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ET&C Focus

Focus articles are part of a regular series intended to sharpen understanding of current and emerging topics of interest to the scientific community.

Environmental stressor importance: science versus media

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Abstract: It is well established that human perceptions of risk depend on a multitude of factors, such as subconscious processes, heuristics and biases, conscious reasoning and social influences (Norgaard 2011). Even risk scientists are affected to some degree by non-scientific drivers, such as "known unknowns" and "unknown unknowns" (i.e., uncertainty). Another aspect affecting scientific investigations of environmental risk is media focus, which can influence research (Burton 2017). Given the daily news about climate change, natural disasters, endangered species and chemical exposures it is useful to understand the perceptions of risk by the public – which are influenced by both science and media releases.

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METHODS

Environmental stressors

To determine scientific, media, and public interest on climate change and other environmental stressors, we established relationships between research articles and media coverage from August 2018 to August 2019; and explored the volume of internet searches through Google Trends in selected environmental topics over the last 15 yr. Initially, 50 environmental topics were selected using Google search and Scopus (Figure 1). The criteria for selecting keywords were:

1) Words or phrases representing related queries for climate change on Google search and Scopus;

2) Words or phrases with sufficient search volume in Google Trends to facilitate the analysis;

3) Overlap with previous studies (Archibald and Butt 2018; Petersen et al. 2019) looking at online interest in environmental topics; and

4) Words or short phrases which are specific and not prone to confusion with other popular, non-conservation search keywords (e.g. mercury (element) may be used to refer to a famous singer or a planet in the solar system, so were excluded).

Although these keywords were not meant to be a comprehensive representation of conservation or environmental stressor topics, each keyword represents a relevant and common stressor or conservation issue to illustrate our approach.

Research articles database

SJR SCImago Journal and Country Rank were used to select the 50 top ranked scientific journals in the fields of "Ecology", "Environmental Engineering", "Environmental Sciences", and "Global and Planetary Change". An initial screening assessment was conducted to identify the pertinence of each journal for climate change research. Ten journals considered suboptimal for this evaluation were replaced with more suitable journals ranked from 51th to 100th SJR positions *(see Supplementary Material)*.

Using the Scopus database, a search was conducted to gather the total number of research articles related to all environmental topics. For each keyword, we used an advanced search tool to find articles published from August 2018 to August 2019 in all selected scientific journals, as follows: *(ALL ("topic") AND SRCTITLE ("Journal X" OR "Journal Y" OR...) AND PUBYEAR = 2018-2019)*.

News website coverage

News websites were selected using Alexa (Amazon Inc.), which hosts a global online electronic library of website traffic records. A total of 50 worldwide news websites were selected based on popularity (e.g., quantity of search traffic, high readership) and data accessibility (e.g., whether they can be accessed through databases such as LexisNexis, Access World News, Factiva or their own archiving systems). News websites selected

were intended to cover the most representative countries across all continents. A search was conducted for news reported from August 2018 to August 2019 using each of the 50 environmental topics as the search term.

A search for online news was conducted using all environmental topics. For example, climate change was initially searched for 8 English speaking countries: Australia, Canada, England, India, Ireland, Scotland, South Africa, and the United States. Moreover, to provide a more geographically comprehensive picture, we entered the same keyword translated into the languages of 9 additional countries (in parentheses): cambios climaticos (Argentina, Mexico, and Spain); mudanças climáticas (Brazil and Portugal); cambiamento climatico (Italy); klimawandel (Germany); réchauffement climatique (Belgium and France); and 氣候變化 (China).

Trends on climate change

To identify public interest on climate change over time, we used the search topic queries in Google Trends platform. Google Trends is a publicly accessible online Alphabet Inc. portal, which analyzes a portion of billions of daily Google searches, generating data on geographical and temporal patterns according to specified keywords.

Google Trends uses a fraction of searches for a specific keyword and then analyses the outcome according to geographical location and time frame. A relative search volume (RSV) was then assigned to the keyword, standardizing it from 0 to 100, where 100 represents the highest share of the term over a time series.

A worldwide geographical scope over a 15-yr period was determined from January 2004 (when Google Trends data were first available) to August 2019. Specific environmental topics were searched without quotation marks; therefore, results included all searches irrespective of word order (e.g. "climate change" includes "climate change" and "change climate"). Queries were exported as CSV files from Google Trends for further statistical analysis.

Additionally, we downloaded the top (most common queries searched including the term) and rising (recently popular queries searched including the term) search queries, which contributed to the RSV. This provided an understanding of how users were interacting with Google. We found that the majority of search queries for climate change related to learning more about the topic. Thus, we are confident that the RSV aligns with the magnitude of online awareness of climate change.

Data analysis

To provide a quick visual overview of search volumes for research articles and news websites related to environmental topics, we created 2-word clouds using the online website Wordclouds. The keyword *global warming* was considered as an earlier synonym for *climate change* and was excluded in both word clouds.

The Mann-Kendall (MK) statistic *S* test (Mann, 1945, Kendall, 1975) was applied to detect the presence of trend in public interest for each environmental topic over the year. Mann-Kendall tests the data against a null hypothesis of no trend and calculates Kendall's tau statistic τ based on *S*, the subtraction of the discordant pairs from the

number of concordant pairs across all possible pairs in all the *n* observations in the time series. A positive or negative value of S (and thus τ) indicates an upward or downward trend, respectively. Testing trends were carried out on a seasonal basis (12 mo period) at $\alpha = 0.05$ significance level using the XLSTAT® Premium package for Microsoft Excel®.

RESULTS AND DISCUSSION

Climate change was the most popular topic reported in the public media last year (Figure 2) with over half million news articles (average 12,169 per website). From pollution to corruption, environmental journalism often aims at highlighting problems and may lead toward sensationalism to entice readership. This results in less focus on finding solutions, other causes of environmental impacts, or studies reporting an absence of adverse effects.

Climate change is fueling more frequent and intense precipitation, leading to more devastating flooding events. More than 3,800 articles covering *flooding* were in the media last year, mostly framing flash flooding or devastation caused by hurricanes. Media focus on climate related disasters, such as flooding, drought and wildfires tend to overlook non-climate exacerbation of impacts from public or government mismanagement of forests, water consumption, draining of wetlands, or environmental justice inequalities. By highlighting these factors that contribute to the severity of climate-related disasters, the media can better educate both the public, environmental managers and policymakers.

Failure to report on all these related issues likely exacerbates public opinion divisions between liberal and conservative viewpoints. According to a CBS poll released in September 2019, while nearly seven in 10 Democratic voters understand that humans

significantly influence the climate and 80% want immediate action, just 20% of Republicans think humans are a primary cause and barely a quarter want rapid action (YouGov 2019).

Environmental news reporting also varies depending on country wealth. Our results show in developed countries, climate news tends to focus on scientific discoveries, controversies and uncertainty. From the media outlets, *The New York Times* and *The Guardian* had the highest coverage of environmental topics (approximately 2,200 yr^{-1} each) compared to the top 50 journals. Their stories primarily dealt with politics and regulations.

Climate change coverage in developing countries is similar in magnitude to developed countries; however, their reporting centers more on the economics of natural impacts – such as deforestation and weather-related disasters. Deforestation and related fires in Brazil's Amazon rainforest were highlighted this year. As of August 2019, 72,000 wildfires are at an 84% increase over the same period in 2018. More than 6,000 total news reports globally had the term *deforestation* in 2019 and 80% of which were during wildfire season (July and August). The Brazilian Amazon lost 430 sq miles – an area equivalent to Hong Kong – in the first 26 days of August, according to preliminary data from the government's satellite monitoring agency. An area half the size of Philadelphia was reportedly lost in July (NISR 2019).

Climate change was the second most popular topic reported by the scientific community (8,971 total research articles), so is similar to the news media in importance. According to a CBS poll, more than a quarter of Americans consider climate change a "crisis," with

a further 36 percent defining it as a "serious problem." Two in 10 respondents said it was a minor problem, with just 16 percent considering it not worrisome at all. Regardless of concern over climate change, there appears to be skepticism among Americans about how much humans can do about it. Just 19 percent said humans can stop rising temperatures and the associated impacts, with nearly half thinking it is possible to slow but not stop the changes and 23 percent refusing to believe humans can do anything at all (YouGov 2019).

Climate change scientists of developed countries focused their research keywords dealing with climate change on *regulation*, *priority journals*, and *animals*. While scientists in developing countries, focus their searches on the biological services and the chemistry aspects of climate change. Thirty percent of the research papers on climate change (2,642 articles) were from developing countries (Argentina, Brazil, China, India, Mexico, and South Africa), and most of their keywords were *China*, *nonhuman*, *biodiversity*, and *chemistry.*

We were surprised that *Hunting* was the second largest environmental subject reported by the media. It was mainly related to African and American news, with more than 6,000 reports last year. Nevertheless, a survey by the U.S. Fish and Wildlife Service in 2018 showed only about 5 percent of Americans, 16 yr old and older, actually hunt. This low value is half of what it was 50 yr ago, with accelerating declines expected over the next decade. Results also suggest millennials are driving a global shift away from eating meat because of sensitivities over animal cruelty, and young adults may be less likely to own

guns than past generations (FHW 2018). The hunting news tended to focus on the decision to lift a hunting ban on elephants in some African countries.

The least popular topic in scientific reporting was *noise pollution*, while in media it was *Ecotoxicology*. Only 1 news article per year (average of 50 web sites) emphasized the importance of linking toxic effects of chemicals on ecosystems and their organisms. Despite the fact that our human-dominated ecosystems receive many thousands of chemicals through atmospheric, terrestrial and aquatic discharges, there is little focus on these exposures to wildlife and how climate change accentuates their impacts. This lack of public education raises the question of whether this linkage between chemical toxicity and climate change is simply too complicated to report. We believe the public would be interested in learning more of this aspect of climate change, such as how chemical exposures to both humans and wildlife dramatically increase following disasters.

Despite the high level of confidence the public has in science, scientists may not deliver convincing or effective messages to educate journalists and the public of climate-related risks – which are often complex and tied to many other issues such as poor zoning, inadequate infrastructure, loss of natural buffers such as wetlands, sand dunes and mangroves.

As an example, last year's most popular topic in scientific publishing was *metals*, with over 13,500 research articles (Figure 3); however, metals are of little interest to the public or media. So why this emphasis on metals? Perhaps it is because metals are common in our environment and everyday life and frequently associated with environmental contamination. It may also be related to the fact metals are less expensive and easier to

measure than high profile organic chemicals, such as polychlorinated biphenyls (PCBs), dioxin, per- and polyfluoroalkyl substances (PFAS), and endocrine disruptors. This allows limited research funding to stretch further, particularly for scientists in developing countries.

Our evaluation of public interest on environmental stressors (all searches) is shown in Figure 4. Google Trends showed how search topics are trending up and down since 2004. For example, there has been a significant upward trend (0.82) in searches on *antibiotics* since 2004. This is likely resulting from a growing awareness (often through scientific publications) of the presence of antibiotics in our foods, waterways, and wastewaters, and the danger of increasingly drug-resistant pathogens.

Ozone depletion and global warming were at the top of environmental concerns in the 1970s and 80s. Both of those subjects are declining in searches. The search for *global warming* declined ($\tau = -0.68$) since 2004, as public interest for *climate change* (0.25) increased. One possible reason driving the decline in searches may be that the term *climate change* is more correct as a descriptor than *global warming*, encompassing all changes in global climate (such as increasing cold and heat extremes).

Earlier this year, *The Guardian* updated its style guide to introduce new terms that more accurately describe the environmental crises facing the world. It now favors the terms "climate crisis" and "climate emergency" over "climate change". *The Guardian* also began putting global CO_2 levels in the daily weather forecast in its print publication earlier this year.

Access to fresh water is a major driver of social conflict in developing countries – and as both population and vulnerability to climate change have increased, so has public interest. Water policies have profound impacts on food, land, wildlife and relationships with neighboring countries. At the same time, multinational corporations are seeking new supplies in some of the world's thirstiest places. The relative search volume for *drinking water* doubled over the past decade (45 to 90 from 2009 – 2019), with an average $\tau = 0.64$ (2004 to present).

Over the past decade, compounds in the class known as PFAS have emerged as major water contaminants around the globe. Relative search volume for PFAS was <10 until 2016; but has dramatically increased (81 in 2019). The true risk of the myriad of PFAS chemicals is highly uncertain to humans and wildlife, and only recently have significant efforts been directed towards increasing our understanding (USEPA 2019). Overall, Google Trends seems to be more influenced by media clamor.

Another example of rapidly increasing attention is microplastics, which we now know are pervasive around the globe. Microplastics showed a significant upward trend ($\tau = 0.45$) in search interest from 2004 to present – with most being in the last 5 yr. The environmental threats to aquatic organisms and humans from microplastics have been a common news item. Both the media, advocacy groups and some scientists have clamored over their prevalence and risks to humans and wildlife. Despite the paucity of field data showing impacts to populations and communities (e.g., SAPEA 2018) – a minor component of microplastics (microbeads) have been banned in many countries. There has not been a call for banning the dominant microplastic, fibers, which primarily originate from our

clothes washing. Some well-meaning scientists have perhaps overstated the risks of microplastics by not taking into account environmentally realistic exposure concentrations. The PFAS and microplastic examples are but two that point to a need for better science, more research, and better communication of the science to journalists, the public, and policymakers.

Recently, *Our World in Data* did a comparison of actual causes of death in 2016, share of Google searches, and share of media coverage. They showed dramatic differences between reality and media coverage, with over 33% of news on terrorism (actual deaths <1%) whereas approximately 15% on cancer and heart disease (actual deaths ~60%). Also, what Americans search on Google is a much closer reflection of what kills us than what is presented in the media. One way to think about it is that media outlets may produce content they think readers are most interested in, but is not necessarily reflected in our preferences when we search for information ourselves (Our World in Data 2019). It is well known that risk perceptions are often dominated by our most recent experiences, including what we hear. In a time of limited, even shrinking, research funding - it is critical we focus limited resources on increasing our understanding of the exposures and possible adverse effects from the most important environmental stressors in our rapidly changing world.

Often it appears environmental scientists have little impact on views of the public and policymakers. It is difficult to meet the needs of journalists and media to attract attention and viewers, with complicated issues, particularly if they are politically charged. One success story, however, was the effective communication on the dire consequences of a

declining ozone layer in the 1970s and 80s. The media captured the attention of the public and policymakers using a simple story: There's a hole in the atmosphere's protective layer; Without it the risk of skin cancer greatly increases, and CFCs (chlorofluorocarbons) in aerosols were primarily responsible. The public and policymakers responded, and the ozone is reestablishing.

At the end of April 2019, the *Columbia Journalism Review* and *The Nation* launched "Covering Climate Now", a project aimed at encouraging news organizations to raise their game when it comes to climate coverage. Covering Climate Now goal was to gather all climate stories under one umbrella in the lead up to the United Nations Climate Summit on September 23, 2019. The project included more than 250 outlets worldwide, and dozens of institutional and independent partners, with a combined audience of more than 1 billion people.

So, what is our message? First, big and important environmental problems that hurt humanity and wildlife need a simple storyline, with both short- and long-term solutions so the public and policymakers can respond effectively. Scientists are the critical component of defining the problem, solutions and communicating to the media and policymakers. The media needs a clear story of risks locally, not just in far-away places to people we do not know. Also, our scientific preoccupation with complex models and uncertainty has consequences opposite of our hope. People need solution and these too must include simple, local options and not just country-wide emission goals, carbon taxes and complaining about fossil fuels. Reducing our use of environmental stressors in everyday life may not seem like much compared to China and India's role in climate

change – but it forms the building blocks for bigger change, future policy and our children.

Disclaimer — The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data accessibility — Please contact the corresponding author (ecervi@umich.edu) for any requests for access to data.

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Figure 1. Flowchart outlining the search methods for gathering research articles, news websites, and public interest trend over the years.
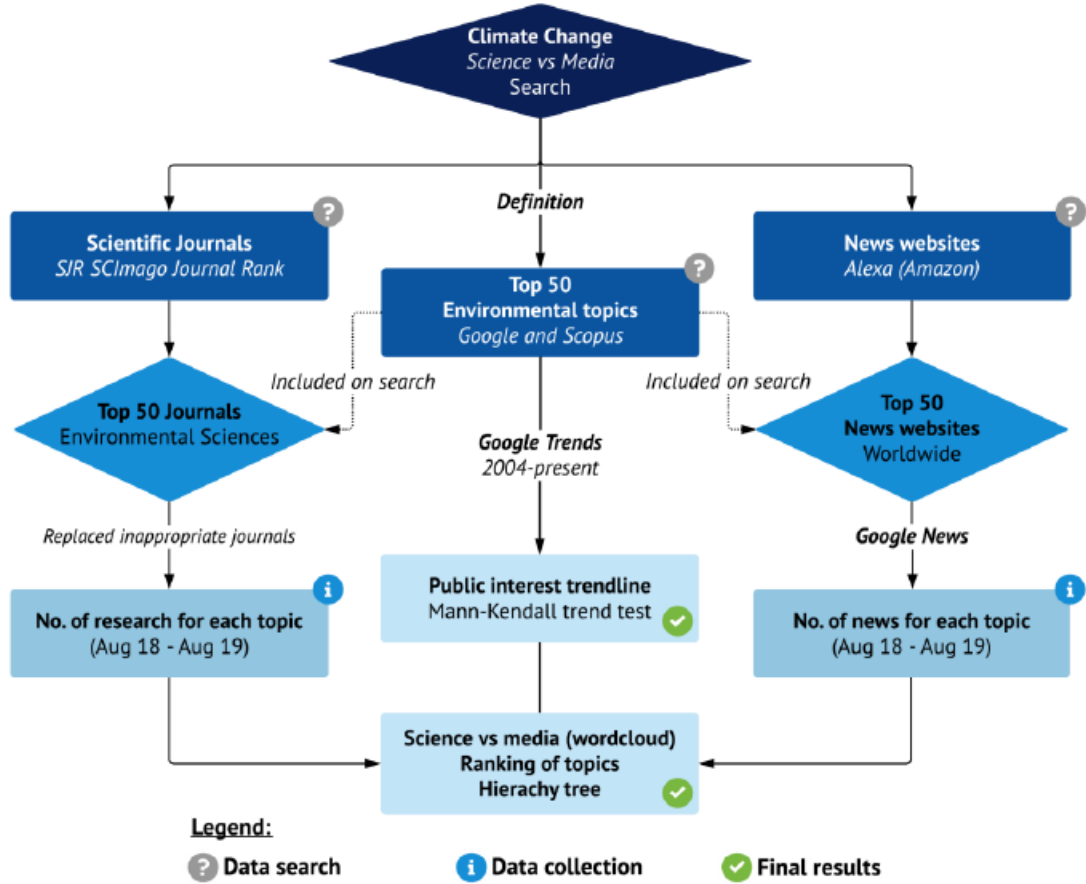
Figure 2. Top 50 environmental topics covered by news websites from August 2018 to August 2019.

Figure 2

Figure 3. Top 50 environmental topics published on top 50 scientific journals from

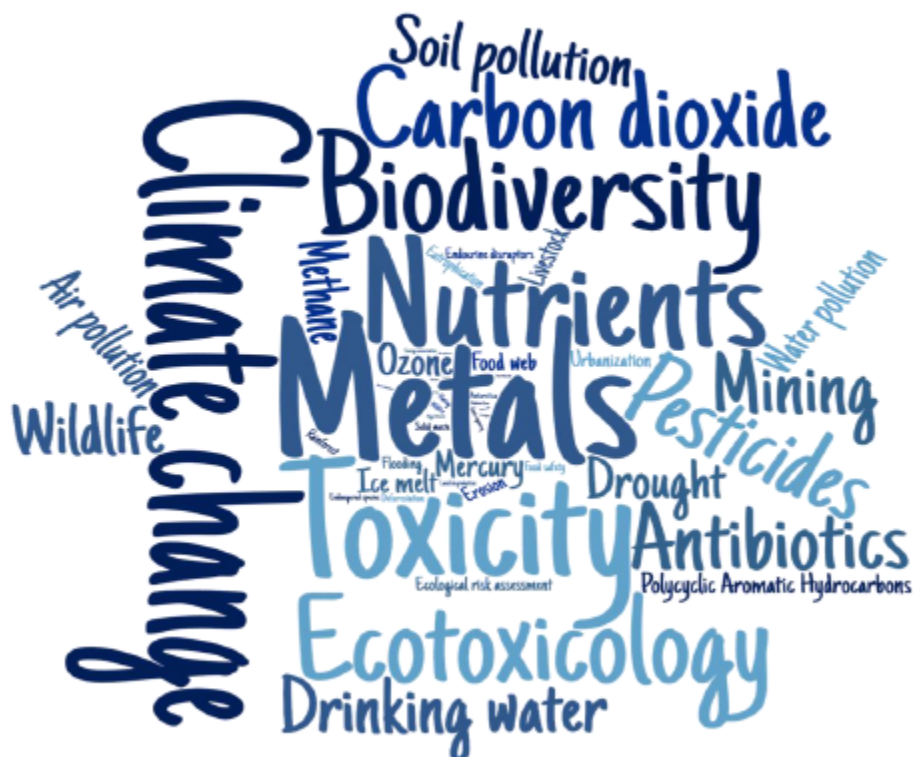August 2018 to August 2019.

Figure 3

Figure 4. Public trends in Google searches of the top 50 environmental topics from 2004 to present.

Figure 4