






CONTRIBUTED PAPERS

Evaluating global interest in biodiversity and conservation

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Abstract

The first target of the Convention for Biological Diversity (Aichi target 1) was to increase public awareness of the values of biodiversity and actions needed to conserve it—a key prerequisite for other conservation targets. Monitoring success in achieving this target at a global scale has been difficult; however, increased digitization of human life in recent decades has made it easier to measure people's interests at an unprecedented scale and allows for a more comprehensive evaluation of Aichi target 1 than previously attempted. We used Google search volume data for over a thousand search terms related to different aspects of biodiversity and conservation to evaluate global interest in biodiversity and its conservation. We also investigated the correlation of interest in biodiversity and conservation across countries to variables related to biodiversity, economy, demography, research, education, internet use, and presence of environmental organizations. From 2013 to 2020, global searches for biodiversity components increased, driven mostly by searches for charismatic fauna (59% of searches were for mammal species). Searches for conservation actions, driven mostly by searches for national parks, decreased since 2019, likely due to the COVID-19 pandemic. Economic inequality was negatively correlated with interest in biodiversity and conservation, whereas purchasing power was indirectly positively correlated with higher levels of education and research. Our results suggest partial success toward achieving Aichi target 1 in that interest in biodiversity increased widely, but not for conservation. We suggest that increased outreach and education efforts aimed at neglected aspects of biodiversity and conservation are still needed. Popular topics in biodiversity and conservation could be leveraged to increase awareness of other topics with attention to local socioeconomic contexts.

KEYWORDS

Aichi targets, conservation outreach, convention on biological diversity, culturomics, google trends, interest in biodiversity, interest in conservation, socioeconomic variables

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Evaluación del interés mundial en la biodiversidad y la conservación

Resumen: La primera meta del Convenio sobre la Diversidad Biológica (Meta 1 de Aichi) era aumentar la conciencia pública sobre los valores de la biodiversidad y las acciones necesarias para conservarla, un requisito previo clave para otras metas de conservación. Ha sido difícil monitorear el éxito en la obtención de esta meta a escala mundial; sin embargo, la creciente digitalización de la vida humana en las últimas décadas ha facilitado la medición de los intereses de la gente a una escala sin precedentes y permite una evaluación más exhaustiva de la Meta 1 de Aichi que la que se había intentado previamente. Utilizamos datos sobre el volumen de búsquedas en Google de más de mil términos relacionados con distintos aspectos de la biodiversidad y la conservación para evaluar el interés mundial en la biodiversidad y su conservación. También investigamos la correlación del interés por la biodiversidad y la conservación en los distintos países con variables relacionadas a la biodiversidad, la economía, la demografía, la investigación, la educación, el uso del internet y la presencia de organizaciones ambientalistas. Las búsquedas mundiales sobre los componentes de la biodiversidad aumentaron de 2013 a 2020, impulsadas sobre todo por búsquedas de especies carismática (el 59% de las búsquedas correspondían a especies de mamíferos). Las búsquedas de acciones de conservación, impulsadas principalmente por búsquedas de parques nacionales, han disminuido desde 2019, probablemente debido a la pandemia de COVID-19. La desigualdad económica se correlacionó negativamente con el interés en la biodiversidad y la conservación, mientras que el poder adquisitivo se correlacionó indirectamente de manera positiva con niveles más altos de educación e investigación. Nuestros resultados sugieren un éxito parcial en la obtención de la Meta 1 de Aichi en el sentido de que aumentó ampliamente el interés por la biodiversidad, pero no por la conservación. Sugerimos que se necesitan mayores esfuerzos de divulgación y educación dirigidos a aspectos desatendidos de la biodiversidad y la conservación. Los temas populares de biodiversidad y conservación podrían aprovecharse para aumentar la conciencia sobre otros temas si se presta atención a los contextos socioeconómicos locales.

PALABRAS CLAVE

alcance de la conservación, culturomía, Convenio sobre la Diversidad Biológica, interés en la biodiversidad, interés en la conservación, metas de Aichi, tendencias de Google, variables socioeconómicas

评估生物多样性和保护的全球兴趣

【摘要】《生物多样性公约》的第一个目标(爱知目标1)是提高公众对生物多样性价值和保护生物多样性所需行动的认识,这也是其他保护目标的关键前提。在全球范围内监测实现这一目标的进展一直十分困难;然而,随着近几十年来人类生活数字化程度提高,在前所未有的尺度上衡量人们的兴趣变得更加容易,这也让我们可以比以往更全面地对爱知目标1进行评估。我们使用了与生物多样性和保护的不同方面有关的一千多个搜索词的谷歌搜索量数据,评估了生物多样性及其保护的全球兴趣。我们还调查了各国对生物多样性和保护的兴趣与其生物多样性、经济、人口、研究、教育、互联网使用和环保组织等相关变量的相关性。结果表明,从2013年到2020年,全球范围内对生物多样性组分的搜索量有所增加,主要由搜索有魅力的动物而驱动的(59%的搜索针对哺乳动物)。对保护行动的搜索(主要是对国家公园的搜索)自2019年以来有所下降,可能是由于COVID-19疫情。经济不平等与对生物多样性和保护的呈负相关,而购买力则与较好的教育和研究水平间接地呈正相关。我们的结果表明,爱知目标1的实现取得了部分成功,即对生物多样性的兴趣有广泛增加,但对保护的没有明显增加。我们认为仍需针对生物多样性和保护中被忽视的方面加强开展宣传和教育工作。可以利用生物多样性和保护的热门话题来提高人们对其他话题的认识,同时还需考虑当地的社会经济背景。【翻译:胡怡思,审校:聂永刚】

关键词: 蜜蜂, 爱知目标, 保护宣传, 《生物多样性公约》, 文化组学, 谷歌趋势, 对生物多样性的兴趣, 对保护的利益, 社会经济变量

INTRODUCTION

The United Nations Convention on Biological Diversity (CBD) is an international treaty to improve conservation and use of biodiversity. In 2010, the CBD set 20 global conservation targets to be achieved by 2020 (Aichi Biodiversity Targets). At the time, all current United Nations member states were signatories of the CBD, except for Andorra, the United States, and South Sudan, which was not yet an independent country. Since then, Andorra and South Sudan have signed the treaty (cbd.int/information/parties.shtml). The first Aichi target, described as a prerequisite for the success of all other targets, was that “by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably” (Convention on Biological Diversity, 2010). Although awareness by itself is insufficient to effect behavior change (Maibach, 2019), it is often a necessary condition (Maibach, 1993), making information outreach a crucial tool for reversing the current biodiversity crisis. The 2020 Global Biodiversity Outlook report of CBD estimated that none of the Aichi targets were fully met in that year (Convention on Biological Diversity, 2020). However, the evaluation of Aichi target 1 was based on insights from only a few countries and may not be generalizable (Mcowen et al., 2016).

Increased digitization of human life enables quantitative studies of cultural trends based on digital data sources, an approach known as culturomics (Ladle et al., 2016). One of the most important digital data sources is Google’s search engine, the most visited website globally (alexa.com/topsites), which is used worldwide to find information on topics of interest. Analyses of search volumes on Google have been used in a variety of fields, including nature conservation (Correia et al., 2021). In marketing theory, awareness (realization of the existence of a subject) generally precedes information seeking, and both are considered crucial components of intention and behavior formation (Jansen & Schuster, 2011). Thus, information-seeking behaviors, such as internet searches, can provide valuable insights pertaining to Aichi target 1. Previous research leveraged search engine data to evaluate progress toward Aichi target 1 (e.g., Buchanan et al., 2020; Cooper et al., 2019). However, these were limited to a few search terms (Buchanan et al., [2020] considered only the term *biodiversity*) and short time scales (Cooper et al. [2019] examined only 1 year) or examined interest by language rather than by country (Millard et al., 2021). Therefore, an evaluation of Aichi target 1 across all countries, over longer time frames, and with a wider range of search terms is needed.

Internet search volumes are influenced by various social, economic, and political factors (Jeong & Mahmood, 2011). Uncovering which of these factors are more strongly correlated with interest in biodiversity and conservation can help design context-appropriate interventions to increase awareness of biodiversity and conservation where it is most needed. Nevertheless, no study to date has formally examined potential drivers correlated with country-level differences in biodiversity awareness and interest. Such an exploration of broad sociopolitical drivers of interest in biodiversity and its protection can provide important information for conservation policy and planning.

We evaluated progress toward meeting Aichi target 1 by examining Google search volumes for a wide variety of biodiversity and conservation topics across all countries from 2013 to 2020. We further investigated how progress toward this target is associated with several country-level factors. We then used our results to devise recommendations on how information outreach and education campaigns can be more efficient in promoting awareness of biodiversity and conservation.

METHODS

We used Google Health Trends API (application programming interface) to download data on relative search volume (search volume of a specific term divided by the overall search volume in a region and period [Zepecki et al., 2020]) for biodiversity topics for 191 of the 193 countries recognized by the United Nations (China and North Korea were excluded due to minimal use of Google search engine) from 2013 to 2020. As opposed to the online Google Trends API, Google Health Trends API does not scale relative search volumes inside each time series; thus, it is preferable for comparing topics and regions (Zepecki et al., 2020).

We used unique identifiers assigned to each search topic by the Google Knowledge Graph to obtain our search volumes (obtained through gkgraphR package [Correia, 2021]). This feature allows inclusion of synonyms and different languages in the search volume data for a particular topic and exclusion of irrelevant homonyms (Google News Initiative, 2022). For example, when searching for the words *puma*, *congar*, *mountain lion*, *suçuarana*, or *onça-parda* (the last 2 are names used in Brazil for the same animal), the search engine will autocomplete and show the option “puma (animal).” All these synonyms will share the same unique identifier in Google Knowledge Graph, which is distinct from the identifier for the homonym *PUMA* (a clothing brand). Our analyses spanned the years 2013–2020 due to the merger between Google Insights for Search and Google Trends in 2012 and because the topics feature mentioned above was not available previous to this merger (Google Inside Search, 2012). Although Google is the dominant search engine worldwide, its use is less widespread in some countries, either due to state restrictions, as in China, or due to user preferences, as in Russia (Statcounter, 2022). Therefore, results regarding these countries should be interpreted with care. We highlighted countries in which Google is not the only major dominant search engine (i.e., <75% of the search engine share) in our maps and appendices. We excluded China from all analyses because of the very low percentage of use of Google and North Korea because of state restrictions on internet use (Warf, 2015). Other limitations to and nuances of the use of Google Trends as a proxy for public interest are discussed extensively in Troumbis and Iosifidis (2020).

We selected biodiversity topics to fit 4 broad categories: the 500 most viewed taxonomic entities in Wikipedia from 2013 to 2020 plus the 10 most viewed in all of the 320 different languages identified by Wikipedia (989 search terms total); global biomes of Olson et al. (2001) (15 search terms);

biodiversity concepts (20 terms based on CBD's [2008] Biodiversity Glossary); and conservation actions (27 terms based on International Union for Conservation of Nature's [2012] Conservation Actions Classification Scheme). To identify the top most viewed taxonomic entities in Wikipedia, we used wikidata (Chamberlain & Welty, 2020) to search for all taxa in each Regna in the Wikispecies taxonomy ("Archaea," "Bacteria," "Protista," "Virus," "Fungi," "Plantae," "Animalia") and their associated Wikidata identifiers. Once we had the list of all taxa, we used wikipediatrend (Meissner, 2020) to download page view data from 2013 to 2020 for all taxa across 320 languages in Wikipedia. We included every language available, even those with less developed Wikipedias, to increase the variety of search terms and try to capture local interests, but nonetheless, we acknowledge that less developed Wikipedias might not be representative of these local interests.

We removed terms related to public health concerns (e.g., *Coronavirus*, *Ebola*, *Taenia saginata*, *Aedes aegypti*) because they are more likely to reflect an interest in public health than in biodiversity. The complete list of search terms is in Appendix S1. We define *interest in biodiversity* as the sum of the relative search volumes for the terms in the first 3 categories and used it to evaluate the first part of Aichi target 1 ("[awareness of] the values of biodiversity"). We define *interest in conservation* as the sum of the relative search volumes for the terms in the fourth category and used it to evaluate the second part of Aichi target 1 ("[awareness of] the steps they can take to conserve and use it sustainably").

We deliberately included searches for organisms themselves rather than explicit descriptors of their values (e.g., ecosystem services provided; intrinsic biodiversity value). We hypothesized that most Google users are more familiar with such concrete elements of biodiversity than with academic descriptors and that most of their engagement is with biodiversity itself rather than such conceptualizations. Consequently, users will more frequently search for the names of the organisms they value and want to learn more about. This approach also has the advantage of being more likely to capture values specific to local cultural contexts that may not usually be expressed using formal descriptors of value. As for the choice of topics in the conservation actions category, we recognize that different groups of scientists will likely have different ideas as to which steps are necessary to conserve biodiversity, so we relied on reputable sources, such as the International Union for the Conservation of Nature (IUCN), which often informs policy making. Moreover, the terms used by these reputable sources have unique identifiers associated with them in Google Search, which allowed us to evaluate searches for them across languages. Put together we aimed to minimize the potential of personal biases in our selection of keywords by including lists from reputable sources and species lists gathered similarly across many languages and regions in the hope that these keywords would reflect a wide consensus.

Our methods may give greater emphasis to countries with many local languages (e.g., India) and less emphasis to widely spoken languages (e.g., Spanish, French, English). However, we found no correlation between number of languages represented

on Wikipedia spoken in each country and the median interest in biodiversity ($t = -0.66265$, $df = 174$, $p = 0.5084$) or conservation ($t = 0.90907$, $df = 189$, $p = 0.3645$ [details in Appendix S2]). This may have been caused by a large overlap between the most popular taxa in each language and the global 500 most searched-for terms. We identified only an additional 489 unique taxa from a potential 3200 (if there was no overlap), which represents an average of only 1.5 unique taxa per language (out of a potential 10).

We calculated the median of aggregated biodiversity and conservation interest for each country over all years to represent overall levels of interest during the study period. We further used a Bayesian structural time series (BSTS) model to estimate temporal trends in biodiversity and conservation interest (i.e., median slope coefficient of a linear trend component) with the *bsts* R package (Scott, 2022). The algorithm BSTS is efficient and flexible and allows decomposition of time series to seasonality and trends (Scott & Varian, 2014). We used bivariate choropleth maps to visualize trends and overall interest across countries. Bivariate choropleth maps are a plotting technique in which 2 color scales are used to represent trends across 2 variables on a map (Carstensen, 1986). We also regressed trends against median interest in either biodiversity or conservation across countries to explore associations between overall interest and its temporal trend.

We further investigated correlates of trend and median interest in biodiversity and conservation. We assembled 15 country-level variables divided into 7 broad categories (biodiversity, economy, demography, research, education, internet use, and presence of environmental organizations [complete list of variables and sources in Appendix S3]). We based our choices on previously published research on correlates of internet searches (Jeong & Mahmood, 2011). However, we added several correlates pertaining specifically to biodiversity and conservation. Because there has been no previous study on this topic to support our choice of variables, we relied on personal expertise. Therefore, the choice of variables is subject to our personal biases and should be viewed as an initial exploration of potential candidate factors that should be explored in future analyses more focused on uncovering causal relationships. Our reasons for choosing these variables are as follows: a more diverse natural environment might generate more interest for biodiversity and conservation (biodiversity); biodiversity and conservation may not be a priority interest in underdeveloped or unequal economies due to more immediate material needs (economy); urban and rural populations might have interests in different aspects of biodiversity and conservation due to different degrees of contact with nature or familiarity with more global topics (demography); higher investment in research and education can indicate greater valuing of scientific topics in general, including biodiversity and conservation (research and education); greater access to the internet may allow representation of the interests of a wider variety of demographics (internet use); and presence of environmental organizations can lead to actions that increase awareness of biodiversity and conservation (environmental organizations).

We used linear models to test relationships between trends and median interest in biodiversity or conservation and our variables. This was performed within a multimodel inference approach with MuMIn (Bartoń, 2022). We then performed a path analysis with plspm (Sanchez et al., 2015) to uncover associations between variables and ultimately interest in biodiversity and conservation. We used only those variables selected by MuMIn (average sum of weights >0.5) for the path analysis. We set up the path analysis structure so that all variables could directly influence the response variable (trend or median interest in biodiversity or conservation). We also specified paths from all economic and demographic variables to each variable in the research, education, internet use, and environmental organizations categories. We then sequentially removed nonsignificant paths to reach the final structure, a common practice known as “theory trimming” (Thakar, 2020). These paths can highlight direct and indirect ways variables act to influence interest in biodiversity and conservation.

RESULTS

Variation in the interest in biodiversity was driven mostly by searches for taxonomic entities (99% of variation in search volumes). This was expected due to the higher number of search terms in this category. The most influential taxa were mammals (59% of variation in interest for taxonomic entities), followed by plants (31%) and invertebrates (8%). The 10 species with the most views on Wikipedia were mammals, 6 of which were classified as threatened by IUCN (Appendix S4). Interest in conservation was driven mostly by the term *national park* (66% of variation in search volumes). Results for each country can be visualized in our online Shiny app (conservationculturomics.shinyapps.io/aichi1_app/).

Spatiotemporal patterns

Global interest in biodiversity rose steadily during the studied period (Figure 1). When examining the different categories of biodiversity topics, a similar pattern was observed for taxa and biodiversity concepts, but not for biomes, which showed greater variation (Figure 1). Global interest in conservation increased moderately until 2019, after which there was a large decline (Figure 2). Without the dominant search term (*national park*), interest in conservation declined steadily throughout the study period (Figure 2). Removing countries that were not CBD signatories in 2010 did not substantially affect the results (Appendix S5).

Trends in interest across the study period for the different countries are in Appendix S6. These were calculated based on the posterior distribution of the trend coefficients of the BSTS models used to evaluate temporal trends in the interest in biodiversity and conservation. Ninety-five countries (out of 191) showed significant increase in interest in biodiversity, whereas one country (Uzbekistan) showed a significant decrease (Appendix S6). Twenty countries showed significant increases

in interest in conservation, and 15 countries showed significant decreases (Appendix S6). When excluding the dominant term *national park*, 8 countries showed significant increases and 28 showed significant decreases (Appendix S7). Twelve countries showed increases for both biodiversity and conservation (Bosnia and Herzegovina, Algeria, Finland, Israel, Croatia, Portugal, Russia, Sweden, Slovakia, Thailand, Turkey, and Vietnam [Appendix S6]). By 2020, 86 out of 191 countries had biodiversity search volumes similar to the top 20 countries in 2013 (Appendix S8). However, for conservation searches, 8 countries had search volumes in 2020 similar to the top 20 countries in 2013 (Appendix S9).

Across countries, higher median interest in conservation was associated with decreasing temporal trends. No such trend was observed for interest in biodiversity (Appendices S10 & S11). There was substantial intraregional variation in trends and median interest in biodiversity and conservation, with only a few regions presenting consistent patterns for interest in biodiversity (e.g., northwestern Africa and central Europe) and conservation (e.g., southeastern Africa and western Latin America) (Figure 3).

Correlates of interest in biodiversity and conservation

Because our models provided an initial exploration of the complex relations between interest and country-level attributes (see “METHODS”), they explained only a moderate proportion of the responses’ variance ($R^2 = 0.219\text{--}0.327$) (Appendix S10). Trends in interest in biodiversity and conservation were both mainly associated with education, economy, and research, whereas trends in interest in biodiversity were also associated with biodiversity variables (Appendix S12). Median interest in biodiversity and conservation were associated with environmental organizations and research variables. Median interest in biodiversity was also associated with internet use, and median interest in conservation was associated with economy and demography variables (Appendix S12; model coefficients in Appendix S13).

Inequality (Gini index) had direct and indirect negative effects on trends of interest in biodiversity and conservation. It had a positive direct effect on median interest in conservation and a negative indirect effect, mediated by a research variable (Figure 4). Purchasing power parity had indirect positive effects on trends of interest in biodiversity and conservation, mediated by research and education variables, respectively (Figure 4). Percentage of urban population had a negative direct effect on median interest in conservation, but positive indirect effects, mediated by environmental organizations and research variables (Figure 4).

Number of researchers per million inhabitants had a positive effect on trends of interest in biodiversity and median interest in conservation, but a negative effect on median interest in biodiversity (Figure 4). Biodiversity and internet use variables had positive effects on trends and median interest in biodiversity but were not relevant for interest in conservation

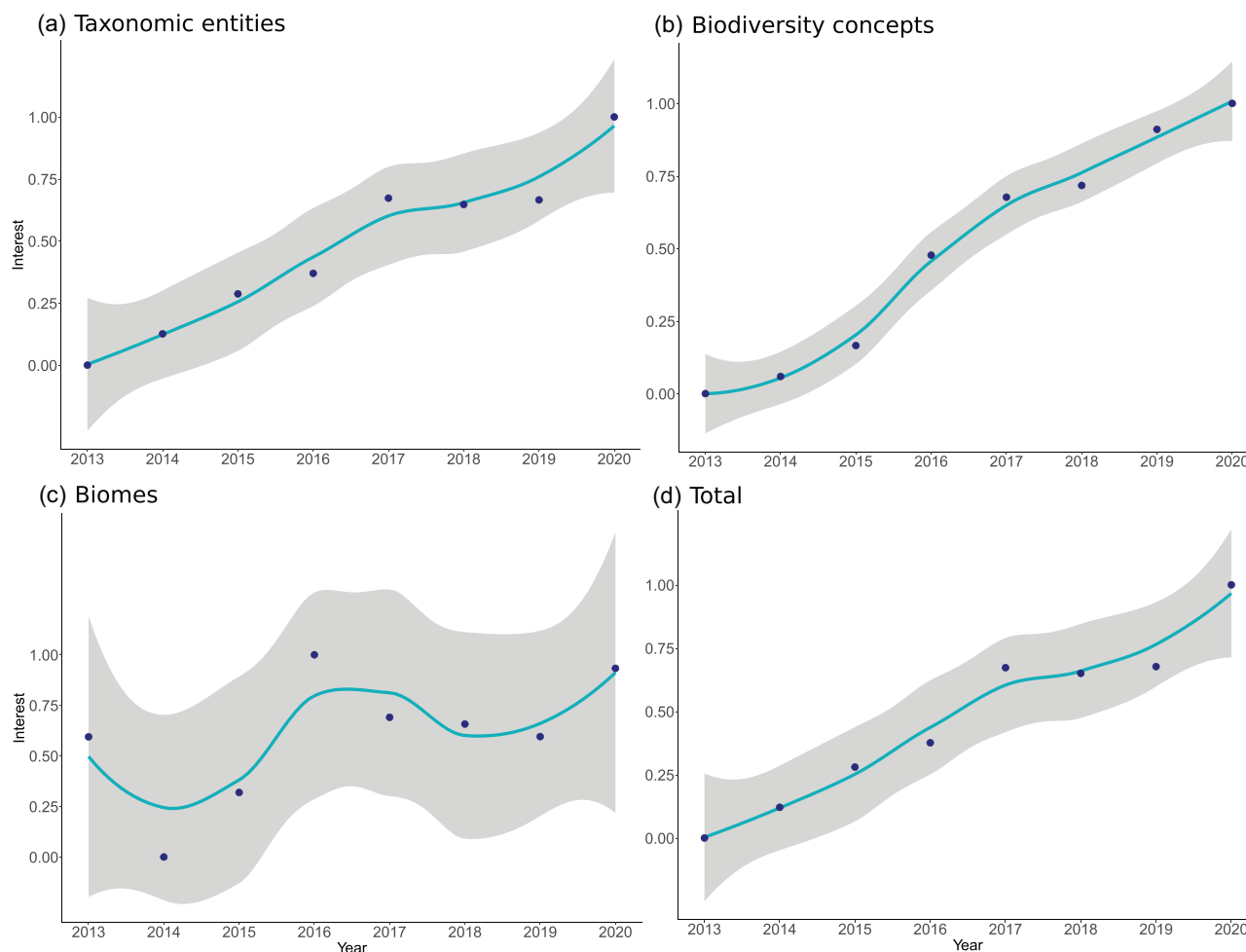


FIGURE 1 Global aggregate of relative search volumes on Google search engine for search terms related to biodiversity from 2013 to 2020: (a) 500 most viewed Wikipedia taxonomic entities and 10 most viewed for each language (989 search terms), (b) biodiversity concepts (20 terms from Convention on Biological Diversity's [2008] glossary), (c) global biomes (Olson et al., 2001, 15 search terms), and (d) aggregate of categories in (a), (b), and (c). Lines represent LOESS-smoothed time series and shading the confidence intervals for the smoothed time series. Relative search volumes scaled from 0 to 1 for display purposes. A complete list of search terms is in Appendix S1.

(Figure 4). Education variables had a mixed effect. Adult literacy rate was negatively correlated with trends in interest in biodiversity, whereas enrollment in tertiary-level education was positively correlated with trends in interest in conservation (Figure 4). Variables related to presence of environmental organizations had a negative effect on median interest in biodiversity and conservation, except in one instance, where the number of IUCN member organizations had a positive effect on median interest in conservation (Figure 4).

DISCUSSION

Our results showed partial success for Aichi target 1. Global aggregate interest in charismatic organisms and general biodiversity topics increased from 2013 to 2020 (Figure 1). However, interest in conservation decreased across the board, mostly due to a decrease in searches for *national park* after 2019 (Figure 2). This incongruence suggests interest in biodiversity is insuffi-

cient to drive interest in its conservation and that conservation outreach and education need to make a clear link between biodiversity elements and conservation action. Our results likely provide a conservative evaluation of progress toward Aichi target 1 because internet searches for a topic require awareness of it, but awareness does not necessarily lead to internet searches. Furthermore, our results do not encompass more informal modes of communication, which might be more relevant in traditional communities without widespread access to the internet. However, currently there is no other data source on people's interests with a comparable scope in space or time. The Union for Ethical BioTrade Biodiversity Barometer conducted surveys on biodiversity awareness with similar temporal scope, but they were limited to only 6 countries (Union for Ethical BioTrade, 2020). The Biodiversity Barometer shows an increase in the awareness of the term *biodiversity* for 5 out of 6 countries surveyed: Brazil, France, Germany, the United Kingdom, and the United States. Our results showed a similar increase in the biodiversity category for these countries, except the United

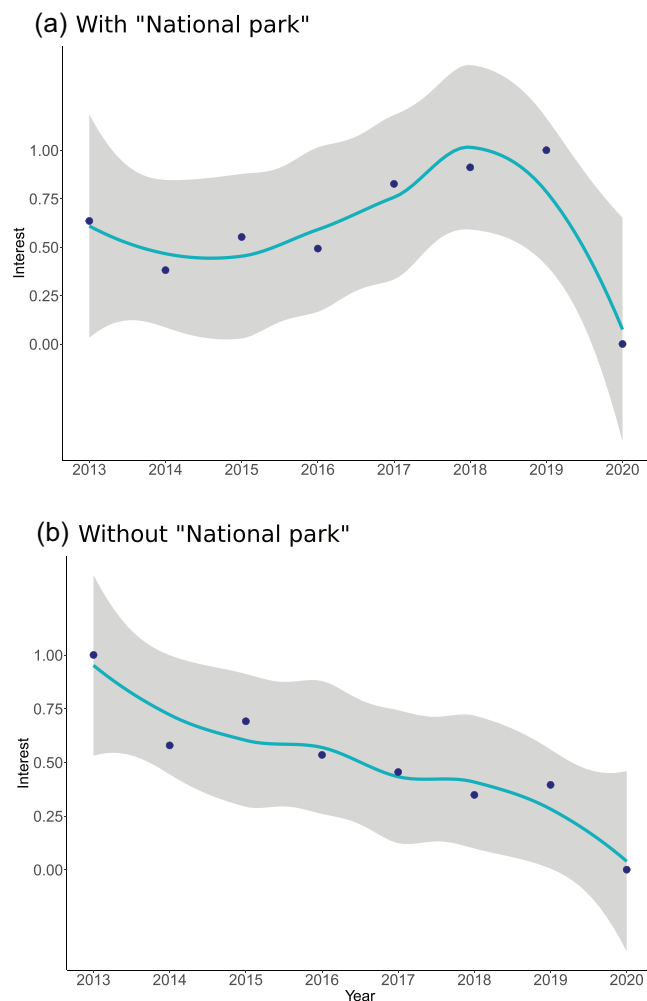


FIGURE 2 Global aggregate of relative search volumes on Google search engine for 27 search terms related to conservation from 2013 to 2020 (terms based on International Union for Conservation of Nature's [2012] Conservation Actions Classification Scheme) (a) with and (b) without the search term *national park*. Lines represent LOESS-smoothed time series and shading the confidence intervals for the smoothed time series. Relative search volumes are scaled from 0 to 1 for display purposes. A complete list of search terms is in Appendix S1.

States (Appendix S6). The similarity of the results of both studies, despite the big differences in methodology, indicate that awareness of biodiversity has increased in the last decade.

Organisms are the most concrete elements of biodiversity, so they are expected to generate more interest than academic topics (but see Lundberg et al. [2020]). This interest could be extended to more abstract biodiversity topics by showing examples of how such concepts are applied to conservation of charismatic species. Interest should also be extended to other species, because excessive focus on flagship species can lead to neglect of less charismatic ones (Colléony et al., 2017). The dominance of the term *national park* in the conservation-related terms might merely reflect an interest in tourism. However, search volumes for the term *national park* did not include searches for specific national parks, such as Kruger National Park, or searches for a country's national parks (e.g., Rwanda national park), which have their unique identifiers; they included

only searches for *national park* explored as a general concept. Still, the impact of searches made by tourists might be relevant in a few countries with low internet penetration, and the results might be less representative of the interests of the local population.

We found a positive correlation between the number of national parks per capita in a country and the median interest in conservation ($t = 2.3936$, $df = 163$, $p = 0.01782$), but this relationship disappeared when *national park* was removed ($t = -1.359$, $df = 153$, $p = 0.1761$ [details in Appendix S2]), which indicates an association of the searches with tourism. In any case, the term *national park* by itself reversed an overall decline in interest in conservation, when considering the remaining search terms. This indicated national parks may be the only way most people engage with conservation actions, even if their initial interest is related to tourism. Engagement with a national park either by locals or by foreigners can represent a direct contact with nature and potentially conservation outreach initiatives promoted at the parks. Such experiences might increase people's appreciation for the value of biodiversity and their interest in conserving it, regardless of their initial intentions. It is thus crucial that protected areas continue receiving support. Future studies should better explore how experiences in protected areas affect interest in biodiversity and how to leverage this influence to increase proconservation behavior.

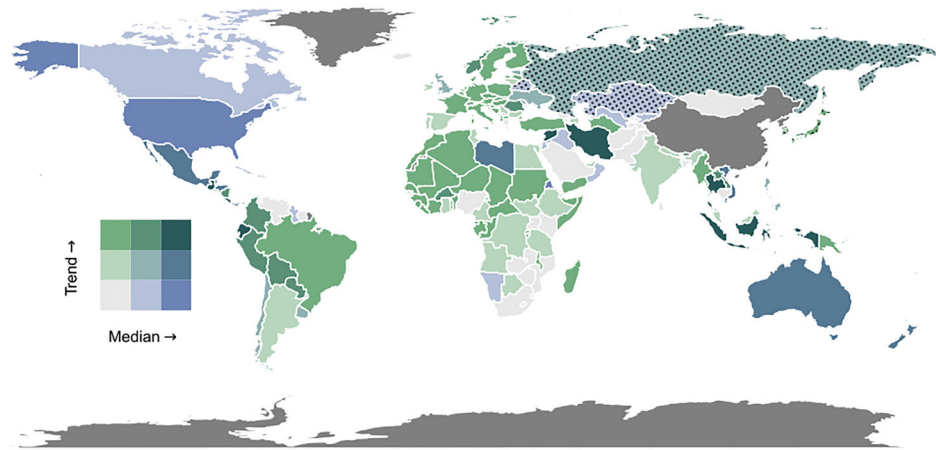
Spatiotemporal patterns

The term *national park* reversed the overall decline in interest in conservation from 2013 to 2019 (Figure 2). Interest in conservation abruptly decreased after 2019 (Figure 2), potentially due to worldwide visitation restrictions to national parks during the COVID-19 pandemic (Souza et al., 2021). National park closures might have substantially contributed to an overall decrease in interest in conservation (Bates et al., 2021).

There was no correlation between trend and median interest in biodiversity (Appendices S10 & S11), indicating that countries with high medians can still increase their levels of interest. This continued increase indicates these countries have not reached saturation in interest and could still benefit from outreach efforts focused on biodiversity. In contrast, a negative correlation between median interest and trends was observed for conservation topics (Appendices S10 & S11); the greatest decreases were in countries with higher median interest. Countries with low median interest in national parks probably had little room for decrease and thus showed less decline during the pandemic. The negative correlation between median interest and trends also indicates a lack of resilience in previously achieved levels of interest in conservation.

Overall, there was a substantial degree of intraregional variation in interest in biodiversity and conservation (Figure 3), indicating a potential influence of processes at the national or subnational level. Median interest in biodiversity was high in North America, Oceania, and Southeast Asia, whereas other parts of the world generally showed medium to low levels of interest. The few notable exceptions were Syria, Iran, Bolivia,

(a) Biodiversity



(b) Conservation

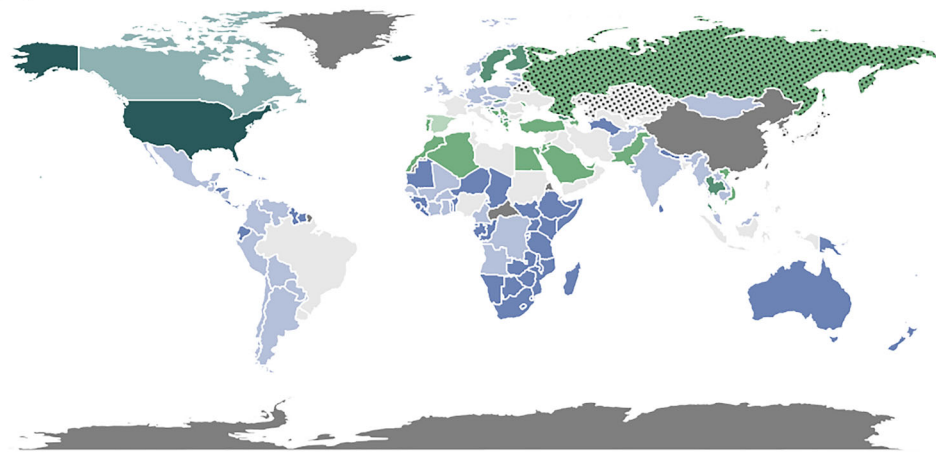


FIGURE 3 Trend and median interest in (a) biodiversity and (b) conservation from 2013 to 2020 in 191 United Nation member states based on relative search volumes at Google search engine (dots, countries with <75% of internet searches performed on Google). Trend was obtained as the median coefficient for a linear increase in a Bayesian structural time series model (Appendix S6). A complete list of search terms is in Appendix S1. Results not displayed for China because it had only 3% of searches conducted with Google or North Korea because of restrictions on internet use.

and Ecuador (Figure 3a). Higher trends were widespread across South America, North and West Africa, Europe, and East Asia, with very few countries showing both low medians and low trends (Figure 3a). Altogether, we found widespread positive results for the first part of Aichi target 1 (increasing awareness of biodiversity), but some countries could benefit from further outreach efforts, such as Venezuela, Nigeria, and Pakistan.

The United States, Australia, and many countries in southern and eastern Africa showed high median interest in conservation (Figure 3b). Ecotourism in national parks is an important source of revenue in these areas (Heagney et al., 2015; Snyman et al., 2021; Thomas & Koontz, 2021). Latin America, Europe, Asia, and North and West Africa overall showed moderate to low median interest in conservation. However, a few countries, such as Portugal and Egypt, had large increases in interest in conservation. Countries that showed both low interest and

low increases should be prioritized for outreach and education efforts, especially those with high biodiversity, such as Brazil, Nigeria, and Indonesia.

Google is not the only major search engine across all of the countries we analyzed. This might have affected the validity of the inferences drawn about such countries. Appendix S6 shows the average percentage of internet searches made on Google for each country during the study period. Six countries had <75% of internet searches made on Google: Belarus, China, Japan, Kazakhstan, Russia, and South Korea. Only in China was this value <50%. In Russia, it was 50.6%. Although North Korea showed a high proportion of Google usage (89.01%), this is likely to represent only a small proportion of users who have access to the global internet; access is heavily restricted in this country (Warf, 2015). We recommend caution when interpreting the results for countries in which Google is not the only major search engine.

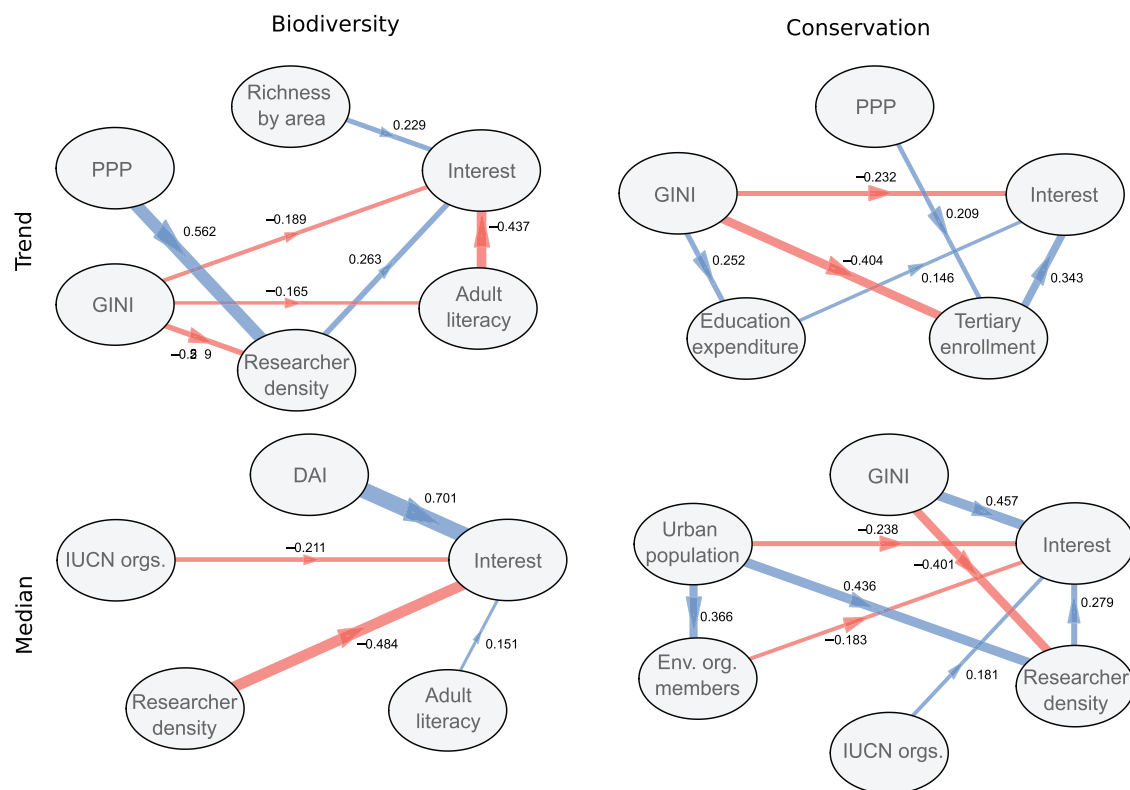


FIGURE 4 Factors affecting trends and median search volumes for biodiversity and conservation terms on Google (numbers, regression coefficients; richness by area, species richness per country area; PPP, purchasing power parity; GINI, Gini inequality index; urban population, percentage of human population living in urban areas; researcher density, number of researchers per million inhabitants; adult literacy, adult literacy rate; tertiary enrollment, rate of enrollment in tertiary education; education expenditure, expenditure on primary education; DAI, digital access index; IUCN orgs., number of International Union for the Conservation of Nature member organizations; env. org. members, number of environmental organization members; blue arrows, positive relationships; red arrows, negative relationships).

Correlates of interest in biodiversity and conservation

Our initial exploration of correlates of interest in biodiversity and conservation is correlative by nature and does not imply causation. These results should therefore be taken as potential basis for future researchers to conduct a more in-depth analysis of the patterns we found, which in turn could support conservation decision-making.

High levels of inequality were associated with low interest in biodiversity and conservation (Figure 4), suggesting that promoting equality may indirectly promote greater biodiversity conservation. Outreach efforts focusing on synergies between socioeconomic and environmental issues may help increase awareness of the value of biodiversity (Kanagavel et al., 2014) and help underprivileged populations understand long-term benefits of conservation (McDonald et al., 2020). We found that economic variables often affected education and research variables, which had predominantly positive associations with interest in biodiversity and conservation (Figure 4). Counter-intuitively, variables related to the presence of environmental organizations were often negatively associated with interest in biodiversity and conservation. However, quantity of environmental or conservation organizations may not reflect their

quality or translate to improved conservation outcomes. Alternatively, the effects of environmental organizations may have already been accounted for by other variables. Contrary to our initial prediction, a country's (area corrected) species richness or its national biodiversity index (according to the CBD) had little association with public interest in biodiversity (Appendix S12). This might suggest a lack of interest in local biodiversity, compared with globally popular species, or that the composition of the local biota, such as the presence of some charismatic species, is more important than overall species richness. Future studies that explicitly investigate the overlap of searches with organisms' distributions might better clarify this and other relevant questions (Mittermeier et al., 2021). The moderate explanatory power of our models (Appendix S14) suggests that unaccounted factors, such as cultural differences, could make interventions highly contingent on local contexts (Waylen et al., 2009).


Our results suggest a positive trend toward achieving Aichi target 1. More work must be done to increase interest in noncharismatic biodiversity and conservation globally. Unfortunately, the Global Biodiversity Framework for the next decade will likely not include a direct successor to Aichi target 1 (awareness is mentioned in target 21, but not as the main focus [Convention on Biological Diversity, 2022]). This is especially

concerning because Aichi target 1 itself states: “Understanding, awareness and appreciation of the diverse values of biodiversity, underpin the willingness of individuals to make the necessary changes and actions and to create the ‘political will’ for governments to act.” Further investment in outreach and education efforts, with evidence-based approaches, such as social marketing and constructing solutions with local stakeholders, is necessary to achieve this goal in the current decade.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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