journals in other languages to be used more, as they provide scientists (who are not able to speak and write in English) a better opportunity to have their work published.

Another major step to reducing parachute science is ensuring that the editorial boards and other important positions within the journals contain a diverse set of scientists. Petorelli et al. (2020) point out how allowing associate-level positions (such as an Associate Editor) to be open instead of invitation-only might lead to greater diversity in these positions. Petorelli et al. (2021) review some of the ways in which one leading journal, the Journal of Applied Ecology, has changed its practices to become more equitable. This journal used to only have its senior editor positions open to anyone but has now opened up some junior-level positions within editorial boards, allowing for more opportunities for scientists around the world. This need for greater inclusion is also true at the reviewer level. Additionally, the Journal of Applied Ecology encourages its reviewers and editors to focus mainly on the science behind a submitted article, rather than the grammar and language (Petorelli et al. 2021). Lastly, the Journal of Applied Ecology also makes its articles open access for two years after publication, allowing scientists and readers from around the world to read the findings, and possibly be able to replicate the study (Petorelli et al. 2021). The proactive measures above provide three mechanisms by which journals can support more collaborative and inclusive STEM, and more journals should follow suit. In fact, if more attention is brought to non-English articles, there could be a possibility of expanding the geographical coverage of biodiversity scientific evidence by 12% to 25% and the number of species covered by 5% to 32% (Amano et al. 2021).

At a level above journals, groups like the *Times of Higher Education* should incorporate non-Scopus-indexed journals into their rankings, as scientific research, regardless of which journal or form of media it is published as, can provide valuable info about our world and help us to better solve the complex global issues that we are facing.

Finally, emphasizing community-engaged research provides a method for international researchers to work with local communities and scholars. It occurs when members of communities and research-based institutions collaborate throughout the research process toward shared outcomes (Adams et al. 2014). One of the methods of utilizing a community-engaged research approach is using conscience as the main method of conducting scientific research. Conscience is when a natural phenomenon is examined through both indigenous (or in this case, more local) and western methods, in which each approach is assumed valid within its own set of rules and neither replaces the other (Thornton and Sheer 2012). Applying different forms of knowledge can provide different methods to be utilized and can help bring in new findings that may have been missed.

Caveats and Future Directions

There are several limitations to my study. The most substantial limitation is that I used the home institution as an indicator of the researcher's home country. It is possible to have an author who is from a different country but works for a foreign institution. This limitation could impact my results in either direction; GS scientists might be publishing from GN institutions, and GN scientists might be publishing from GS institutions. North et al. (2020) similarly point out the issue of brain drain having an impact on their results (focusing on Geosciences and African authors), as 90% of African immigrants move to OECD countries that are considered to be highly developed. In future research, it would be interesting to include a component about researchers who go abroad for work but return home for research purposes. It could provide more insight into *who* is practicing parachute science versus someone who might be considered a local but works abroad.

Another potential limitation is that articles might be about a country but not include the country in the abstract (e.g., they might instead include the continent or region); the likelihood of a country being named specifically might also vary depending on the country. Country names might also be shortened in abstracts (e.g., USA rather than the United States). The likelihood of these two things occurring might differ by country and be linked to inequity, with GN countries being mentioned with higher specificity. For example, a paper about Uganda may be more likely to refer to the study taking place in "Africa" than it would be for a paper about the United States to be referred to as taking place in "North America". It is also worth mentioning that another caveat from this study is the usage of single words for the country names, as countries might have different variations of names (e.g. Ivory Coast and Côte d'Ivoire).

Future work should also compare the results focusing on ecological field studies with other fields of studies that incorporate some type of fieldwork. Parachute science is not just an ecology issue, and we must make sure that researchers in other fields of work are practicing ethical research methods. It is also important to recognize that each field of study also has its issues regarding diversity, equity, and inclusion. Also, future studies could examine whether certain GN countries practice parachute science in specific GS countries. This addition could provide us insight into how colonialism plays a role in parachute science.

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Tables

Table 1: Mean and SD of Proportion of Papers Involving Local Scientists, Across Countries by Decade			
Decade	**n**	**Mean Ratio**	**SD Ratio**
1980	**31**	**0.32**	**0.41**
1990	**100**	**0.45**	**0.41**
2000	**238**	**0.49**	**0.39**
2010	**366**	**0.60**	**0.39**

Table 2: Wilcoxon Test for Proportion of Papers Involving Local Scientists for Each Country, Compared Across Decades

Decade 1	Decade 2	No. Countries Decade 1	No. Countries Decade 2	Statistic	p-value
1980	1990	31	100	563.5	0.472
1980	2000	31	238	1302.0	0.298
1980	2010	31	366	1577.0	0.044
1990	2000	100	238	8756.0	0.472
1990	2010	100	366	10632.5	0.012
2000	2010	238	366	27844.5	0.004

Table 3: Wilcoxon Test of the Proportion of Papers including Local Scientists, Comparing Global North and Global South Countries by Decade						
Decade	**Group 1**	**Group 2**	**No. Countries Group 1**	**No. Countries Group 2**	**Statistic**	**p-value**
1990	**GN**	**GS**	**33**	**67**	**1297.5**	**9.29E-06**
2000	**GN**	**GS**	**80**	**158**	**7453.0**	**3.04E-08**
2010	**GN**	**GS**	**127**	**239**	**15153.5**	**4.77E-07**

Table 4: Kruskal-Wallis Test of the Proportion of Papers including Local Scientists, Compared Across Continents by Decade			
Decade	**No. Countries**	**Statistic**	**p-value**
1990	**100**	**22.10**	**5.01E-04**
2000	**238**	**32.40**	**4.94E-06**
2010	**366**	**37.47**	**4.83E-07**

Table 5: Wilcoxon Test of the Proportion of Papers Including Local Scientists, Comparing G20 and non-G20 Countries

Decade	Group 1	Group 2	No. Countries Group 1	No. Countries Group 2	Statistic	Degrees of Freedom	p-value
1990	G20	non-G20	17	83	3.25	32.64	0.002660
2000	G20	non-G20	36	202	4.10	65.70	0.000115
2010	G20	non-G20	54	312	3.46	93.76	0.000824

Table 6: Mean and SD of Citation Count based on Author Inclusion in Papers		
Paper Type	**Mean**	**Standard Deviation**
Abstract Only	**47.50**	**72.44**
Address Only	**50.23**	**69.76**
both	**42.45**	**59.63**

Table 7: Wilcoxon Test of Citation Count based on Author Inclusion in Papers					
Group 1	**Group 2**	**No. Papers Group 1**	**No. Papers Group 2**	**Statistic**	**p-value**
Abstract Only	**Address Only**	**8937**	**61822**	**264757592**	**9.37E-07**
Abstract Only	**Both**	**8937**	**19499**	**90940633**	**4.47E-14**
Address Only	**Both**	**61822**	**19499**	**647779761**	**5.27E-73**

Figures

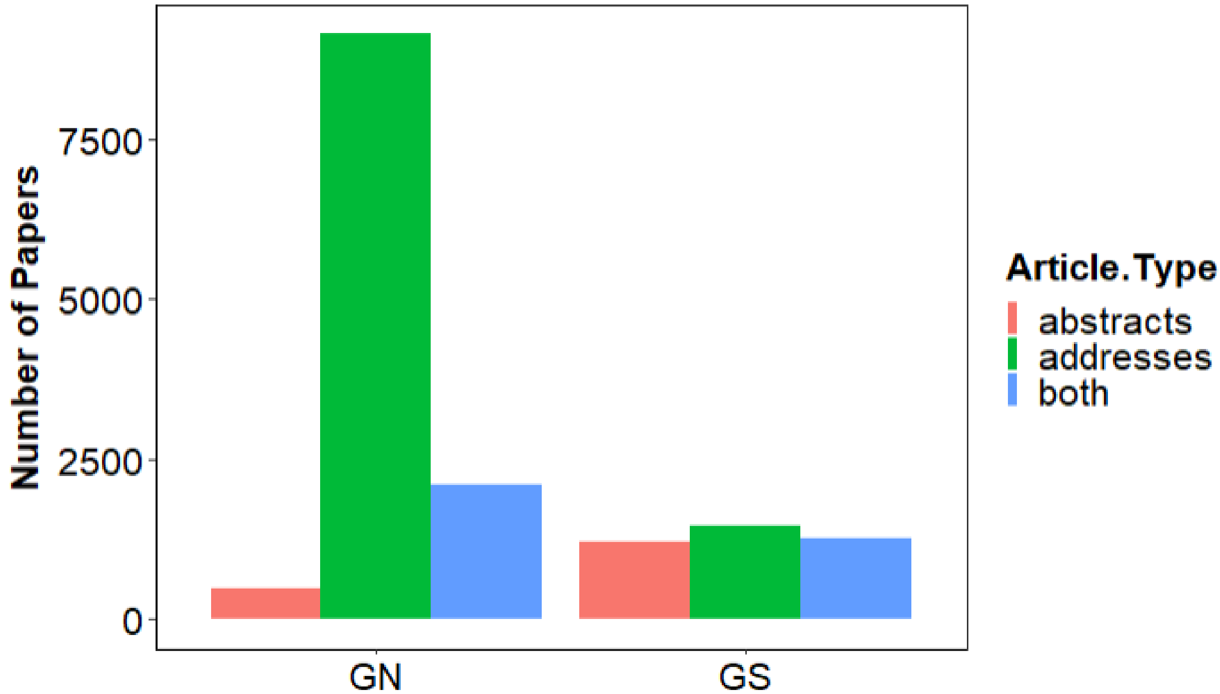

Figure 1: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions). The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. Article Type refers to whether an article had the name of a country in the abstract only ("abstracts"), in the affiliations only ("addresses"), or in both the abstract and the affiliations ("both"). The classification for GN/GS came from the International Telecommunications Union (ITU).

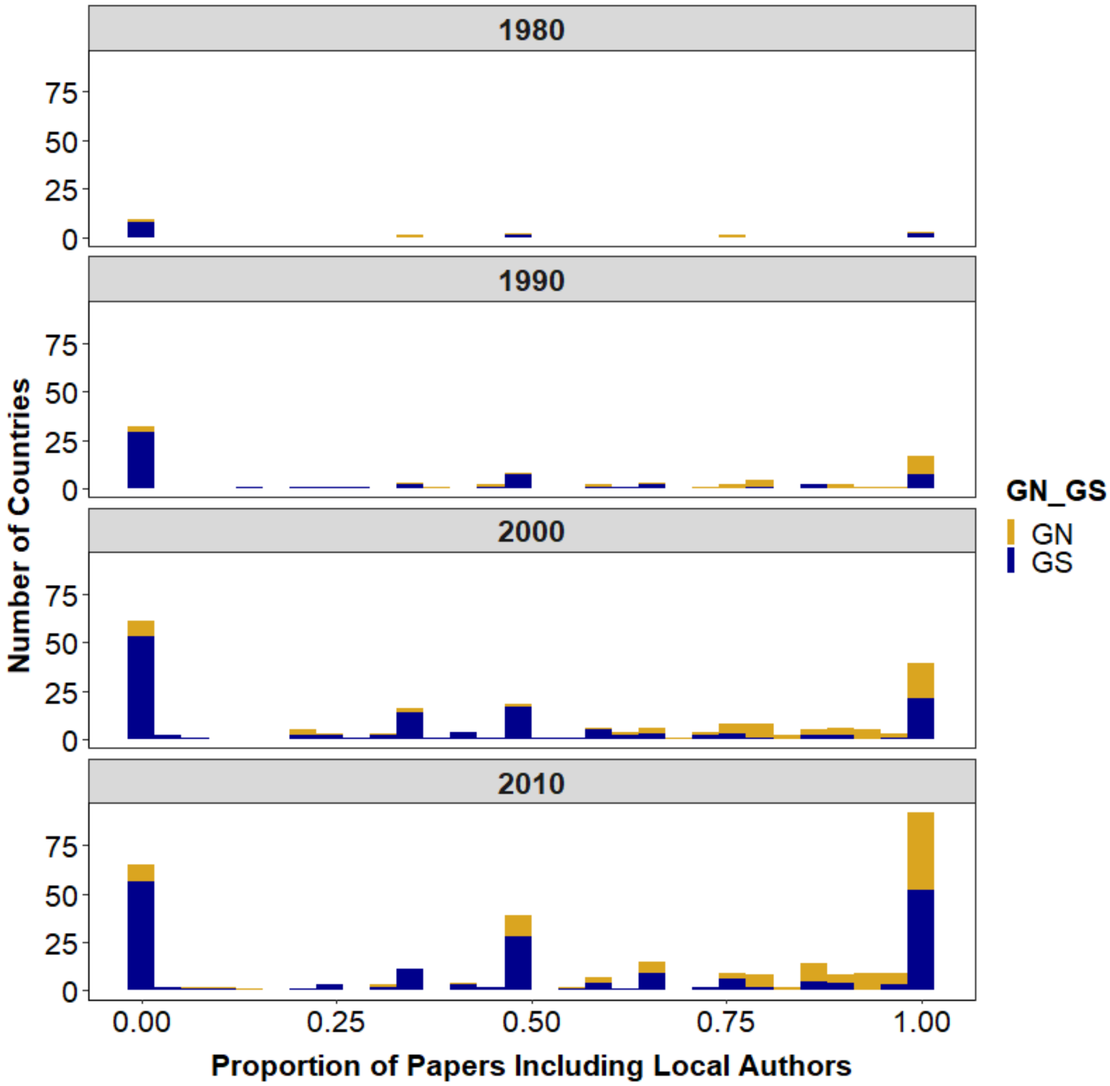

Figure 2: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions). The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. "Both" represents a paper that includes an author from the country where the study is being conducted. "Abstract only" represents papers where the country was only mentioned in the abstract. For the ratio, I used the formula, (both)/(abstract only + both), to find the ratios of local authors being included in papers about their country. A result of zero represents no local authors were included in papers about that country.

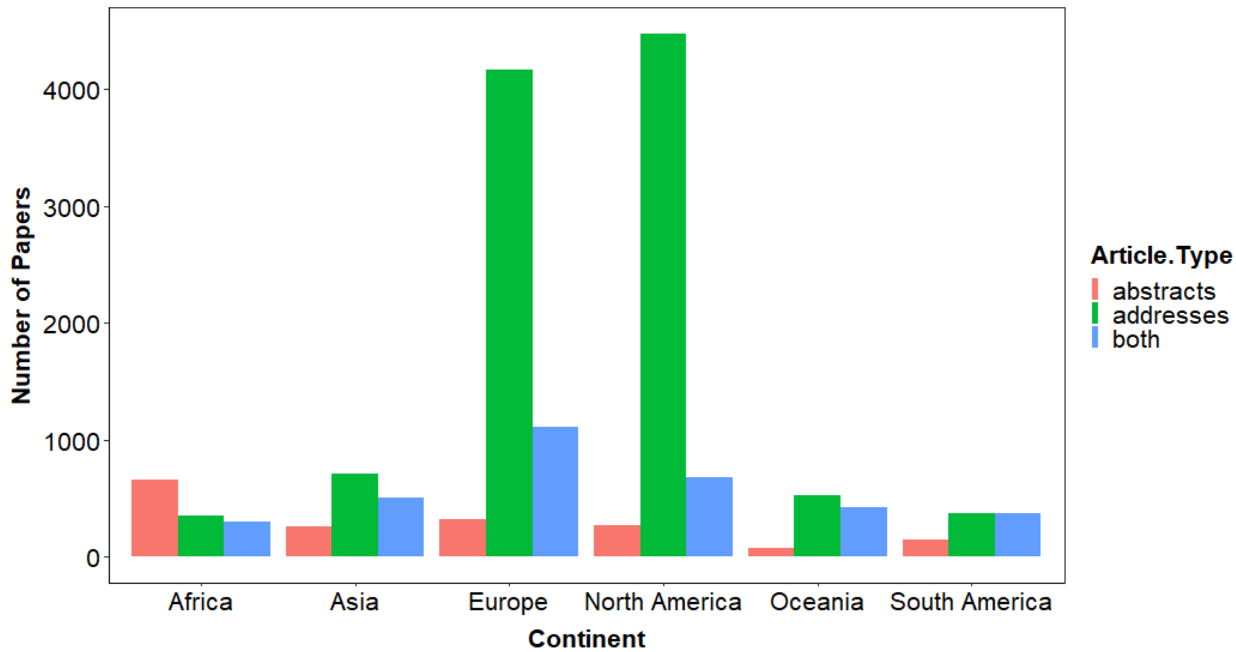

Figure 3: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions) by continent. The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. Article Type refers to whether an article had the name of a country in the abstract only ("abstracts"), in the affiliations only ("addresses"), or in both the abstract and the affiliations ("both").

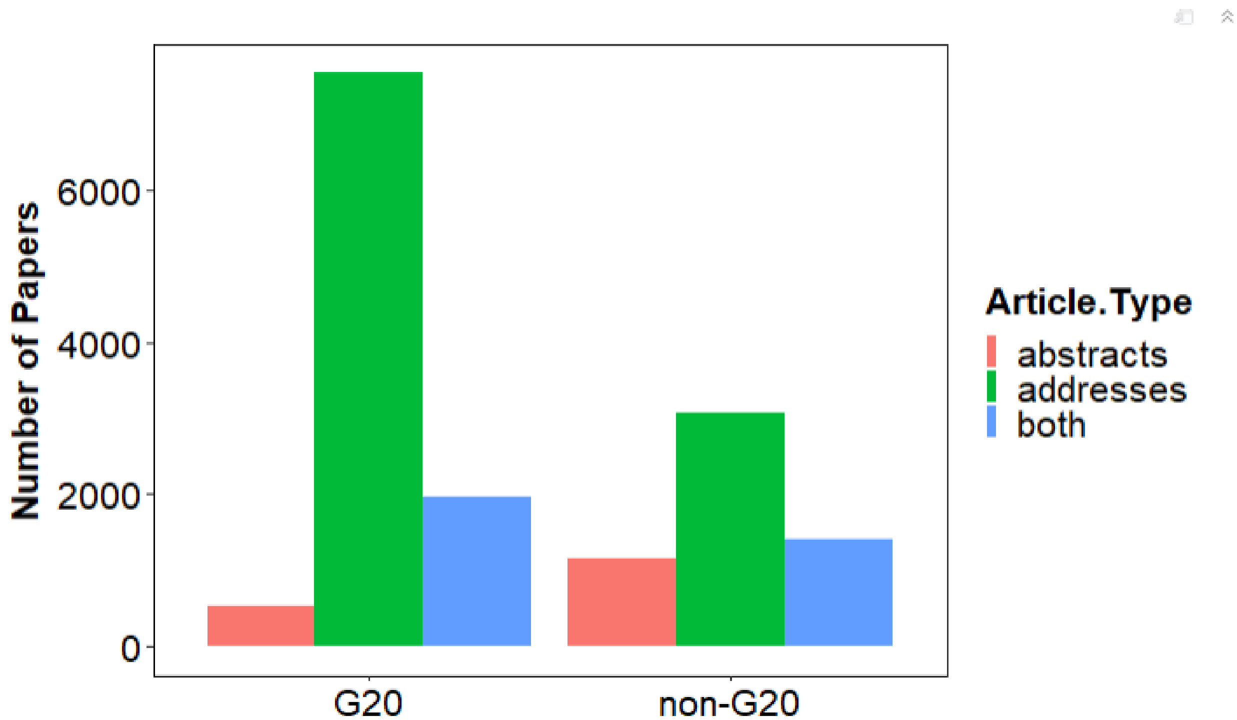

Figure 4: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions) by G20/non-G20 classification. The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. Article Type refers to whether an article had the name of a country in the abstract only ("abstracts"), in the affiliations only ("addresses"), or in both the abstract and the affiliations ("both").

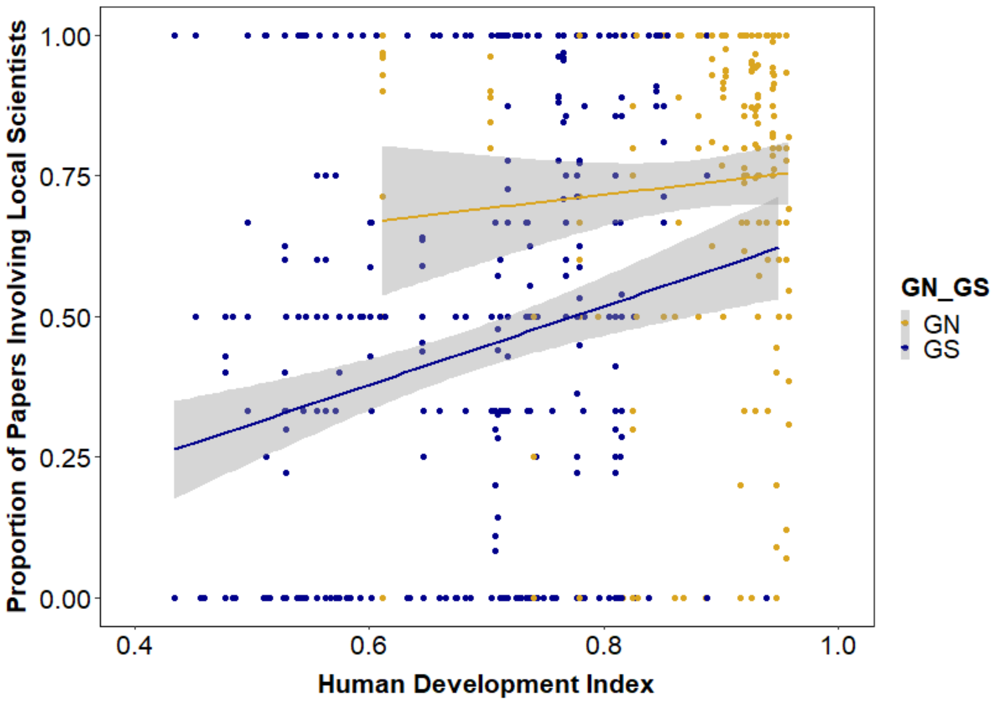

Figure 5: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions). The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. "Both" represent papers that include an author from the country where the study is being conducted. "Abstract only" represents papers where the country was only mentioned in the abstract. I used the formula (both)/(abstract only + both) to find the proportion of local authors being included in papers about their country. A result of zero represents that no local authors were included in papers about that country. The ratios are spread across by Human Development Index (HDI), which I retrieved from the United Nations Development Programme (UNDP). The graphs demonstrate that GN countries have higher ratios and HDIs when compared to GS countries, which means that studies that take place in GN countries are more likely to include local authors compared to studies that take place in the GS.

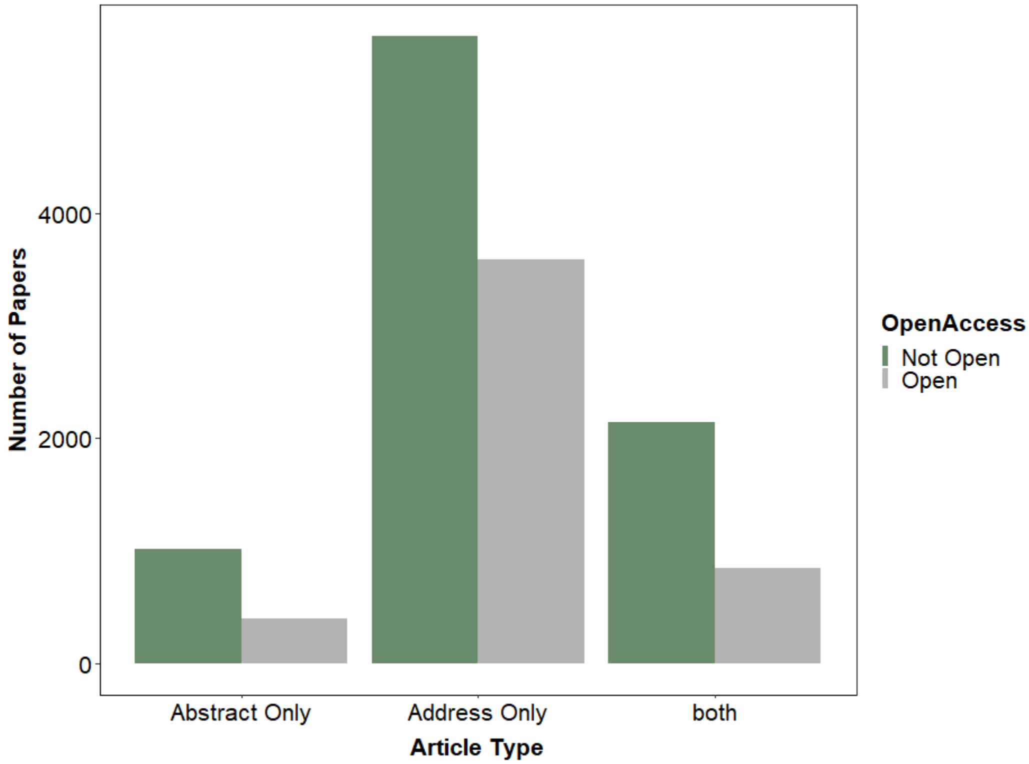

Figure 6: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions). The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. When collecting the data, there were different levels of open access (i.e. Green Open Access, Gold Open Access), all of which I called "Open Access". Those that weren't open access at all were classified as "Not Open". Papers that do not include local scientists are more likely to be open compared to those that include local scientists.

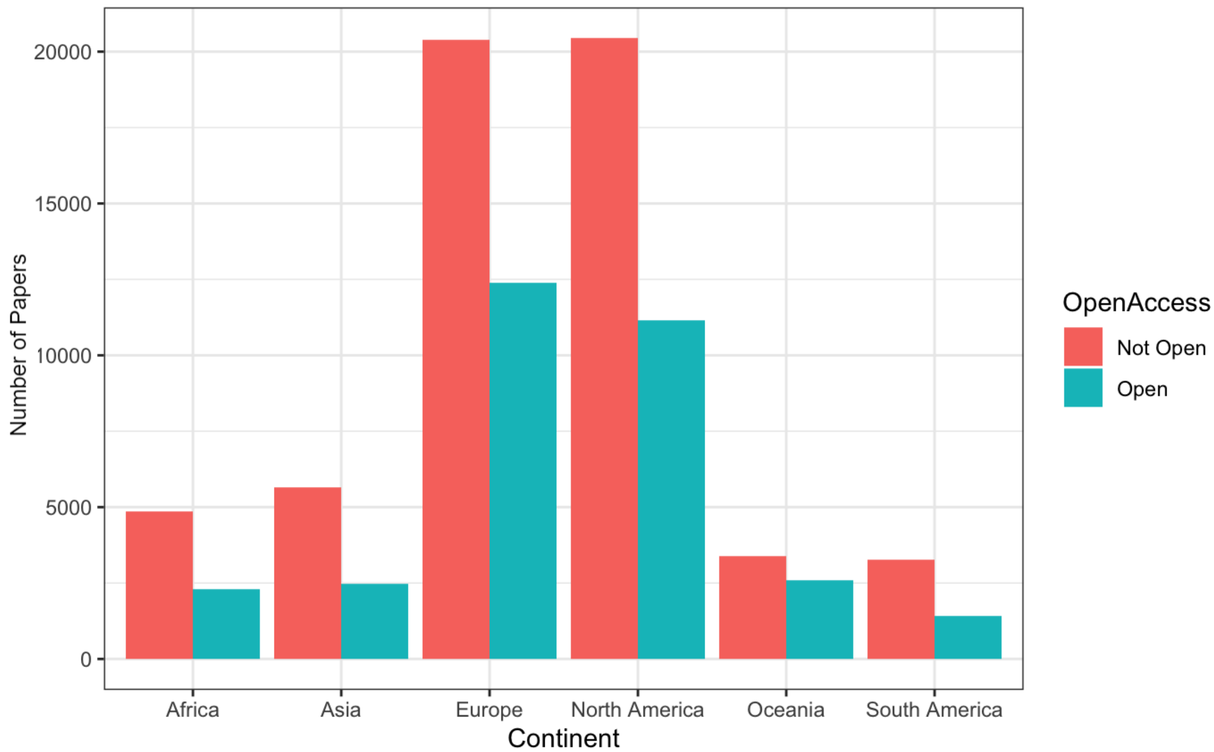

Figure 7: The total number of papers falling under each paper type in this study (n = 8,919 papers and 15,674 country mentions). The study focused on papers published in the top 25 ecology journals from 1980 to 2019 that used terms relating to field ecology. When collecting the data, there were different levels of open access (i.e. Green Open Access, Gold Open Access), all of which I called "Open Access". Those that weren't open access at all were classified as "Not Open". Papers from all continents are more likely to be published as not open compared to papers published as open.