Is there really such a thing as *Tropical* Biology?[1]

Emilio M. Bruna[1, 2, 3]

[1] Department of Wildlife Ecology and Conservation, University of Florida, PO Box 110430, Gainesville, FL 32611-0430, USA

[2] Center for Latin American Studies, University of Florida, PO Box 115530, Gainesville, FL 32611-5530, USA

[3] Email for Correspondence: embruna@ufl.edu

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[1] Inspired by the provocative title of an essay by M. H. Robinson.

Abstract

Abstract, followed by up to eight keywords separated by a comma. Keywords should be in English (with the exception of taxonomic information) and listed alphabetically.

Keywords: up to eight

Word count: X

1. INTRODUCTION

"This is an interesting and useful study, but I feel the manuscript is better suited to a specialized journal focusing on tropical ecosystems."

Subject Editor *(name and journal redacted)*

This decision regarding my submission to one of our field's well-known journals is likely familiar to many members of the Association for Tropical Biology & Conservation (ATBC). All three reviews were positive, with none of the referees identifying significant shortcomings or requesting major changes. So why had the manuscript been rejected? My only clue was in the Editor's conclusion, from which I gathered they felt studies done *in* the tropics were of limited relevance to researchers working *outside* the tropics. That's for whom a specialized journal is published, after all – a smaller community of subject-matter experts – and the journal to which we had submitted our study sought to publish "broad conceptual advances". In short, the Subject Editor was drawing a distinction between *Biology* and *Tropical* Biology, with the latter a specialized subdiscipline of the former.

Sixty years on many of us find ourselves similarly frustrated. Field stations in the tropics remain underfunded (Corner 1946, Eppley *et al.* 2024). Financial support for tropical research continues to decline (Chapman *et al.* 1945, Sohmer 1980, Stegmann *et al.* 2024). And the study of tropical ecosystems – which comprise the majority of the planet's biodiversity (Gaston 2000), ~40% of its terrestrial surface area, and half the human population (Hoornweg & Pope 2017) – continues to be seen by many as a scientific specialization. My objective here is not to review the biological validity (Robinson 1978, Moles & Ollerton 2016) or scientific implications (Zuk 2016) of this generalization, nor to summarize the history, status, and direction of tropical research (Buechner & Fosberg 1967, Janzen 1972, Janzen 1986, Bawa *et al.* 2004, *e.g.,* **chazdonFoundationsTropicalForest2001l?**). Instead, I will try to assess the fundamental assumption : Is there really such a thing as *Tropical* Biology? This limited view

of tropical research is not new. In 1963, P. W. Richards felt it necessary to use his Presidential Address to the British Ecological Society to explain "what the Tropics can contribute to ecology", advocate for the tropics to be studied more intensively, and to encourage students to visit "the most [biologically] exciting part of the world" (Richards 1963). His reason for choosing this topic, while self-deprecating, was pointed - he was concerned that a overview of his own research or recent advances in tropical ecology "would probably bore the large part of my audience." (Richards 1963). That he felt doing so was necessary despite he and others having done so for decades (Huxley 1927, Chapman *et al.* 1945, Park 1945, Richards 1946) was surely frustrating.

1. Why the answer is *'No'.*

"In attempting to study vegetation and to arrive at generalizations... it would be more logical to begin with the floristically rich vegetation of the tropics than, as we now do, with the impoverished vegetation of northern Europe and North America."

P. W. Richards (1946)

One means of assessing if *Tropical* Biology is a distinct academic discipline is by considering the communities into which scientists self-organize. Scholarly societies are one such community; their establishment requires both an intellectual pursuit with which individuals identify and a critical mass of like-minded individuals in search of community. Some of these communities coalesce around broad conceptual domains (e.g., *Evolutionary* Biology, *Conservation* Biology, *Integrative* Biology; Figure 1A). Still others bring together individuals from different conceptual domains that share an interest in a particular system (e.g., *Avian* Biology, *Island* Biology; Figure 1B). Finally, some scholarly societies comprise individuals grounded in a common methodological framework, though they may do so with disparate study systems or to address questions in distinct conceptual domains (e.g., *Molecular* Biology, *Mathematical* Biology, *Systematic* Biology; Figure 1C).

Tropical Biology fails to align with any of these constructs. Its practitioners investigate

fundamental questions across conceptual domains with a broad range of methodological approaches and study systems. Even the adjective that would seem be a unifying thread is challenging to operationalize. 'The Tropics' are geographically defined as the portion of the Earth's surface receiving at least one day of direct overhead sunlight per year — a band delineated by the Tropics of Capricorn (23°26'10.4" S) and Cancer (23°26'10.4" N). However, the ranges of many 'tropical' species extend far beyond these boundaries[2], and a review by Feeley and Stroud (2018) of over 200 scientific articles identified at least eight distinct criteria by which authors defined 'tropical' systems. How then is it that *Tropical Biology* come to be seen as a distinct subdicipline despite the lack the sharp boundaries around which scientific groups typically coalesce?

These contemporary perceptions of 'The Tropics' as distant and different are the result of centuries of historical and cultural reinforcement (Arnold 1996, Driver & Yeoh 2000, Stepan 2001, Miller & Reill 2011). The first Europeans to visit the tropics returned with vivid, captivating, and frequently pejorative descriptions of the places and people they encountered (Putz & Holbrook 1988). Their stories and images established a series of persistent, often contradictory tropes about tropical regions and people that were then repeated and reinterpreted by subsequent visitors (Smith 1950, Stepan 2001). The historian David Arnold has argued that these narratives of *Tropicality* (*sensu* Gourou 1947), and even referring to this part of the globe as *The Tropics*, allowed Europeans simultaneously define the region as environmentally and culturally distinct while also superimposing a common identity on very distinct parts of the tropical world (Arnold 1996).

The view of the tropics as simultanously 'exotic' and 'other' was prevalent during the formative years of von Humboldt, Darwin, and Wallace. Those they inspired that went on to formalize the fields of ecology and evolution, almost all of whom were based in Europe or North America, also grew up immersed in stereotypes about the tropics. They were

[2] Perhaps the most extreme examples are migratory birds such as the northern wheatear (*Oenanthe oenanthe*), which fly over 14,000 km from sub-Saharan Africa to their breeding grounds in the Arctic (Bairlein *et al.* 2012)

obviously not ignorant about these locations and their biology; many considered a trip to the tropics an essential rite of passage for their students (Webb 1960, Raby 2017). Others went even further — in his 1945 Presidential Address to the Ecological Society of America, Orlando Park impressed upon his audience the importance of the tropics and encouraged ESA to establish a "full scale program in tropical ecology" and consider establishing "a new journal…dealing with tropical biology in its broadest aspects" (Park 1945). But given that many of the scientists that Park and Richards were addressing "have never been to the tropics and never intend to do so" (Richards 1963), the inherent challenges in establishing and maintaining tropical field stations (Raby 2017), and how the biology of the tropics quickly overwhelmed paradigms and theory developed to explain temperate patterns (Corner 1946, Richards 1946, 1963, 1964), one can understand how the colonial treatment of the tropics as *culturally* distinct led to the scientific truism that the tropics were *biologically* distinct (Raby 2017).

2. Why the answer is *'Maybe'.*

"…to this day ecology is biased by concepts and ideas appropriate mainly to the study of vegetation in temperate climate."

P. W. Richards (1963)

Even if 'The Tropics' are a historical construct, *Tropical Biology* could still be conceptually distinct field of study if, over time, the scientific community converged on a suite of topics either unique to or best studied in tropical systems. To assess this possibility, I used text-mining tools to compare the content of 11,210 articles reporting research from the tropics with 26,597 studies conducted in other parts of the world. These studies were published from 1990-2022 in N = 10 journals (*Journal of Evolutionary Biology, Ecology, Journal of Applied Ecology, Evolution, Biotropica, Journal of Ecology, Tropical Conservation Science, American Naturalist, Tropical Ecology, Journal of Tropical Ecology*).

A complete description of the methods used to gather and process these data are in the

Supplementary Materials. Briefly, I began by extracting all keywords, title words (e.g., *seed*, *species*), and title bigrams (i.e., pairs of sequential words, e.g., *seed predation*, *species diversity*) from the entire collection of articles; this resulted in N = 62,883 keywords, N= 25,207 title words, and N = 98,036 bigrams. I then calculated the percentage of articles in each category using each of those terms. The results below are based on the top N = 50 terms in each article category. Two major patterns emerge from this analysis. The first is that 32% of the most frequently used keywords from 'tropical' articles reflected geographic locations (e.g., *Costa Rica*, *Amazonia*, *BCI*). In contrast, the overwhelming majority of keywords from non-tropical articles (98%) were conceptual (e.g., *competiton*, *ecosystem function*, *sexual selection*; Table 1). The second is that after removing the system- and location-specific keywords, there is ample conceptual overlap between tropical and non-tropical studies (Table 2) that is consistent with broader trends in ecological research (Carmel *et al.* 2013, McCallen *et al.* 2019, Anderson *et al.* 2021). That said, the most common research topics within each article category often differ dramatically in their relative rankings (Figure S1), and there are notable areas of topical divergence (Table 2). Similar patterns emerge when comparing individual title words and title word bi-grams (Figure S2, Figure S3).

One interpretation of these results is that *Tropical* Biology is indeed a subdiscipline focused on problems and topics unique to or most relevant in tropical locations, and it is undoubtedly true that there are some questions best addressed in or relevant to tropical ecosystems. However, the observed differences could also reflect the historical relegation of certain academic subjects to the tropics, which is then reinforcing by "temperate biases" (*sensu* Zuk 2016) or the overrepresentation of certain research sites (Stocks *et al.* 2008), all of which can shape the development of theory and determine what data are used to test it (Raby 2017). A similar argument has been put forward for the social sciences by Castro Torres and Alburez-Gutierrez (2022), who argue that the far greater prevalence of geographic markers in the titles of articles by authors in the Global South both indicates and

perpetuates "an unwarranted claim on universality" by scholars from North America and Europe. This parallel evidence from a different field is compelling; nevertheless, the patterns presented here are insufficient for affirming the intellectual independence of *Tropical* Biology.

3. Why the answer is *'Yes'.*

"No education complete without trip to the Tropics."

J. E. Webb (1960)

Finally, I believe an argument can be made for treating *Tropical Biology* as a unique discipline, but not one based on the reasons typically put forward by others. What sets *Tropical Biology* apart is not the biology *per se* (*sensu* Robinson 1978). Rather, what Tropical Biologists have in common is the broader context in which their scholarship is embedded and carried out. Research anywhere is challenging, but for tropical biologists the precarious infrastructure, economic volatility, limited resources, and political instability can make the challenges feel insurmountable. These struggles can be compounded by having to communicate one's results in a foreign language (Amano *et al.* 2016) to the potentially biased reviewers and readers (Smith *et al.* 2023) of journals that are increasingly charging publications fees equivalent to several months salary (Smith *et al.* 2021). When added to the physical and emotional toll of disease, crime, working in isolation, habitat loss, and the potential for professional retribution or physical violence (Clancy *et al.* 2014, Ellwanger *et al.* 2020, Palinkas & Wong 2020), tropical biology and conservation can be uniquely dangerous — even deadly. Lamentably, this is also true for the heroic conservationists, indigenous leaders, and journalists with whom we work (Cavalcanti *et al.* 2023).

4. The Future of (Tropical) Biology

"There are few things more presumptuous than a US scientist holding forth on the future of tropical ecology"

D. H. Janzen (1972)

What if the scientific community had paid heed to Richards (1946) and properly centered the tropics when drawing biological generalizations? Perhaps Universities in Europe and North America would offer elective courses in "Temperate Biology". The instructors of these courses might present their research at the annual meeting of the *Association for Temperate Biology & Conservation* (Figure 2) and publish papers in specialized journals, with article titles that — in contrast to the more broadly relevant research from the tropics — emphasize the systems or locations the work was done (Figure 3).

I prefer instead to consider what the ambiguity of my conclusions implies for how we should move forward. I suggest that the future of lies in neither dropping the adjective that motivates so many of us, nor keeping it and accepting status as as specialization. Instead, I call on ATBC members to ***reclaim and reshape the Tropical Narrative*:** to continue taking pride and elevating what makes biology in the tropics distinct and important — the places and context in which we work — while also working to properly recenter tropical ecosystems as the foundation of Biology and focus of conceptual attention. Below are six actions with which I propose anyone can contribute to this movement.

Cite with purpose. Citation is a powerful and political act; it conveys legitimacy on the scholarship in the article being cited as well as its author, helps elevate the profile of the author and study system, and those reading your work will cite these articles when writing their own. For many scientists it also plays an important role in their professional advancement. Be mindful of this impact and the opportunity it presents when choosing whom to cite. Cite scientists whose work or approach you feel is undervalued or overlooked. Cite scientists from countries or institutions that have been ignored by the broader scientific community. Cite scientists whose approach to research you feel others should emulate. Cite studies conducted in the tropics.

Teach with Purpose. All tropical biologists are teachers, whether it be in a classroom or in a meeting with policy makers, and teaching also provides an opportunity to elevate the scholarship of others. Be mindful of whose papers are assigned as readings, the

studies and systems used to illustrate concepts, and the scientists highlighted in presentations. Use your syllabus as a tool to recast the narrative about the tropics and the scientific community that studies them. Train students in the skills needed when working in tropical systems — collaboration, facilitation, conflict resolution, and communication to diverse audiences (Kainer *et al.* 2006, Duchelle *et al.* 2009). Teach collaboratively and cross-nationally (Russell *et al.* 2022).

Collaborate with Purpose. International collaboration can be challenging, but personally and professionally rewarding (Smith *et al.* 2014). Be mindful of global scientific inequities, laws, and 'parachute science' (Gómez-Pompa 2004, Asase *et al.* 2022, Ramírez-Castañeda *et al.* 2022). Allow community members to guide the development of research priorities and questions (Kainer *et al.* 2009). Push for organizations to strengthen collaborations with — and especially within — the Global South (Ocampo-Ariza *et al.* 2023). Partner with communities to identify research questions and return the results of research (Kainer *et al.* 2006). Treat the parataxonomists, field technicians, and station staff that make our work possible with the respect they deserve (Basset *et al.* 2004). Publish in national journals (Bruna *et al.* 2004).

Engage the Public. Public fascination with the tropics and their charismatic species (Albert *et al.* 2018) provides unparalleled opportunities for outreach and education (Moreira & Robles 2017). Take advantage of global sporting events (Melo *et al.* 2014), teams with tropical species as mascots (Sartore-Baldwin & McCullough 2019), movies set in the tropics (Yong *et al.* 2011), tropical images in fashion (Kutesko 2014), or other connections between people's interests and tropica biodiversity. Leverage this universal appeal into support for tropical research and conservation, but beware of doing so in ways that perpetuate stereotypes.

Get in the Game. Help make the process of publishing more fair by serving as a review or subject editor for *Biotropica*. Contribute to capacity building efforts by reviewing student seed grants proposals or serving as a judge for student presentations at the annual

meeting. Join an ATBC committee or chapter and organize a webinar, workshop, hackathon, or reading group. What should the Association be doing differently? Communicate your ideas to the ATBC leadership or stand for election and push for change as a Councillor.

Support and celebrate one another. Finally, remember that the work done by tropical biologists addresses the "neglected problems that afflict most of the world's people" (Annan 2003). Conducting research — regardless of the subject — advances the socioeconomic condition of the country in which it's conducted. It is difficult, frustrating, and not without risk. Take a moment to thank, congratulate, and support each other (Rudzki *et al.* 2022, Nordseth *et al.* 2023) for your contributions and the effort and resilience that they required — you are making the world a better place.

Table 1

Top keywords in tropical articles, non-tropical articles, and keywords that the categories havein common. Keywords in bold refer to species, geographic locations, or systems.

Tropical: Unique Top Keywords (rank)	Non-Tropical: Unique Top Keywords (rank)	Shared Top Keywords (rank in Tropical, Non-Tropical)
tropical forest (1)	sexual selection (1)	diversity (2, 6)
seed dispersal (3)	phenotypic plasticity (4)	herbivory (5, 11)
tropical rainforest (4)	tradeoff (9)	fragmentation (6, 42)
costa rica (7)	adaptation (10)	disturbance (9, 27)
brazil (8)	natural selection (12)	climate change (10, 3)
conservation (11)	population dynamic (13)	species richness (14, 24)
rainforest (12)	density dependence (15)	competition (15, 2)
panama (13)	fitness (16)	speciation (18, 5)
mexico (16)	coevolution (17)	predation (20, 14)
savanna (17)	body size (18)	phenology (21, 46)
frugivory (19)	evolution (19)	pollination (24, 48)
seed predation (22)	local adaptation (20)	dispersal (26, 7)
neotropic (23)	gene flow (21)	nitrogen (28, 44)
tropical dryforest (25)	phylogeny (22)	mutualism (33, 34)
seed germination (27)	quantitative genetic (23)	lifehistory (37, 8)
amazon (29)	food web (25)	temperature (49, 37)
atlantic forest (30)	heritability (26)	
functional trait (31)	coexistence (28)	
seasonality (32)	hybridization (29)	
phosphorus (34)	experimental evolution (30)	
fire (35)	selection (31)	
succession (36)	reproductive isolation (32)	
bird (38)	demography (33)	
biogeography (39)	survival (35)	
biomass (40)	facilitation (36)	
bci (41)	maternal effect (38)	
tropic (42)	metapopulation (39)	
cerrado (43)	**usa (40)**	
regeneration (44)	extinction (41)	
amazonia (45)	mate choice (43)	
africa (46)	sperm competition (45)	
species diversity (47)	ecosystem function (47)	
puerto rico (48)	sexual conflict (49)	
decomposition (50)	mating system (50)	

Table 2

Top keywords from tropical and non-tropical articles that are unique to each category once system-specific keywords have been excluded, followed by the top keywords from each category that they have in common. Keywords in bold refer to species, geographic locations, or systems.

Tropical: Unique Top Keywords (rank)	Non-Tropical: Unique Top Keywords (rank)	Shared Top Keywords (rank in Tropical, Non-Tropical)
seed dispersal (2)	tradeoff (2)	diversity (1,6)
conservation (7)	natural selection (7)	herbivory (3,11)
rainforest (8)	fitness (8)	fragmentation (4,41)
savanna (11)	coevolution (11)	disturbance (5,27)
frugivory (13)	evolution (13)	climate change (6,3)
seed predation (16)	local adaptation (16)	species richness (9,24)
seed germination (18)	gene flow (18)	competition (10,2)
functional trait (21)	quantitative genetic (21)	speciation (12,5)
seasonality (22)	food web (22)	predation (14,14)
phosphorus (24)	heritability (24)	phenology (15,45)
fire (25)	coexistence (25)	pollination (17,47)
succession (26)	hybridization (26)	dispersal (19,7)
biogeography (28)	experimental evolution (28)	nitrogen (20,43)
bird (29)	selection (29)	mutualism (23,34)
biomass (30)	reproductive isolation (30)	lifehistory (27,8)
regeneration (31)	survival (31)	temperature (33,37)
species diversity (32)	facilitation (32)	density dependence (36,15)
decomposition (34)	maternal effect (34)	sexual selection (37,1)
litter (35)	metapopulation (35)	phylogeny (38,22)
beta diversity (39)	extinction (39)	adaptation (40,10)
mortality (42)	mate choice (42)	demography (41,33)
recruitment (43)	sperm competition (43)	body size (45,18)
drought (44)	ecosystem function (44)	population dynamic (46,13)
secondary forest (48)	sexual conflict (48)	phenotypic plasticity (47,4)
community structure (49)	mating system (49)	
mammal (50)	migration (50)	

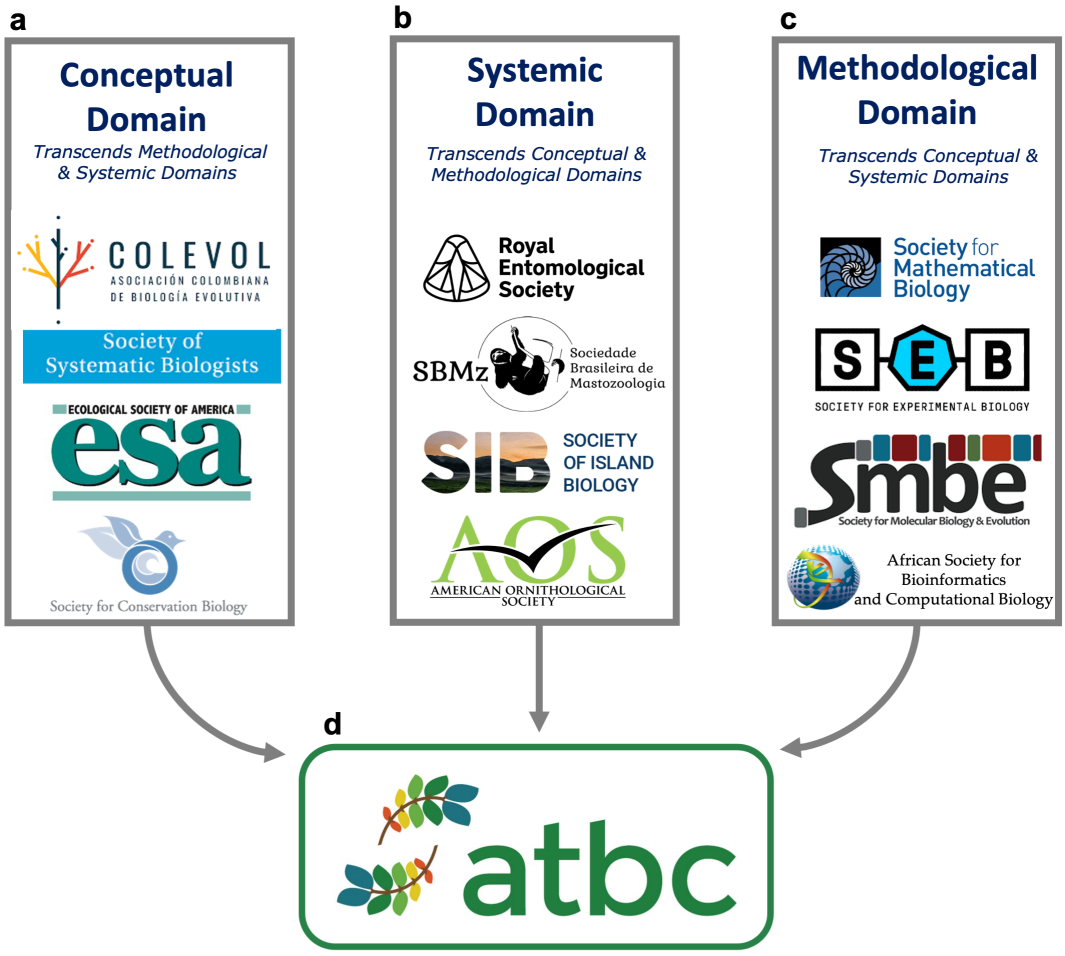

Figure 1. Alternative ways in which researchers self-organize in scholarly societies: (a) Conceptual Domain, (b) Systemic Domain, or (c) Methodological Domain. The Association for Tropical Biology & Conservation (i.e., ATBC) is unique in that transcends the three domains: its members use a broad diversity of species, ecosystems, and methods to address questions grounded in – or even transcending – multiple distinct conceptual domains.

Figure 2. The logo for a proposed new scholarly society for researchers specializing on temperate ecosystems and species.

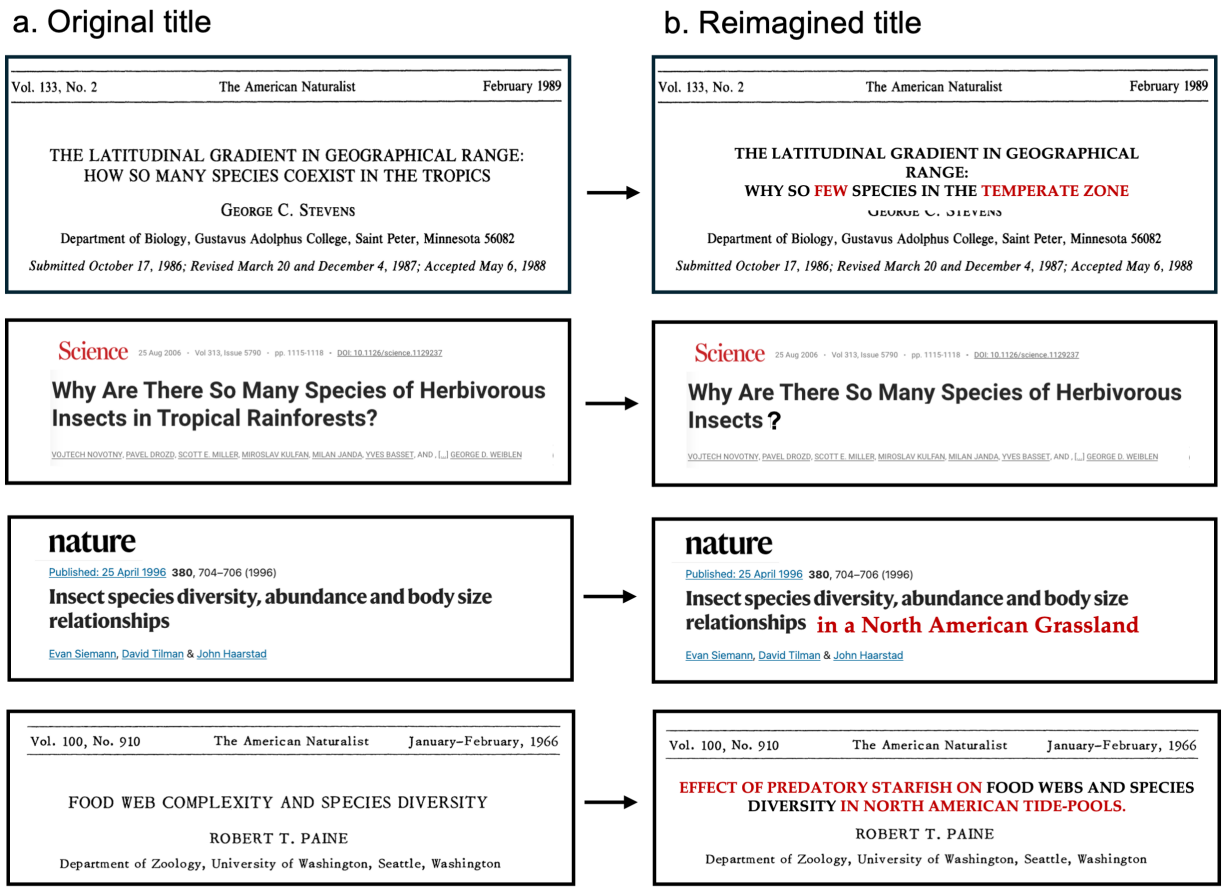

Figure 3. The (a) original and (b) reimagined titles of four high-profile research articles. Comparing these emphasizes how the original titles reflect and reinforce the idea that 'reference' or 'default ecosystems are found in the Temperate Zone.

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DATA AVAILABILITY STATEMENT

The complete data set used in this article is available in Dryad at *<DOI added upon acceptance>*. The version of the code used to review, correct, and prepare this archive (version 1.0.0) is available at Zenodo at *<DOI added upon acceptance>*. The code used to prepare this publication, including statistical summaries reported in the text, tables, and figures, is available at Zenodo at *<DOI added upon acceptance>*.

DISCLOSURE STATEMENT

The author confirms that there have been no involvements that might raise the question of bias in the work reported or in the conclusions, implications, or opinions stated.

AUTHOR CONTRIBUTION STATEMENT

E.M.B conceived the study and is responsible for the methodology, data collection, data curation, formal analysis, validation, visualization, software, and writing.

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SUPPLEMENTARY MATERIALS

METHODS

1. Bibliometric analysis. To identify the conceptual domains studied by researchers working in 'Tropical' and "non-Tropical' locations, I used information extracted from the bibliographic records of articles published These studies were published from 1990-2022 in N = 10 journals (*Journal of Evolutionary Biology, Ecology, Journal of Applied Ecology, Evolution, Biotropica, Journal of Ecology, Tropical Conservation Science, American Naturalist, Tropical Ecology, Journal of Tropical Ecology*). Specifically, I compared (1) article keywords, (2) individual words in article titles (e.g., *seed*, *species*), and (3) title bigrams (i.e., pairs of sequential words in titles, e.g., *seed predation*, *species diversity*). Below I describe how the article records were identified, downloaded, processed, and assigned to the 'Tropical' and"non-Tropical' categories using code written in the `R` statistical programming language (R Core Team 2023) and available at Github (https://github.com/BrunaLab/atbc2022_plenary_talk).

On 8 February 2023, I downloaded all bibliographic data available in SCOPUS and the Web of Science 'Core Collection' for all articles published in the focal journals; both SCOPUS and the Web of Science were queried because they differ in the years indexed for each journal. I then used the `refsplitr` package to process the records and remove any duplicates. After removing all stopwords from article titles (Benoit *et al.* 2021) and keywords, I spell-checked, stemmed, and lemmatized all of the keywords and title words. I also extracted bigrams from titles with the `tidytext` library (Silge & Robinson 2016). Finally, I identified each article as either 'Tropical' or 'non-Tropical'; all articles published in (*Journal of Evolutionary Biology, Ecology, Journal of Applied Ecology, Evolution, Biotropica, Journal of Ecology, Tropical Conservation Science, American Naturalist, Tropical Ecology, Journal of Tropical Ecology*) were assigned to the 'Tropical' category, while articles published in the other journals were assigned to one of these categories based on a search of the titles, keywords, or abstracts for a list of domain-specific terms (e.g., tropical: *amazon*, *andes*, *congo*, *bci*, *chamela*;

non-tropical: *finland*, *boreal*, *eastern decid*, *arctic*, *polar*). These procedures resulted in N = 37,807 total articles published, of which N = 11,210 reported research conducted in the tropics and N = 26,597 were based on work conducted in other locations. Collectively, these articles used N = 62,883, N = 25,207 unique title words, and N = 98,036 title bigrams.

2. Visualization. The number of articles varies widely between journals, as does the number of keywords per article. Comparing counts of keyword frequency in tropical and non-tropical articles could therefore bias results towards the content published a small number of journals. To correct for this, I calculated the percentage of articles in each geographic category that uising each keyword, title word, or bigram. I then selected the N = 50 most frequently used terms in each geographic category, and identified (a) any terms that 'tropical' and 'non-tropical' articles had in common, and (b) any terms that were unique to each article category.

3. Data and Code. Questions regarding the data set or code should be posted as Issues on the project's Github Repository (https://github.com/BrunaLab/----/issues) or referred to E. M. Bruna. Summaries of any post-publication updates will be posted to the NEWS.md file of the Github Repository (https://github.com/BrunaLab/---).

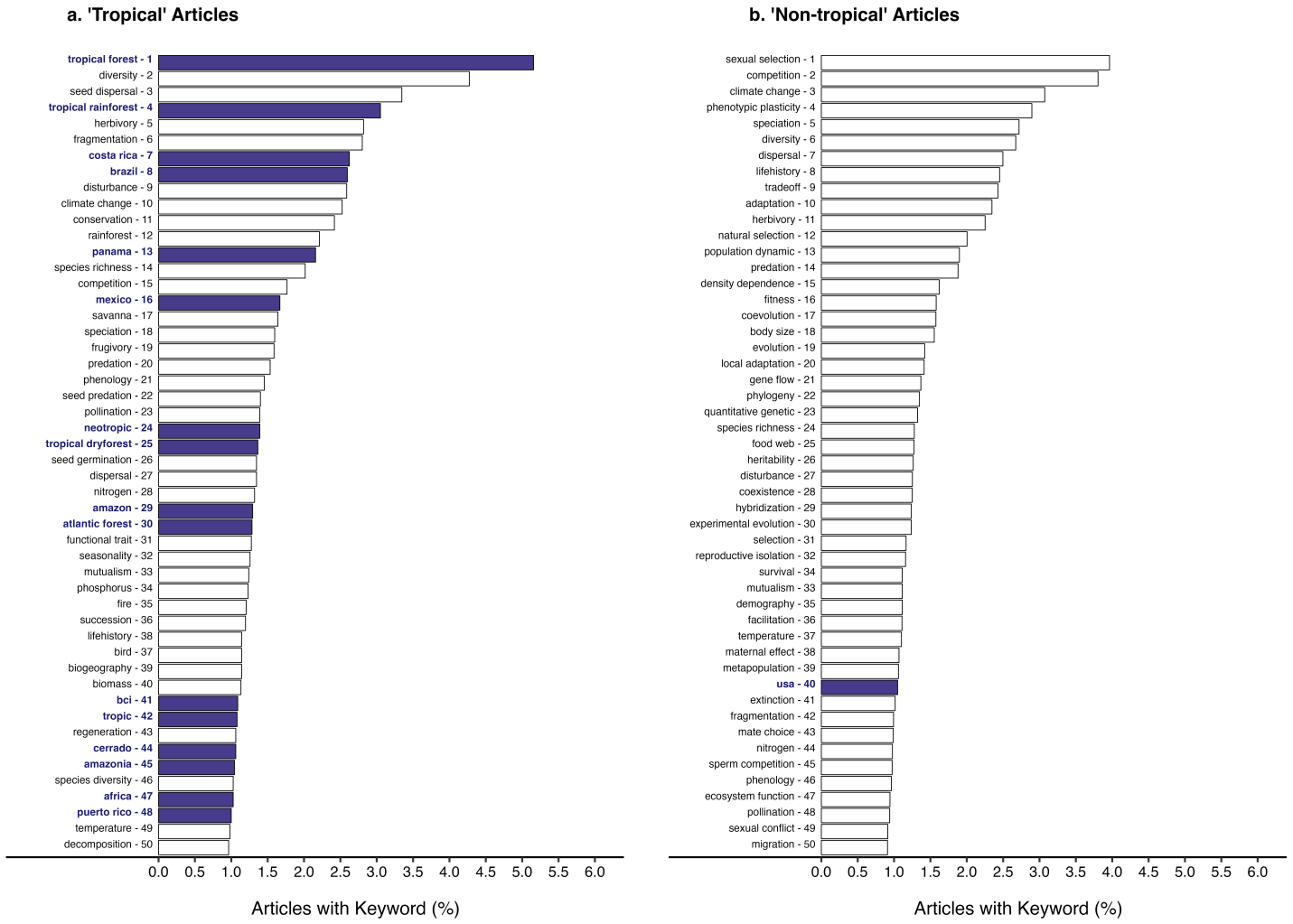

Figure S1. The most common keywords from articles based on research conducted in (a) the tropics and (b) non-tropical regions. The rank of these words is based on the percentage of articles in each category that included them. Terms reflecting geography (e.g., *tropics, Peru, Southern*) are indicated in bold and with filled bars.

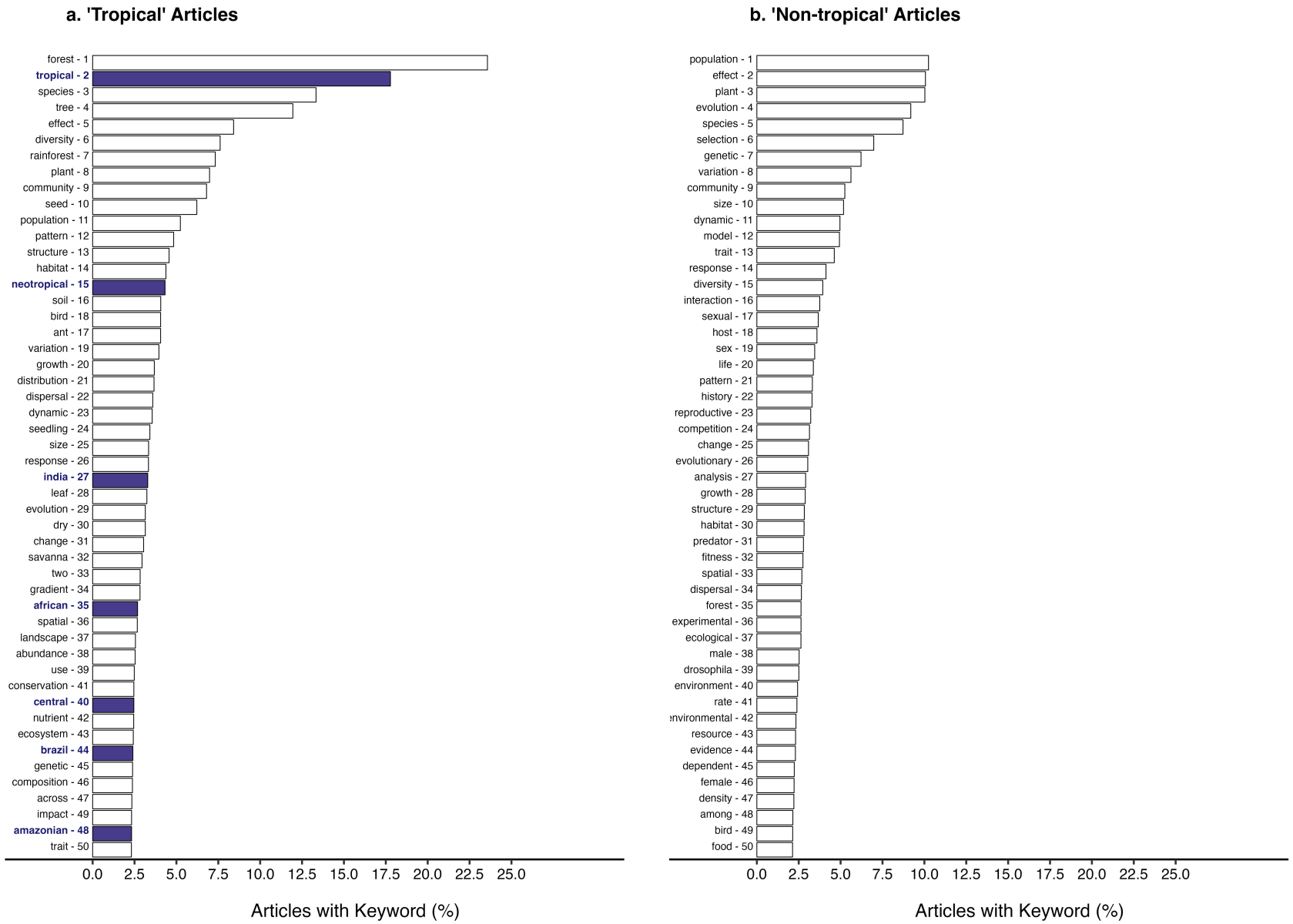

Figure S2. The most common words in the titles of articles based on research conducted in (a) the tropics and (b) non-tropical regions. The rank of these words is based on the percentage of article titles in each category that included those words. Terms reflecting geography (e.g., *tropics, Peru, Southern*) are indicated in bold and with filled bars.

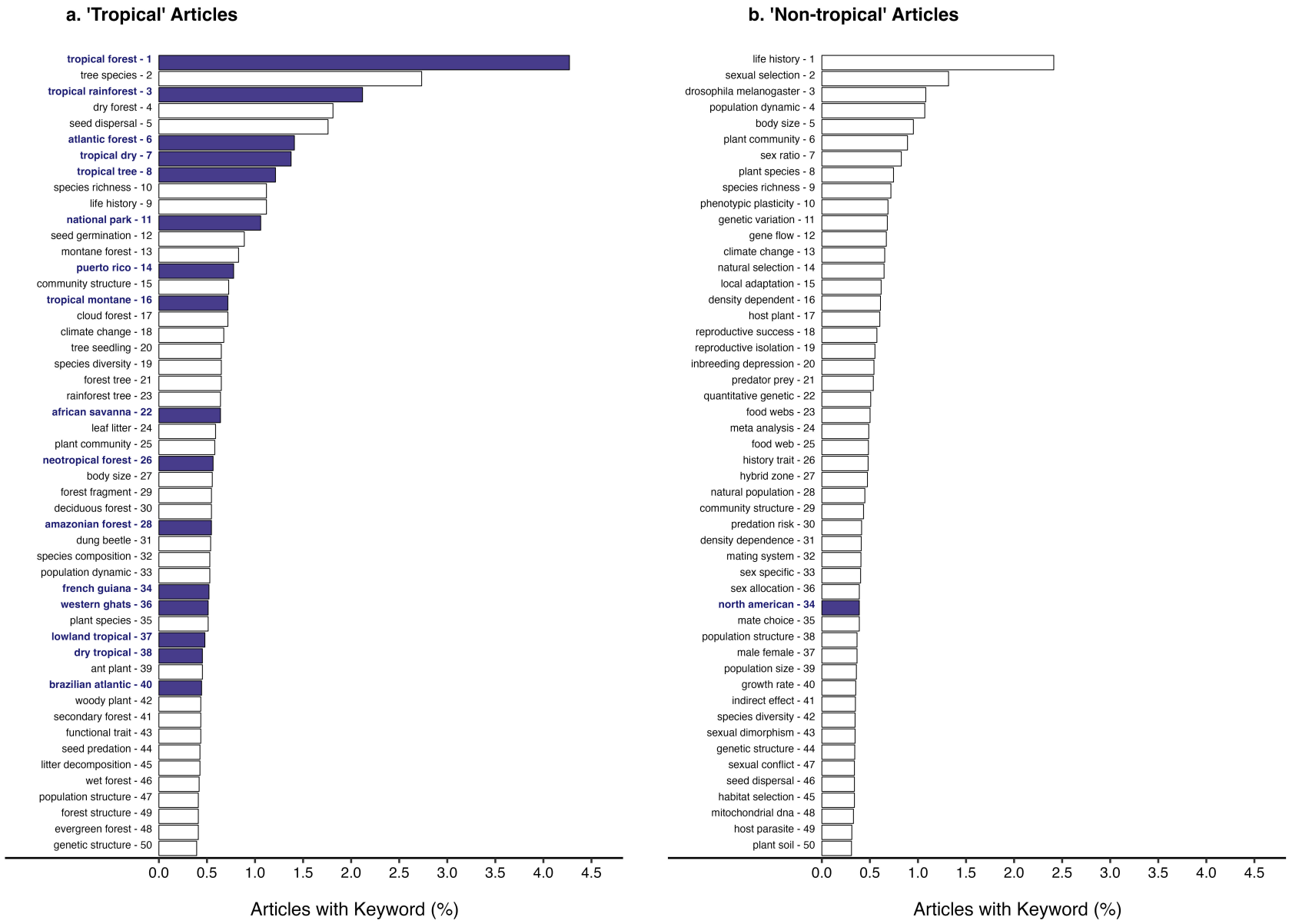

Figure S3. The most bigrams in titles of articles based on research conducted in (a) the tropics and (b) non-tropical regions. The rank of these words is based on the percentage of article titles in each category that included those words. Bigrams reflecting geography (e.g., *tropics, Peru, Atlantic Forest*) are indicated in bold and with filled bars.

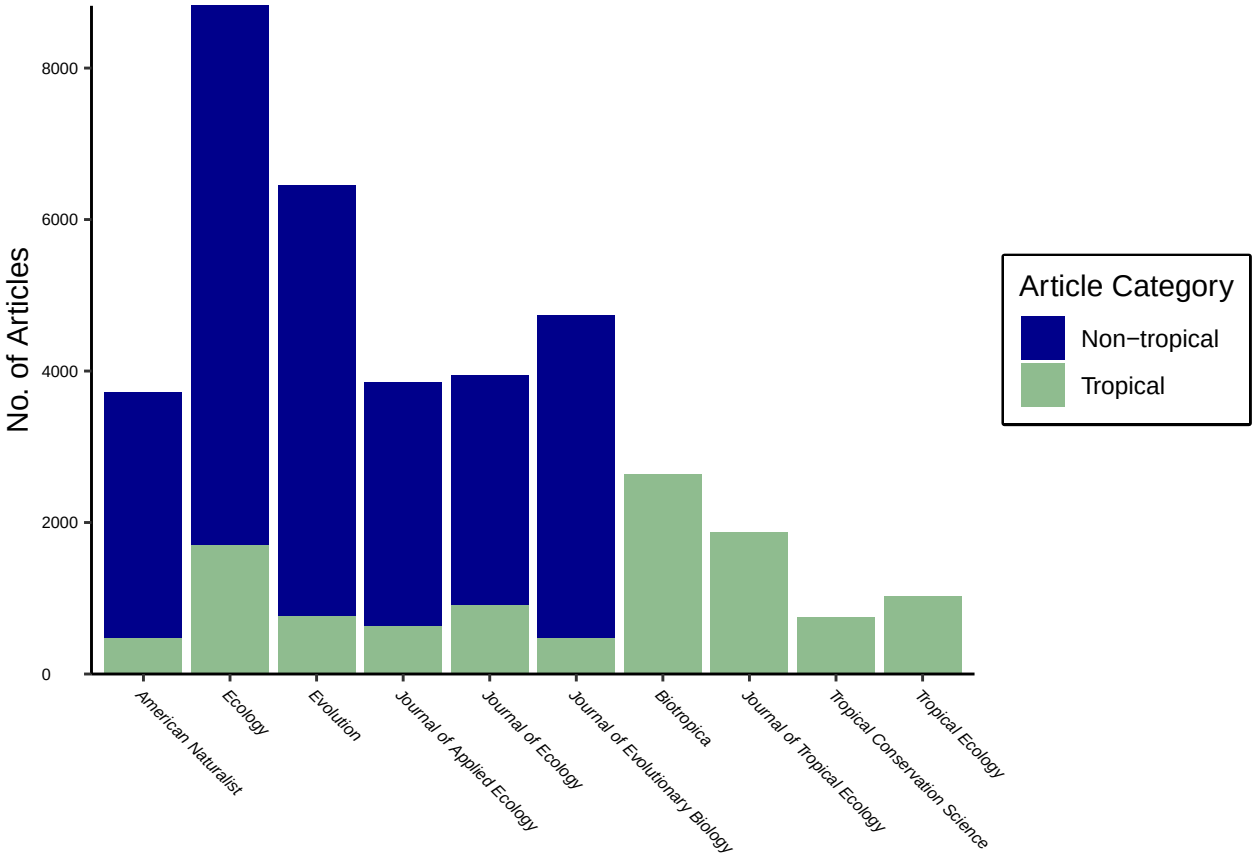

Figure S4. The number of articles from each journal and geographic category that were used in used the analysis of keywords.

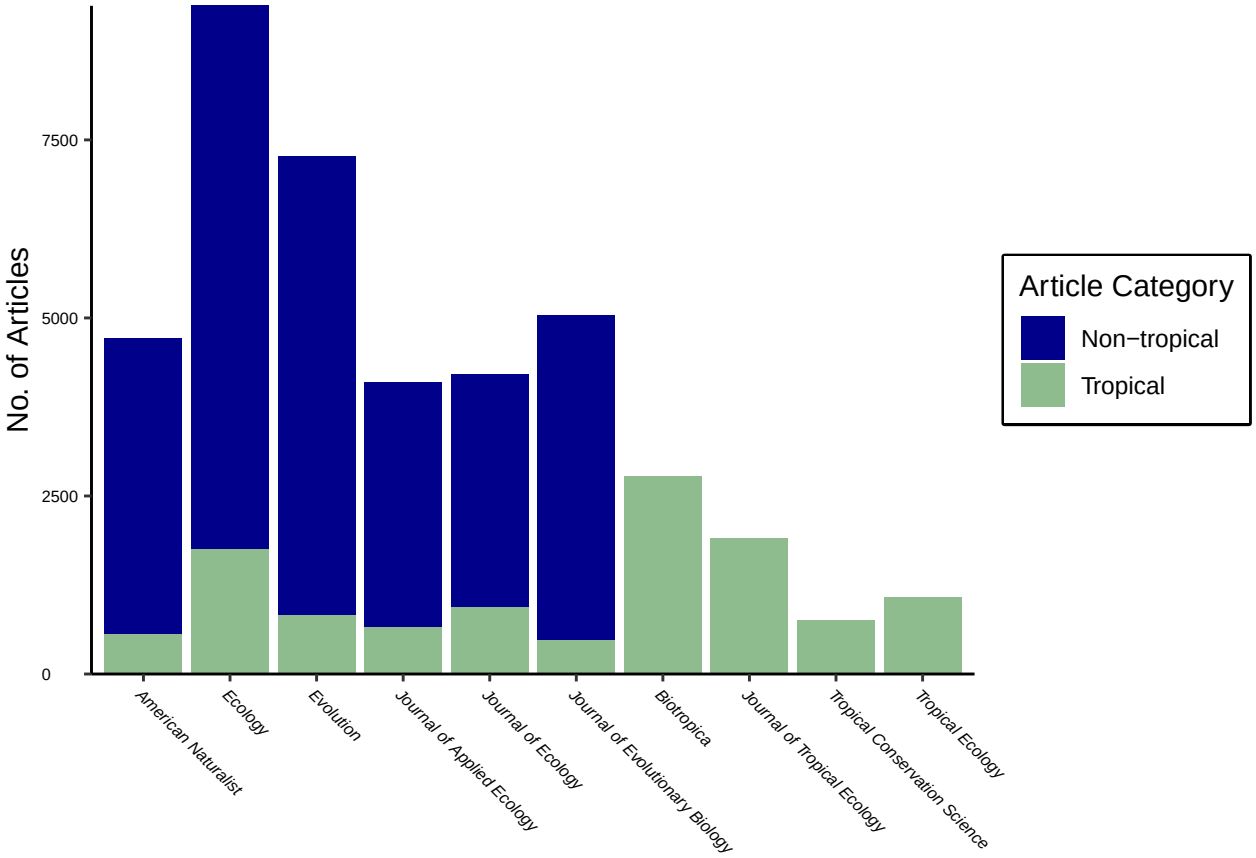

Figure S5. The number of articles from each journal and geographic category that were used in the analysis of title words and title bigrams.