Analyzing Google search data to debunk myths about the public's interest in conservation

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Biodiversity conservation succeeds only if it has public support, yet many conservation scientists suggest that such support is waning and some fear that the public has lost interest in conservation. Moreover, the public's limited interest in the environment overall might be overwhelmed by concern over a single issue – that of climate change. To understand whether these views are justified, we evaluated public interest in different conservation-related terms by examining internet search trends. We found that contrary to commonly held opinions, public interest in conservation is in fact rising, and that it is tightly and positively correlated with interest in climate change, indicating that the public pays attention to both topics at the same time. Conservation scientists should nurture this growing interest and transform it into actual support for conservation by redoubling efforts to present objective, evidence-based findings about conservation in an accessible, engaging, and relatable way. Such efforts are crucial in a time of increasing political polarization, reduced funding, and deliberate misinformation campaigns.

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Biodiversity conservation can succeed only if it has public support (Sarkar 2005). Policy change rarely occurs based on scientists' recommendations alone, no matter how sound they are; policy makers, for example, typically make changes only in response to mounting public pressure (Phillis *et al.* 2013). Much of conservation is implemented by non-governmental organizations (NGOs) that rely directly on public support (Ladle *et al.* 2016), and market-based conservation strategies, such as certification or boycotts, depend on the public being interested in consuming in an environmentally responsible way. In the absence of public support, conservation efforts would stall.

Yet commonly held views among conservation scientists suggest that public support is waning, leading some to express fears that the general public has become largely uninterested in conservation (Troumbis 2017). Tired of hearing about unrelenting environmental crises and numbed by the seeming inability of society to save vanishing species, the public may be simply overwhelmed by the myriad conservation projects that request financial or volunteer support, the petitions that need signing, or the corporate brands that should be boycotted (Wray-Lake *et al.* 2010; Mccallum and Bury 2013; Veríssimo *et al.* 2014).

Moreover, some conservationists also believe that what limited "bandwidth" the public dedicates to environmental causes has become swamped by global warming and climate change, which could lead to an artificial decoupling of these topics from other environmental issues, many of which are tightly linked to climate change (Novacek 2008; Veríssimo *et al.* 2014; Legagneux *et al.* 2018). The fear that public interest in conservation is being overwhelmed by climate change (Curry *et al.* 2007; Novacek 2008) could be justified, or it may be an artifact of the way many polling datasets are collected, in that the commonly used "most important problem" (MIP) technique restricts the number of issues that an individual respondent can raise as MIP; if there is an increase in one issue being raised as MIP, it unavoidably leads to decreases in other issues. Such a limitation is not shared by internet search data, however (Mellon 2014). In addition, the growing number of new conservation strategies (eg debt-for-nature swaps, certification, or Reducing Emissions from Deforestation and Forest Degradation [REDD+]) may not be evidence of a growing conservation toolkit but rather simply represent different approaches that continuously fall in and out of favor with practitioners, NGOs, and policy makers, and consequently with the public (Redford *et al.* 2013).

To ascertain whether these views are warranted, we assessed trends in internet searches for various conservation-related terms using Google Trends (https://trends.google.com). Google Trends measures internet searches on Google, which have emerged as one of the best proxies for gauging public curiosity, attention, and issue salience (Vosen and Schmidt 2011; Mccallum and Bury 2013; Mellon 2014), and provides an indication of how interest in a given search term has changed, on a monthly basis, since 2004. Internet searches are even more effective than traditional surveys at tracking the public's interest (Ripberger 2011; Vosen and Schmidt 2011), the main advantages of the former being a large sample size, low cost, anonymity, and high temporal frequency (Zhu *et al.* 2012; Mellon 2014). The main disadvantage is that Google Trends shows relative and not absolute search-term frequency. With this in mind, we developed an algorithm to back-adjust Google Trends data to reflect the trend in total volume of searches.

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Methods

How Google Trends works

Google Trends does not provide an absolute volume of searches for a term; instead, it adjusts the absolute number of searches in two ways. For instance, if we conducted a search using the term "pangolin", Google Trends first calculates what proportion (p_i) of total searches on Google (S_i) each month (i) were for pangolins (a_i), so that:

$$p_i = \frac{a_i}{S_i} \quad \text{(Eq. 1)}$$

Hypothetically, if there were 10 Google searches overall in May 2004, and 1 of those was for the term pangolin, then p_i would then be 1/10. Next, Google Trends takes the month (i) during which the ratio (p_i) was historically the highest (p_{max}); continuing our hypothetical scenario, in June 2010, 9 out of 10 searches were for the term pangolin, which was historically the highest ratio, p_{max}. This month i, which does not necessarily coincide with the month of the highest absolute number of searches for pangolin, is assigned the value $g_i = 100$ in Google Trends output. All remaining months are then assigned a g_i value between 0 and 100, according to how much smaller their pangolin-to-total search ratio was, such that:

$$g_i = 100\frac{p_i}{p_{max}} \quad \text{(Eq. 2)}$$

Limitations of Google Trends

Google Trends does not provide the absolute volume of searches for a term (a_i), an issue common to other commercially owned data sources (Ladle *et al.* 2016). Whereas the data provided by Google Trends are useful for certain purposes, such as highlighting short-term spikes or patterns in searches that can indicate disease outbreaks or unemployment trends (Mellon 2014; Bakker *et al.* 2016), they are unlikely to yield realistic results for longer-term trends (see WebPanel 1).

Back-transforming Google Trends

We developed an algorithm to back-adjust Google Trends outcomes to reflect the ratio of absolute searches; in other words, we generated a trend, scaled between 0 and 100, in absolute search values. We did so by first estimating the number of total Google searches for each month, S_i. Whereas Google no longer releases official reports on the total number of searches performed, there is an abundance of educated guesses available on the internet. We collected these various approximations (WebTable 1 and WebPanel 1) and fitted an exponential model to them (WebFigure 1).

Next, from Equation 1, we know that:

$$g_{i+n} = 100\frac{\frac{a_{i+n}}{S_{i+n}}}{\frac{a_i}{S_i}} \quad \text{(Eq. 3)}$$

where:

$$\frac{a_i}{S_i} = p_{max} \quad \text{(Eq. 4)}$$

This is generalizable for any g_{i+n} or g_{i+m} within the study period.

Because g_i is known to us from Google Trends, we can find a number k, so that:

$$g_i = kg_{i+n} \quad \text{(Eq. 5)}$$

Combining Equations 3–5, we can establish that:

$$\frac{a_{i+n}S_i}{S_{i+n}a_i} = k\frac{a_{i+m}S_i}{S_{i+m}a_i} \quad \text{(Eq. 6)}$$

which can be simplified as:

$$\frac{a_{i+n}}{a_{i+m}} = k\frac{S_{i+n}}{S_{i+m}} \quad \text{(Eq. 7)}$$

As explained above (Equation 5), we know k from Google Trends, and we have an estimate of S_{i+n} and S_{i+m} from our model of total Google searches (WebFigure 1). Hence we know the ratio of a_{i+n} to a_{i+m} for any n and m within the study period.

Next, values were normalized by comparing all a_{i+n} to a single a_i by calculating the ratio b_i as:

$$b_i = \frac{a_{i+n}}{a_i} \quad \text{(Eq. 8)}$$

Finally, we determined a maximum value of b_i, which we designated b_{max}. In our back-transformed plots (Figure 1; WebFigures 2 and 3), we plotted the values of b_i, scaled so that $b_{max} = 100$. The final back-transformed values are therefore the ratio of the absolute number of searches for a term in a given month to the maximum absolute number of searches for that term in any month (WebFigure 4).

To account for uncertainty about the total number of Google searches, we performed the calculations with upper and lower bounds of the 95% confidence interval (CI) for our model of total Google searches.

Absolute monthly search volumes for individual terms

To provide an idea of the absolute scale (which would not change the shape of our trend lines) and to rely on a second data source, we used the internet browser add-on Keywords Everywhere (https://keywordseverywhere.com) and the commercial service Google AdWords (https://adwords.google.com). From these two sources, we obtained estimates of the absolute monthly search volumes for individual conservation-related search terms (WebTable 2). Both of these websites provide the average number of times people searched for a specific search term, as well as closely related variants. The numbers of searches are presented as searches

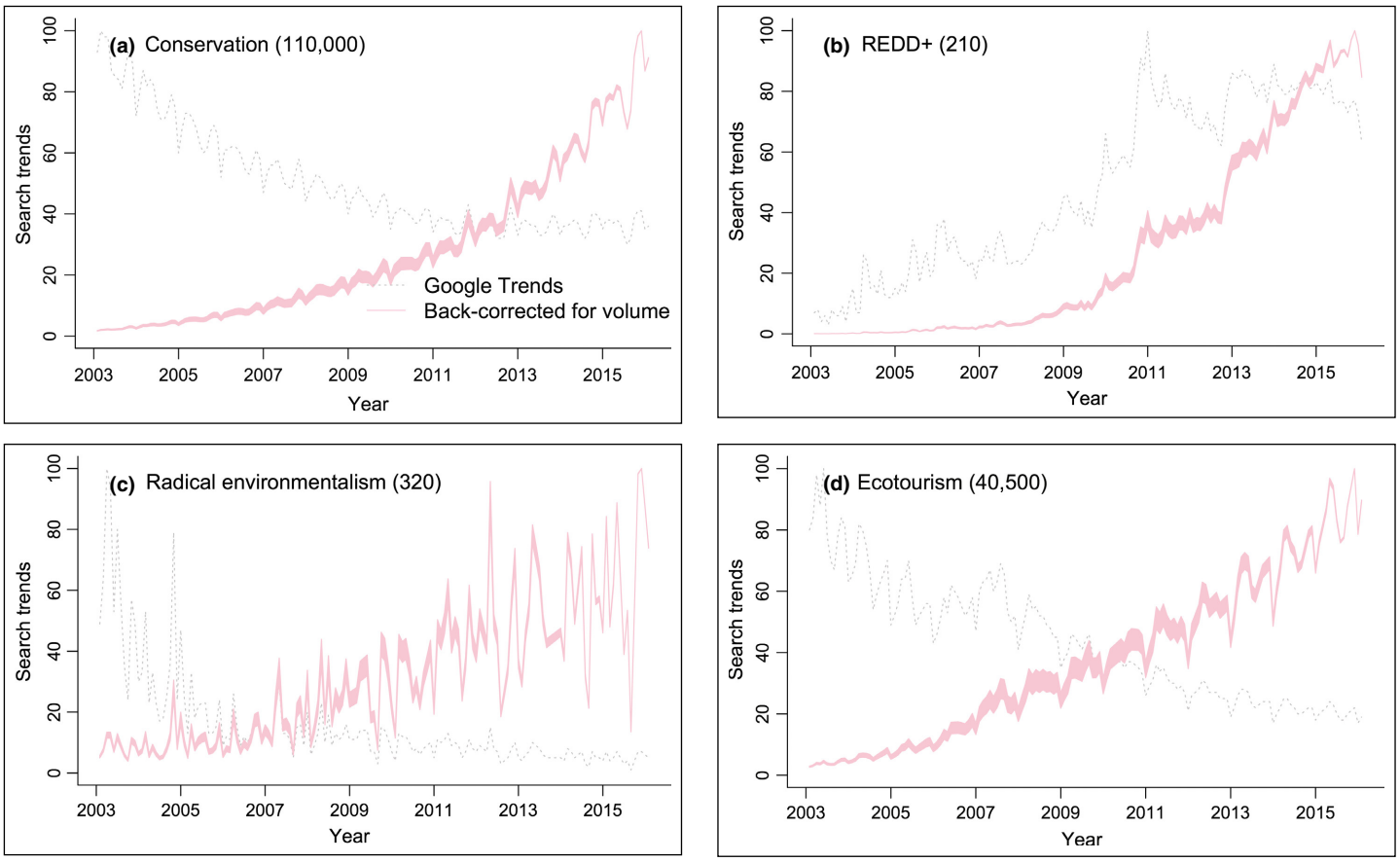

Figure 1. Trends in Google searches for conservation and several examples of specific conservation strategies (see other examples in WebFigures 2 and 3). The y axes are unit-less and express the relative changes in search volumes (see Methods for details). Gray dashed lines are the original Google Trends data (g_i), where 100 represents the month in which the highest proportion of all internet searches was for the researched term; pink lines are the back-transformed Google Trends data (see Methods), where 100 represents the month in which the highest absolute number of searches for the search term was carried out. Line thickness represents the 95% confidence interval. Numbers in parentheses (to the right of each search term) represent the absolute monthly search values at the time of the study (see Methods).

per month, but are averaged for the past 12 months, and therefore do not reflect seasonality. Both sources yielded the same estimates.

Searches

We used the Salafsky *et al.* (2002, 2011) classification of conservation strategies to generate a list of search terms, selecting examples from four broad approaches to conservation to illustrate, rather than exhaustively cover, the breadth of possible interventions (WebTable 2). We also searched for several examples of major specific certification schemes. To explore the correlation between searches for climate change and conservation, we compared the terms "climate change" and "global warming" with "biodiversity", "extinction", and "endangered species". Whereas in reality all of these terms are clearly related (eg climate change leads to species being endangered), some researchers worry that when the public began to identify climate change as the most important environmental threat (Curry *et al.* 2007), interest in other environmental issues diminished and became disconnected from climate change, thus reducing overall public engagement (Novacek 2008). As controls, we also compared the search terms with two unrelated terms, "HIV/AIDS" and "cupcakes" (while there is some scientific research linking climate change to HIV/AIDS, we assumed that this link has not yet reached the public).

Caveats

What motivates internet users to search for each term is unknown, and curiosity about an issue does not necessarily equal support for that issue (Ripberger 2011). However, motivations have likely diversified and changed in importance since 2004, which is when the Google Trends data series start. Google searches have also shifted in the way they represent the global population in terms of geography and demography (Mellon 2014).

Google Trends requires a minimum number of searches (this threshold is not disclosed by Google) to produce a trend line, and we find it encouraging that searches of many conservation-related terms occur frequently enough to exceed this threshold. There are, however, terms that do not exceed the unknown threshold, such as "Integrated Conservation and

Development" plans or projects (ICDPs, ~30 searches per month), "market-based conservation" (~20 searches per month), or "Convention for Regulation of Whaling" (~0 searchers per month). In the case of some interventions, such as ICDPs, this may be because public interest peaked before 2004 (Salafsky and Margoluis 1999).

Finally, there is some evidence that Google Trends is biased toward developed Anglophone countries. To account for this, at least in part, we used search terms that appear as "topics" on Google Trends, which means that the search includes the same or very similar terms in other languages, as well as variations of the search term, or its spelling, in English that have a similar meaning (eg ecolabeling as well as eco-label).

Results and discussion

Mounting public interest in conservation

We found that the number of Google searches for conservation-related topics overall is increasing (Figure 1). This rise in interest could be due to several factors, such as the growing number of conservation-related university courses across disciplines of study (Kitazawa and Zhou 2011); increasing numbers of conservation practitioners seeking information on the internet; and a mounting general interest in conservation on the part of the public, contrary to the findings of previous studies (Mccallum and Bury 2013; Anderegg and Goldsmith 2014; Troumbis 2017), none of which back-corrected for total search volumes (Ficetola 2013). Our findings, however, correlate with the growth in individual donations globally to two major environmental NGOs, The Nature Conservancy (https://bit.ly/2PdTnsG) and World Wildlife Fund (www.worldwildlife.org/about/financials), over the past 5 years, which reflects an increased engagement in conservation on the part of the general public.

The overall online interest in conservation (~110,000 searches per month) is of a similar order of magnitude to interest in poverty (~165,000 searches per month) and malnutrition (74,000 searches per month). Conservation is not a topic of interest solely to North Americans and Europeans, however; for example, internet users in East Africa, India, and Nepal are increasingly performing searches using the word "conservation" (Figure 2). This interest must be taken into account by international environmental NGOs that are implementing conservation programs in many different countries, whether the reasons for interest in conservation are pragmatic, such as direct dependence on natural resources, or based on cultural and individual values, such as respect and care for nature.

Biodiversity conservation versus climate change

The public appears to pay attention to both climate change and biodiversity conservation simultaneously, and may not see these two topics as disconnected (Figure 3), despite a recent finding that media coverage of biodiversity issues is lower than that of climate change (Legagneux *et al.* 2018). In fact, interest in these two broad topics is tightly and positively correlated (WebFigures 5 and 6), as short-term

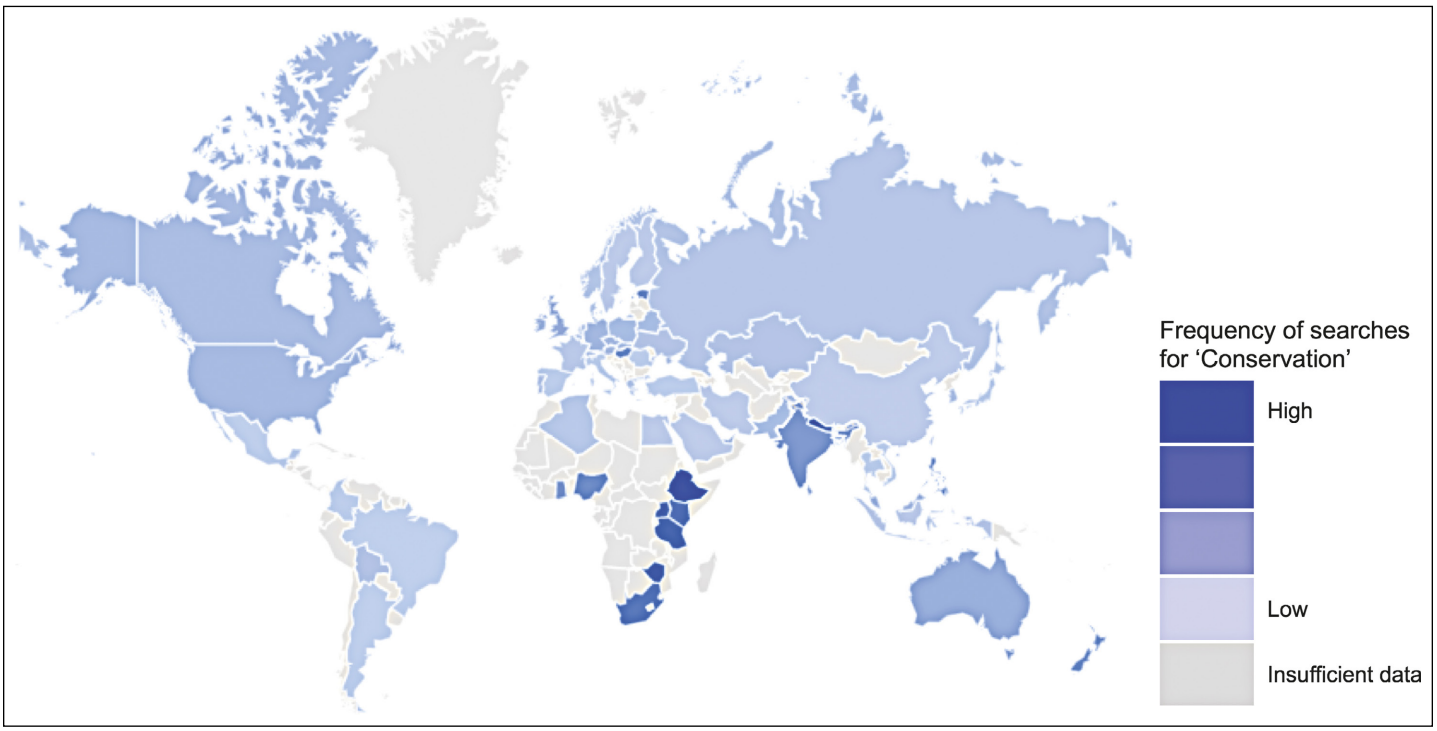

Figure 2. Geographical representation of interest in the topic of conservation, defined by internet searches for the term "conservation" from 2004 to 2017. The darker the blue, the higher the proportion of internet searches for "conservation" relative to the total number of internet searches performed in that country between 2004 and 2017. Gray represents insufficient data. Based on original (ie non-back-corrected) Google Trends outputs.

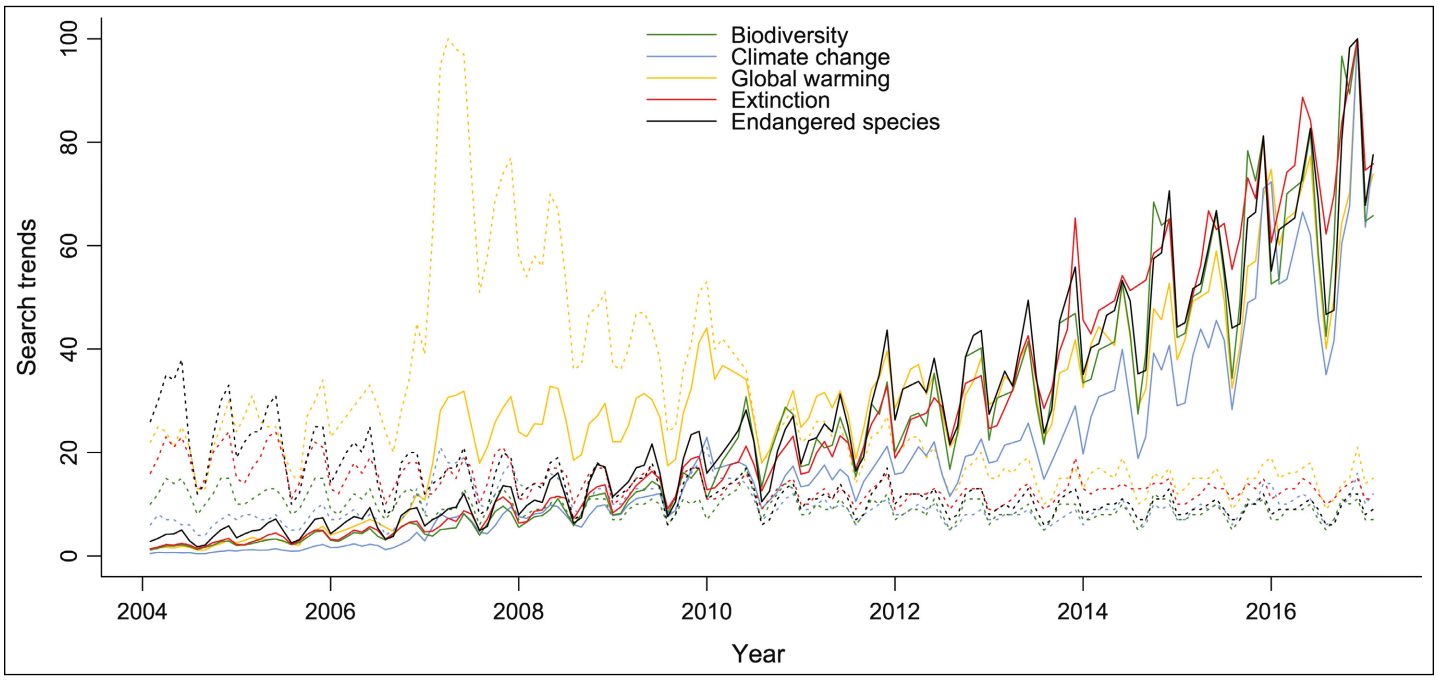

Figure 3. Search trends for "climate change" and "global warming" compared with search trends for "endangered species", "biodiversity", and "extinction". The y axis is the same as that described in Figure 1. Solid lines represent changes in absolute volumes of searches (back-corrected data; see Methods), whereas dashed lines represent trends in relative volumes of searches (original Google Trends data).

increases in interest in climate change correspond to similar increases in interest in extinction and endangered species. Over the longer term, public interest in climate change and global warming apparently began to increase in 2007 – possibly due to the 2006 release of *An Inconvenient Truth*, a movie about climate change – and has since caught up with, but not displaced, interest in biodiversity conservation, with interest in the two topics eventually attaining similar levels over the past 5 years. We propose that the tight correlation of interest in climate- and biodiversity-related topics reflects public awareness of the strong overlap and interaction of these issues (Novacek 2008) but validation of this hypothesis requires further research.

Favored conservation interventions?

If conservation practitioners, scientists, policy makers, and the public perceived new conservation interventions as ephemeral ideas rather than components of a growing toolkit, we would expect internet searches for particular interventions to peak and fall rather than grow over time. Instead, interest in most of the conservation interventions that we searched for has increased over the past 13 years (Figure 1; WebFigures 2 and 3; WebTable 2). Only a few interventions did not increase substantially in popularity, and these included interventions associated with more extreme forms of environmentalism, such as monkeywrenching (non-violent sabotage carried out by environmental activists).

Some of our search terms exhibited short-term spikes in popularity, such as the International Union for Conservation of Nature's (IUCN's) Red List in late 2012 and early 2013, coinciding with the release of the IUCN Red List in 2012 at the Rio+20 Earth Summit. There was a sudden and marked increase in the frequency of searches for REDD+ in the second half of 2013, presumably reflecting attention derived from the 19th Conference of Parties creating the "Warsaw Framework on REDD-plus", which largely completed the overall framework of REDD+. A previous study found that events highlighted in the media, when examined via Google Trends, had a half-life of about 6 days, as was the case for the "climategate" scandal (Anderegg and Goldsmith 2014). Waning interest in web searches of Millennium Development Goals, which contained many conservation-related items, was countermanded by growing interest in the Sustainable Development Goals as of late 2015, the year the latter were introduced by the United Nations.

Conclusions

Making conservation science count

What can we learn from evaluating interest in conservation through the lens of Google Trends? Some conservation scientists and practitioners have expressed concern that global interest in conservation may be declining (Mccallum and Bury 2013), possibly as a result of displacement by mounting and artificially disconnected concern about climate change (Novacek 2008; Veríssimo *et al.* 2014), or due to conservation strategies falling in and out of favor (Redford *et al.* 2013). Our research shows otherwise: public interest in conservation in general and in specific conservation interventions does not seem to have decreased over the past 13 years.

The fact that public interest in conservation appears to be waxing and not waning has important implications. First, interest does not necessarily equal support; conservation scientists and practitioners should therefore encourage this growing interest by redoubling efforts to present objective, evidence-based findings about conservation in an accessible, engaging, and relatable way. This may require academics and conservation practitioners to explore new ways of communicating scientific findings, for example through collaborations with educators, journalists, storytellers, filmmakers, celebrities, illustrators, and so forth. Importantly, it appears that the public's interest in conservation rises and falls simultaneously with the public's interest in climate change, rather than competing with it, and therefore the two issues can benefit from each other's popularity.

We believe that conservation scientists can and should be more aggressive and strategic about communicating their results (Legagneux *et al.* 2018). For instance, by using Google Trends and other culturomics tools for tracking trends on social media platforms (Ladle *et al.* 2016), scientists may be able to determine appropriate terms to use in their own communications to maximize traffic, public awareness, and pickup by media outlets. The terms that scientists initially use likely shape the terminology that the media and therefore the public uses, although the pathway is unlikely to be simple and linear (Phillis *et al.* 2013).

We emphasize the importance of communicating strategically to reach the broadest possible audience and doing so in a way that maintains long-term engagement of the public in conservation, which is especially important in times of increasing political polarization, reduced funding, and widespread misinformation campaigns.

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Supporting Information

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