

THE UNIVERSITY OF CHICAGO

**Knowledge Production for a Healthy Planet:  
The Evolution of Environmental Social Science  
and Environmental Activism**

Mike Clifford Packard

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Faculty Advisor and Preceptor: Sanja Miklin

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## **ABSTRACT**

The state of environmental crises demands increased efforts to shift society away from its current course, which is doing damage to the biosphere at an alarming rate. This research uses computational methods to explore the evolution of environmental activism and environmental social science from 2005 to 2021, as well as the uses of social science in environmental activism and vice versa. Relying on online environmental magazines and academic journal abstracts, the primary methodologies employed are keyword frequencies, LDA topic models, and skip-gram word embedding models. Results show an increasing focus in both communities on climate change, social justice, and community-based solutions. The potential for increasing collaboration between environmental activists and environmental social scientists is discussed.

### **I. INTRODUCTION**

Human activity is causing unfathomable and irreparable harm to the ecosystems and natural landscapes within which we evolved and upon which we depend. Biodiversity loss, disrupted nutrient cycles, plastics pollution, climate change, and land-system change each threaten the ability of the biosphere to continue supporting complex human civilizations (Steffen et al., 2015; Stockholm Resilience Centre, 2022). Researchers have estimated that the current rate of species extinction is at least 1,000 times greater than normal background rates, and the intergovernmental panel on climate change (“IPCC”) has warned that time is rapidly running out on the goal of limiting warming to 1.5 or even 2 degrees Celsius above preindustrial levels (De Vos et al., 2015; UN News, 2021). This is the state of the world as we go about our lives; it continues as we mow our lawns, write our emails, fly our airplanes, and cook our dinners.

As cultures and societies have made sense of these developments in recent decades, two communities have been particularly important in advancing the conversation: scientists and activists. Of course, these are not the only groups talking about climate and the environment. Politicians and industry leaders have also added their voices, but it is fair to characterize these

institutions as at best following the lead of scientists and activists, and at worst, fiercely resisting the ideas those communities brought to the fore. It is now well known that the fossil fuel industry engaged in disinformation campaigns to muddle public opinion and thereby stop any significant environmental regulation in its tracks (Mulvey et al., 2015). Because I am primarily interested in how human groups can and should respond to these issues, this report will focus on the interactions between these two discursive communities that appear to be the most honest and thoughtful about the situation (scientists and activists) and the interactions between them.

The commonly held notion of how these communities interact is unidirectional: scientists discover or produce knowledge, and activists subsequently use that knowledge to shift behavior by informing the wider public and pressuring policymakers. This report will add to a growing body of literature arguing that the true shape of the interaction is bidirectional, involving input and feedback from the activist community in the process of knowledge production itself. Rather than serving as mere messengers for science, activists are vital participants for the functioning of a healthy intellectual ecology. The goal of this research is to produce useful insights into the untapped potential for how these two communities can better support one another as we work toward the shared goal of a healthy, sustainable society. Because the focus is on social change, particular attention is paid to the social sciences. The research questions that this report will seek to answer are listed below, organized into two categories.

### **RQ1. Discursive Evolution**

- **1a:** How has environmental discourse shifted or evolved from 2005 to 2021?
- **1b:** How has social scientific research on environmental issues shifted or evolved from 2005 to 2021?
- **1c:** What similarities or differences stand out between the evolution of environmentalism and the evolution of environmental social science?

### **RQ2. Uses and Attitudes**

- **2a:** How do environmentalists refer to, discuss, or use science in their writings?

- **2b:** How do environmental social scientists refer to, discuss, or draw from activism in their scientific work?

While the methods used to explore these questions are explained in much greater detail in section IV, it is worth noting here that they would not be possible without the advent of modern computational technologies and associated methodologies. Prior to these developments, the analyses in this report would have required close reading of thousands of magazine and journal articles to understand the discursive patterns of these two communities, which would have required many hours of human labor, and likely significant funding. Instead, this work was completed with no funding and only through the efforts of one author. As such, the research and findings in this report owe a debt to the open-source programming languages and the relative ease of access to large-scale computing resources that are available in the modern landscape of social science.

The remainder of this report is organized as follows. Section II will provide background and a literature review, covering research that has examined the relationship between science and activism, and introducing environmental social science. Section III will introduce the data collected and studied. Section IV will describe the methods used to analyze the data. Section V will lay out results and findings. In Section VI, a discussion of the results is presented, along with limitations and directions for future research. Section VII will briefly conclude.

## **II. BACKGROUND**

The choice to focus specifically on social science, rather than on physical science or science in general, stems from the notion that information alone is not enough to produce the societal shift that is necessary. Activists need social scientific knowledge so that they can better strategize how to bring about change, and social scientists need the hard-won wisdom of activists

to inform their knowledge production. The next subsection will describe some relevant work on the relationship between social science and activism.

### **A. Science and Activism**

Some research has documented how environmental activists find scientific knowledge, assess its relevance, and put it into practice. In 2018 Brite Faehnrich explored this question, framing activists as “alternative science communicators,” and conducting a “situational analysis” with in-depth interviews related to Canadian forest preservation. In this context, the primary scientific discipline deemed relevant to the participants was ecology, “in addition to some sociological, ethnographic (e.g., with regard to the First Nations), and economic (e.g., with regard to forestry) resources.” The social sciences are entering the conversation, but only in a minor role. Faehnrich also noted that “the use of science in environmental communication and activism has been addressed rather sparsely” (Faehnrich, 2018). The current research adds to Faehnrich’s work in studying how information moves from science to environmental activism and will broaden the theoretical understanding of this relationships to allow for influence to flow the opposite direction as well.

The concept of ideas moving from activism into social science is not altogether new. In an illuminating piece from 2014, Joan Martinez-Alier and her collaborators documented many specific terms that arose in the environmental justice movement and made their way into academia and policy. Chief among these is the term *environmental justice* itself, which originated among a coalition resisting waste dumping centered in poor and minority neighborhoods in North Carolina in 1982. Other terms the authors document include *food sovereignty*, *land grabbing*, and *ecological debt* (Martinez-Alier et al., 2014). These examples

provide a rich background to this research, and make a strong case for the active inclusion of environmental activists in the production of knowledge on environmental social change.

Another example of mutually beneficial interaction between science and activism, albeit not social science, comes from a study of the AIDS epidemic by Steven Epstein in 1995. Epstein asserted that in this context “[t]he arena of fact making encompasses not just immunologists, virologists, molecular biologists ... it also encompasses a strong and internally differentiated activist movement along with various organs of alternative media, including activist publications and the gay press” (Epstein, 1995, pp. 408–409). This is of course a completely different situation than the environmental movement for many reasons, but one difference noted by Epstein will be useful to highlight. Epstein notes that “most AIDS treatment activists share with doctors and researchers a profound investment in the belief that the truth is, in principle, knowable through some application of the scientific method” (Epstein, 1995, p. 425). In the case of environmental action, it is not clear that there is any ground truth on what actions *should* be taken across contexts. This highlights the difference between physical sciences (like biomedicine, in the case of Epstein’s work) and social sciences, whose findings are always contextual to the culture and society within which the knowledge is generated. For this reason, it is possible that direct activist engagement with the social sciences will be more likely to be seen as political, and perhaps toxic to the independence of the scientific method.

## **B. Environmental Social Science**

The field of environmental social science has gradually grown out of existing fields of social science, and its engagement with activism will be a key piece of the focus in this research. In a 2010 textbook on the subject, Emilio F. Moran describes a list of research priorities for the emerging field:

1. *“Improving the understanding of environmentally significant consumption.*
2. *Improving fundamental understanding of decision making.*
3. *Improved understanding of how social institutions affect resource use.*
4. *Improving the understanding of socioeconomic change as a context for climate change impacts and responses.*
5. *Valuation of biodiversity and ecosystem goods and services.*
6. *Educating a new generation of scientists in integrative sustainability science.”*

On the last of these points, Moran comments that “Scientists working in this integrative area regularly report at academic meetings and in panel reports that our universities are failing to provide the kind of multi-disciplinary training needed to address contemporary environmental problems” (Moran, 2010, pp. 145–148).

Journals associated with environmental social science tend to describe their focus as multidisciplinary and goal oriented. The goal is specified similarly to the motivation I brought to the Introduction of this report: human wellbeing depends on our ability to foster a healthy relationship with the natural environment, and we must aim our scientific efforts at correcting this relationship. Quotes from select journals are displayed below, with key phrases in bold.

- *Ecology & Society*: “The journal seeks papers that are novel, integrative and written in a way that is accessible to a wide audience that includes an **array of disciplines** from the natural sciences, social sciences, and the humanities **concerned with the relationship between society and the life-supporting ecosystems on which human wellbeing ultimately depends**” (*Ecology and Society: Editorial Policies*, n.d.).
- *Ecological Economics*: “Ecological economics is an **interdisciplinary field** defined by a set of concrete problems or challenges related to governing economic activity in a way that **promotes human well-being, sustainability, and justice**. The journal thus emphasizes critical work that draws on and integrates elements of ecological science, economics, and the analysis of values, behaviors, cultural practices, institutional structures, and societal dynamics” (*Ecological Economics - Journal - Elsevier*, n.d.).
- *Environmental Science & Technology*: *ES&T* is an impactful environmental science and technology research journal that aims to be **transformational and direction-setting**, publishing rigorous and robust papers for a **multidisciplinary and diverse audience of scientists, policy makers and the broad environmental community**. . . . The journal advances rigorous scholarship on complex environmental phenomena, particularly with respect to fate, transport, and transformation in natural and engineered systems, while

simultaneously **facilitating the solution of critical environmental problems.**” (*About the Journal*, n.d.).

One might describe these statements as explicitly activist, given that the production of knowledge is aimed at advancing a specific worldview. This report will explore the extent to which this kind of scientific activity has evolved to be more useful for environmental activists, who presumably are interested in the same kinds of outcomes.

### **III. DATA**

To computationally explore the patterns in environmental activism and environmental social science, text data from two distinct sources were collected and analyzed: (1) online archives of environmental magazines, and (2) abstracts of articles published in environmental social science journals. In the remainder of this report, the environmental magazines dataset will be referred to as “EM,” and the environmental social science abstracts dataset will be referred to as “ESSA.” EM represents a novel dataset constructed specifically for this research, with ESSA was queried from an existing database. This section will describe the collection and details of each of these datasets, followed by a description of the text cleaning process that prepared the data for analysis.

#### **A. Environmental Magazines (“EM”)**

Environmental magazines are an appropriate data source for this research for several reasons. First is the availability of the data and its spread across time, which are key requirements to any study seeking to evaluate the temporal evolution of a discourse. The magazines used in these datasets are available online, with free access to their extensive archives. Three of the four stretch back to at least 2005, with the fourth becoming available in 2009.

Second, the length of the articles provides a nuanced look into environmental thinking, more so than an analysis of social media or other potential data sources might. In articles and blog posts (which are often reposted by these magazines), environmentalists have room to expound on issues, argue their positions, and generally explore ideas. The fact that these sites sometimes operate as aggregators from smaller blogs also contributes to the confidence that the final database is representative of the state of U.S. environmentalism across time.

Third, and perhaps most importantly, environmental magazines are important resources created by and for environmental activists. Bill McKibben, the famous climate activist and founder of 350.org, is on the board of one of the magazines included this dataset (*Grist Team*, n.d.). Many of the authors that appear frequently in these magazines are journalists focused on environmental reporting and argumentation; the most frequently appearing authors from each magazine are listed in the appendix (**Figure A-1**), alongside a short web-sourced biography. A brief description of each of the four environmental magazines that were used in this research is included below.

1. **Grist.org** is “a nonprofit, independent media organization dedicated to telling stories of climate solutions and a just future” (*Grist – About Us*, n.d.). Founded in 1999, their online archive stretches back to 2005, and their articles are organized into a long list of topics, including agriculture, economics, cities, food, technology, and transportation, and many others. Grist is funded by donations.
2. **Resilience.org** is a product of the Post Carbon Institute, a nonprofit based in Corvallis, Oregon. The site is self-described as a “community library” that hosts news, think pieces, and articles on “energy, economy, environment, food & water, and society.” From 2004-2012, the site was called “The Energy Bulletin”, and it was more narrowly focused on

topics related to fossil fuel depletion. Resilience.org is also funded by donations (Resilience.org, 2016).

3. **InsideClimateNews.org** was founded in 2007 and describes itself as a “news organization that provides essential reporting and analysis on climate change, energy, and the environment, for the public and for decision makers.” Their topics include “science,” “politics & policy,” “justice,” “fossil fuels,” and “clean energy.” InsideClimateNews is also funded by donations (“About Us,” n.d.).
4. **EMagazine.com** is the only data source included in this study that was once a print magazine. Founded in 1990, they switched to an online-only format in 2013. The magazine’s mission is described as follows: “to provide information about environmental issues and to share ideas and resources so that readers can live more sustainable lives and connect with ongoing efforts for change” (“About,” n.d.). The articles in their archive prior to 2004 are quite sparse. Unlike the other three, EMagazine is funded by advertising and sponsorships (“Advertising & Sponsorships,” n.d.).

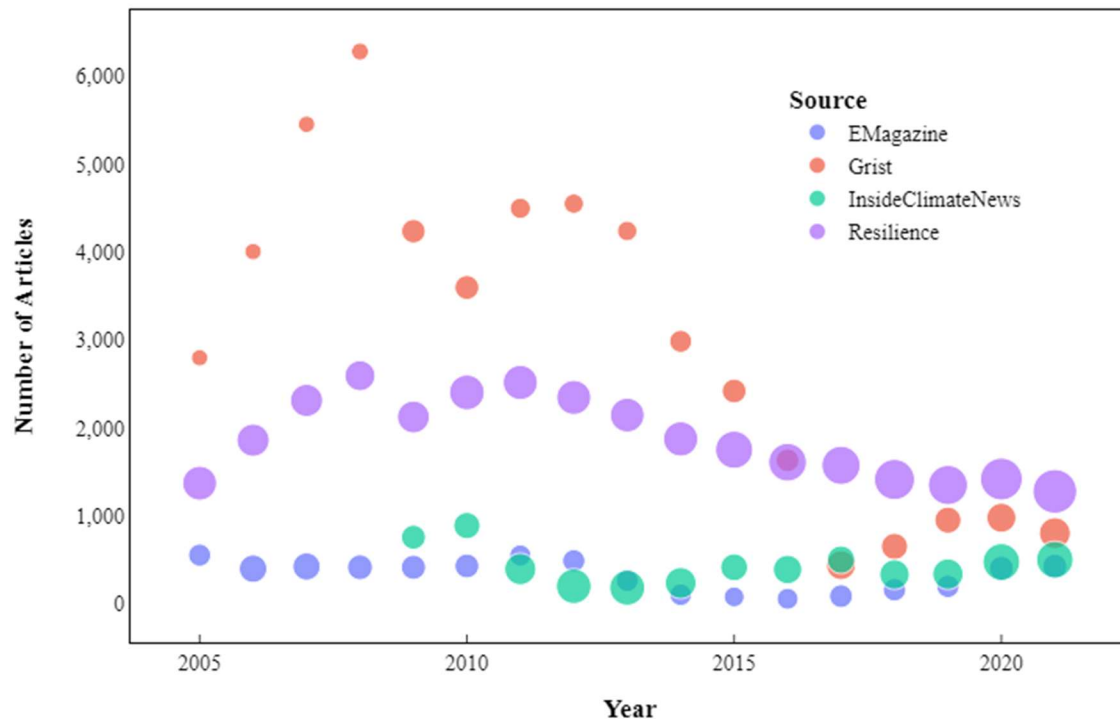
Together, these four sources constitute a diverse and rich environmental discourse. The overwhelming majority of articles on these sites are published in English and are primarily directed toward American or western audiences. Importantly, none of these websites have terms and conditions policies that exclude web scraping as an appropriate use of the site.

Data were collected using hierarchical web scraping in python, primarily using the *requests* and *BeautifulSoup* python packages. The process was set up separately for each site, but generally involves first scraping a high-level page to get links to any specific topic pages, then scraping each topic pages to collect links to individual articles, and finally scraping each individual article to collect data on title, author, date, and text. Because data were sparse prior to

2005, the dataset was limited to the 17-year period from 2005 to 2021. Duplicate articles and articles with fewer than 100 words were dropped, resulting in a corpus of 86,172 articles. Note also that although Resilience.org changed names in 2012 (from EnergyBulletin.org), I refer to it as Resilience.org in the entirety of the data and in all analyses presented in this research.

A summary of the number of articles and the average number of words per article can be seen in **Figure 1**. In the early years, Grist has by far the most articles, but the sheer count comes down later in the dataset. Note also that Resilience.org tends to have longer articles than the other sources.

**Figure 1. EM Articles by Source**  
Sized by Avg. Word Count

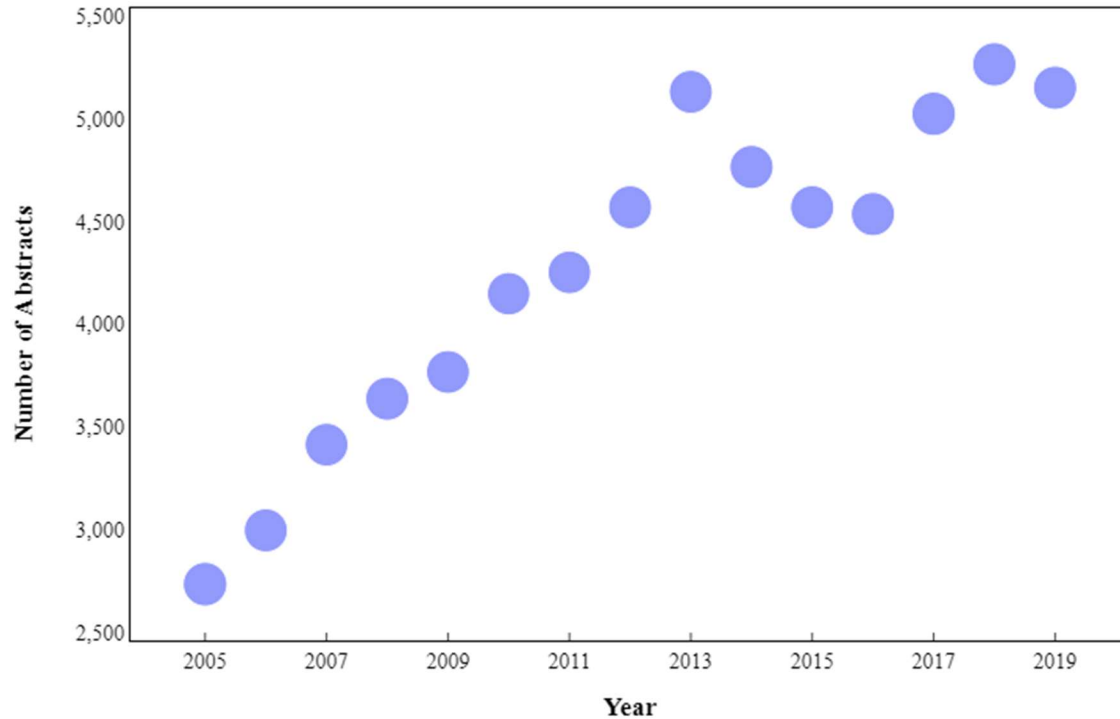


## B. Environmental Social Science Abstracts (“ESSA”)

To explore the evolution of environmental social science (RQ1b) and the attitudes and references toward environmental activists (RQ2b), abstracts were collected from a database of academic publications called *Web of Science*. The *Web of Science* database is hosted by the Knowledge Lab at the University of Chicago (Hart, 2015). A list of 45 environmental social science journals was drawn from Wikipedia, and of these 30 were found in the *Web of Science* database (“List of Environmental Social Science Journals,” 2022). The annual number of abstracts in this dataset is shown in **Figure 2**. As shown, the number of abstracts increases steadily throughout the timeframe, which spans until 2019, after which data are not available in the database. The increasing trend reflects the growth of the field of environmental social science. In total, 63,972 abstracts were included in the database. A full list of the included journals is provided in the appendix as **Figure A-2**.

Abstracts were used primarily because the *Web of Science* database does not contain the full text of the journal articles. One consequence of this is that the EM dataset has a significantly higher average number of words per document than the ESSA dataset. This contributes to the need to plot some metrics on different axes, as will be discussed further in the following section, but overall, the limitation to abstracts is not a debilitating issue. It is reasonable to assume that abstracts should capture the key motivations, methods, results, and discussions that are expounded upon in the full text.

**Figure 2. Annual ESS Abstracts**  
Sized by Avg. Word Count



### C. Text Cleaning

To prepare the EM text data for analysis, several cleaning and processing steps were performed. Several site-specific phrases were removed, including editors' notes appearing mainly in Resilience.org articles ("Ed. note:") and donation requests appearing mainly in Grist.org articles ("Grist thanks its sponsors. Become one."). A series of transformations were then applied, first "tokenizing" the text by splitting into lists of words, removing punctuation and spaces, and transforming to lowercase. A standard list of "stop words" from the *spaCy nlp* python package were removed, along with all numbers (Honnibal et al., 2014/2020). Words were then "lemmatized," also using the *spaCy nlp* package, transforming different word forms into common bases (e.g., "changing" to "change", "temperatures" to "temperature", etc.).

Next, in a process called “n-gram tagging,” common word phrases were replaced with single terms joined by underscores, to be treated as a single concept (e.g., “climate change” to “climate\_change”). N-grams of length two are called “bigrams” and those of length three are called “trigrams.” The process for determining which n-grams to replace was as follows. In a random sample of 20,000 articles, the 100 most commonly occurring bigrams and trigrams were identified. After consideration of whether each set of commonly cooccurring words represented a singular concept, 54 bigrams and 30 trigrams were included in a final list. One example of a common bigram that was not included was “oil gas”, which probably appeared as “oil and gas” or “oil & gas” in the texts. Oil and gas are commonly referenced together, but they are truly separate concepts. Four “quadgrams” were also added to the final list, which were manually generated from pairs of common trigrams that clearly represented the beginning and ending of a common four-word phrase (e.g., “intergovernmental\_panel\_climate” and “panel\_climate\_change” became “intergovernmental\_panel\_climate\_change”). The final list of bigrams, trigrams, and quadgrams is given in the appendix as **Figure A-3**.

The same set of processing steps were applied to the ESSA dataset to prepare the social science abstracts for analysis, and the same list of n-grams was used.

## **IV. METHODS**

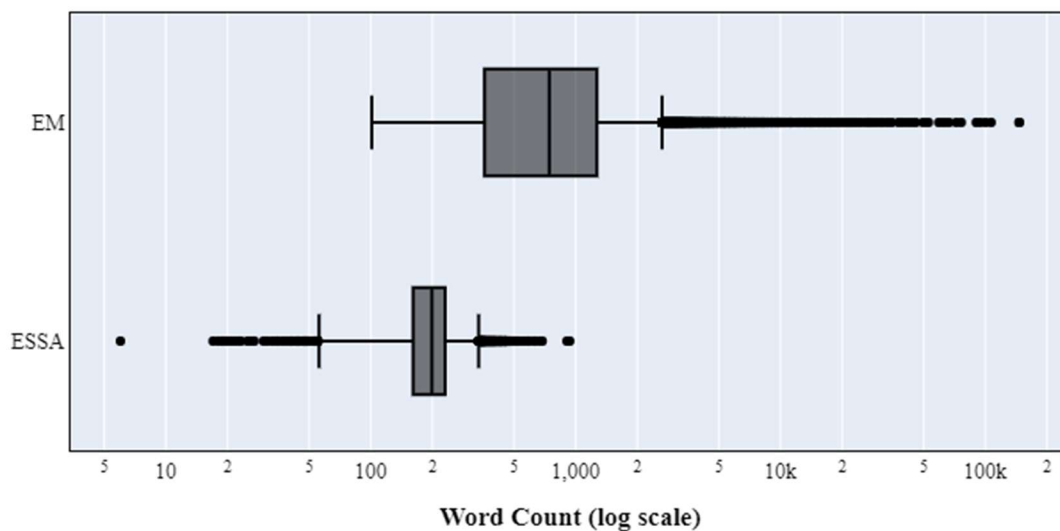
### **A. Keyword Counting**

The first and simplest method employed in this research explores the proportion of documents in either dataset that contain certain words. Examined over time, these “keyword frequencies” offer a first perspective on RQ1, regarding the evolution of environmental activism and environmental social science from 2005 to 2021 (or 2019 in the case of ESSA). In their textbook *Text as Data*, Grimmer, Roberts & Stewart note that this method “can provide evidence

about the evolution of a particular concept or idea” and that “it is clear and easy to communicate” (Grimmer et al., 2022, p. 178). The process for performing this analysis was to generate a group of keywords based on a rough hypothesis of the directions these two communities might be moving. For each keyword, a time-series plot was generated.

As alluded to earlier, it is important to recognize that abstracts, by their nature, contain fewer words than most of the articles in the EM dataset. This is shown empirically in **Figure 3**, below, which is a boxplot with a logarithmic scale on the x-axis. Shorter documents inherently have less room for more unique words, so the proportions of documents containing a given keyword are likely to be lower in the ESSA dataset than the EM dataset. To handle this, and to highlight that the primary interest is in the trends over time rather than the absolute values, the keyword frequency metrics from each dataset are plotted on separate y-axes. These plots can be found in the results section in **Figure 4**, and additional keywords are plotted in the appendix in **Figure A-4**.

**Figure 3. Distribution of Word Counts**



For a more comprehensive look at trends in term frequencies across the two datasets, the ordinary least squares (“OLS”) slope coefficients were computed for all words appearing at least 300 times in each dataset. In **Figure 5**, a scatterplot displaying these coefficients on the x- and y-axes reveals which terms are trending which direction in which dataset, without relying on a predetermined set of keywords.

## **B. Word Co-occurrence**

A slightly more sophisticated approach looks at not only whether certain words appear in each document, but rather at the pairs of words that tend to appear in close proximity. This is the first strategy used to assess RQ2, dealing with how each discursive community refers to and views the other. Specifically, in the EM dataset, words that occur in sentences that also mention “research,” “science,” “scientific,” or “scientist” are counted and ranked. For the sake of clear visualization, this is done in two-year bins, covering 2005-06, 2007-08, and so on. The same process is undertaken in the ESSA dataset, but instead of using science-related terms, terms related to activism are used “activism,” “activist,” “environmentalism,” “environmentalist.” The patterns that emerge reveal distinct shifts in the ways these two communities may interact and serve as a guide for where to dig deeper into specific patterns in word use.

## **C. Topic Modeling**

Moving to more complex computational methods of analyzing text, topic models are a powerful tool for studying the underlying themes that give structure to a discourse. The most common form of topic modeling is called latent Dirichlet Allocation (“LDA”) and was developed for use in analyzing text by David Blei (Blei, 2003, 2012). LDA takes a predetermined number of topics and stochastically updates topic-document and topic-word

distributions to minimize within-topic variance and maximize between-topic variance. One interpretation of what LDA topic models return is which themes contributed to the creation each of document, and in what proportions. In this research, topic models are implemented on both the EM and ESSA datasets using the *gensim* python package.

One additional text-cleaning step is required to improve the performance these models: exclusion of all words that appear in fewer than three or more than 50% of the documents in the given corpus. This step allows the model to focus on words that are neither overly common nor exceedingly rare, and it improves the interpretability of the topics significantly.

In each dataset, determination of the appropriate number of topics followed a trial-and-error process. Models were trained with various values of this parameter, and the resulting top words in each topic and top documents in each topic were examined for distinctiveness and clarity. I settled on nine and seven topics in the EM and ESSA datasets respectively, finding that these choices produced topics that were easiest to interpret as distinct themes. A *PyLDAvis* visualization is included in the appendix for each of these models, which shows the size and distribution of each topic on the axes on the first two principle components analysis (PCA) dimensions. These visualizations are interactive when generated in a Jupyter Notebook, and can be helpful in understanding distinctiveness of words and relationships between topics (*PyLDAvis — PyLDAvis 2.1.2 Documentation*, n.d.).

With the topic models trained, the results are useful to this research in multiple ways. First, in answering RQ1, the document-topic loadings can be averaged within years and plotted to show which themes become increasingly or decreasingly important to the discourse over time. **Figure 7** displays these trends and will be discussed in the following section. Second, for RQ2, subsets of documents can be isolated based on mentions of specific keywords, and their topic

distributions can be analyzed to detect any significant differences. In the EM dataset, this strategy is adopted for articles mentioning social science terms versus those mentioning physical science terms. This analysis adds clarity to the question of how environmental activists use or refer to different kinds of scientific work. A similar strategy is undertaken in the ESSA dataset, using subsets that mention activism or environmentalism vs. those that mention policy or government.

#### **D. Word Embeddings**

The fourth and final computational method that will be useful in analyzing these data is word embeddings. Word embeddings are a method by which unique words are encoded in a high-dimensional vector space, such that they can then be compared quantitatively. There are many embedding methods available, and the most recent developments in the field are immense in their complexity and impressive in their performance on difficult tasks like language generation (Grimmer et al., 2022; Hamilton et al., 2018; Jiao & Zhang, 2021). For this research, a method that is relatively simple and computationally inexpensive will suffice: the skip-gram with negative sampling (“SGNS”) method. This method was developed by a team at Google in 2013 and operates by optimizing a neural network on a word-prediction task that takes the “target word” as given and predicts the “context words” that are likely to appear within a fixed proximity (Mikolov et al., 2013). This is an appropriate method in this context because it will serve the primary function required, which is to encode word co-occurrence patterns in such a way that generates reasonable similarity scores for similar words. Also, as mentioned, the resulting word vectors are not so large as to be computationally taxing to explore and manipulate: the default, maintained in this analysis, is 100-dimensional word vectors.

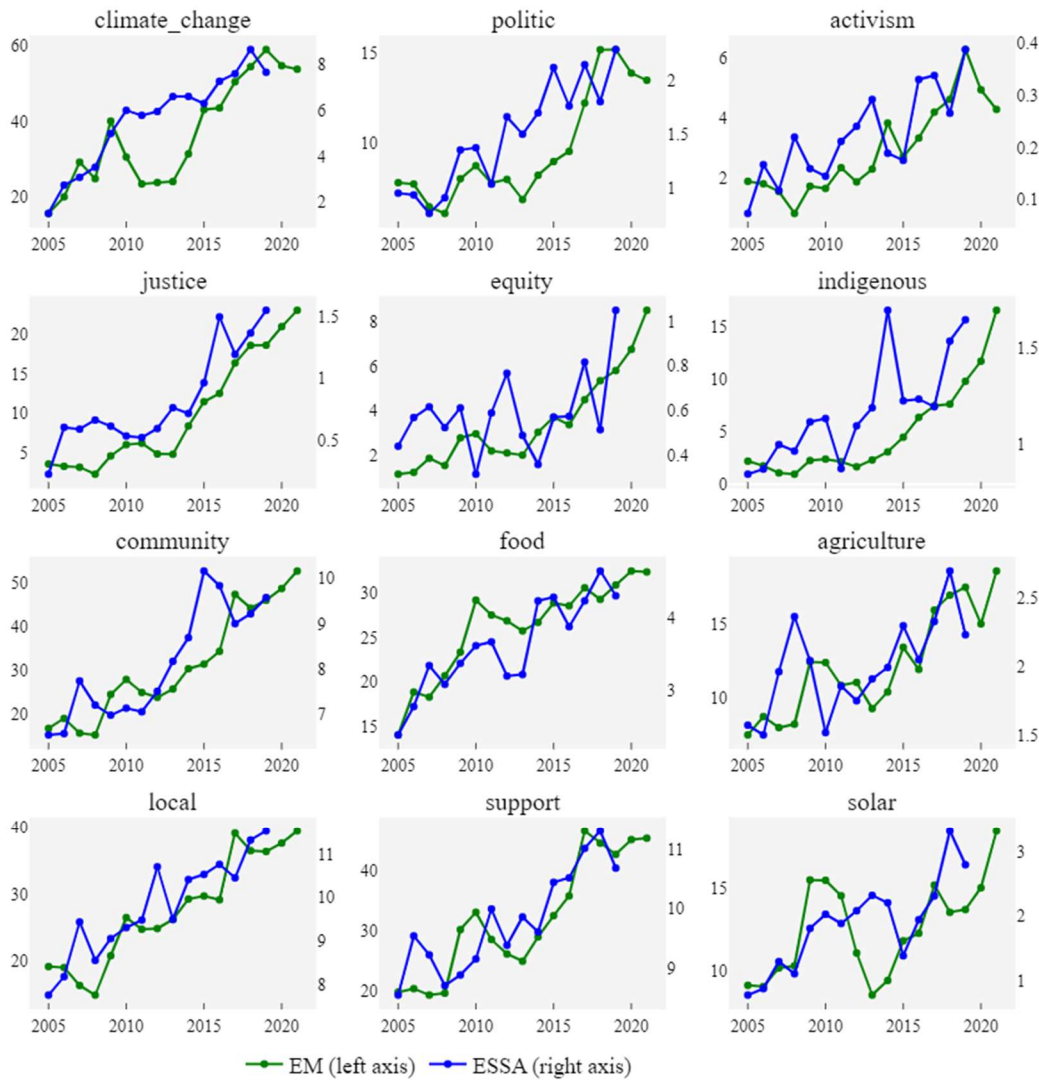
With words encoded as vectors, one can explore how similar or different certain words are to one another, typically using a metric like cosine distance. In this analysis, a new dimension is generated spanning from the centroid of the vectors for “sustainable” and “sustainability” to those for “unsustainable” and “unsustainability.” With this dimension established in the vector space, it is possible to project other vectors onto that dimension to answer the question: “how sustainable is X according to the author of this corpus?” This strategy is taken using skip-gram models trained separately on the EM and ESSA datasets, and words related to social science and activism are tested in each. The results shed light on RQ2 and can be found in **Figure 12** in the next section, alongside a description of their implications.

## V. RESULTS

As introduced in RQ1, and as mentioned in the previous section, one of the primary goals of this research has been to capture changes in environmental activist discourse and environmental social science in the 21<sup>st</sup> century. While many changes can be detected, the most important appears to be that **both groups are increasingly focused on climate change, social change, and community-level action.**

Multiple analyses point toward this result. First, the keyword frequencies plots, displayed in **Figure 4**, clearly show increasing trends in both datasets in the percentage of documents mentioning “climate\_change,” “politic,” “justice,” “equity,” “community”, and “local”, among others. As mentioned previously, it is important to keep in mind the different y-axes when interpreting these plots. For example, “climate\_change” follows a similar upward trend in each dataset, but peaks at being mentioned in around 60% of magazine articles and around 9% of journal abstracts.

**Figure 4. Annual Percentage of Documents Containing Keywords**



Other terms on upward trajectories in **Figure 4** include “indigenous,” “food,” and “local.” These represent important developments that coincide with and reinforce the major result stated above. Respect for indigenous wisdom and social organization is increasingly seen as key to addressing the environmental issues (*How Indigenous Knowledge Can Help Prevent Environmental Crises*, 2021; Kimmerer, 2013; Nicholas, 2018; Yunkaporta, 2020). Food and the

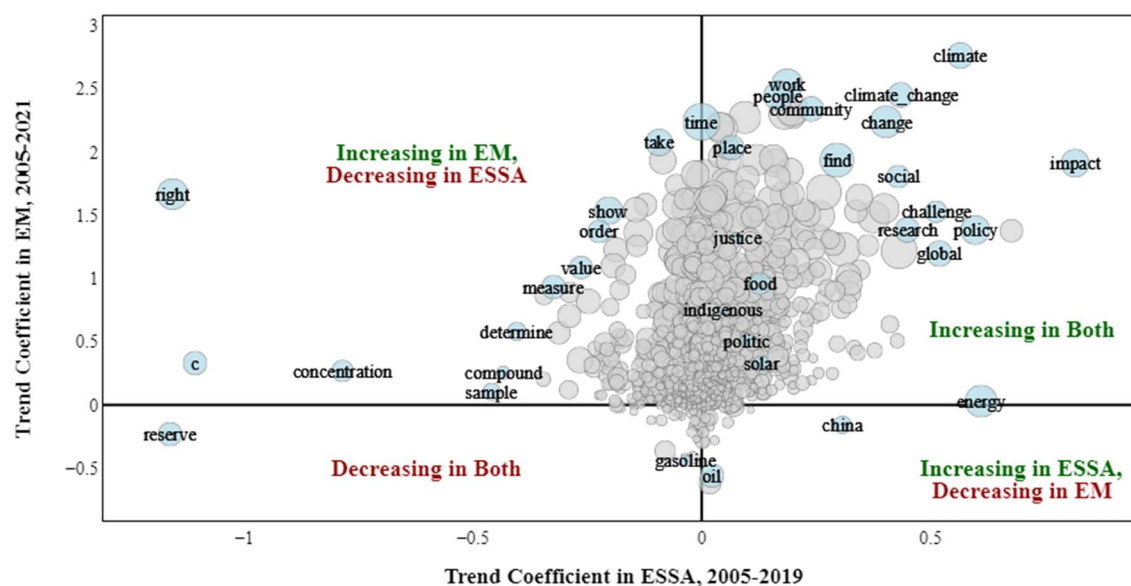
agricultural system is important topic tied to social change and community action, which sometimes takes the form of community gardens and food forests (Aptekar & Myers, 2020). Localism relates in many ways to all these subjects, but perhaps more poignantly in its opposition to economic globalization, which is seen by some as a fundamentally unsustainable trend (Newton, 2013).

Because the choice of keywords in **Figure 4** was at least partially subjective, **Figure 5** takes a more comprehensive look at trends in the same metric: the annual percentage of documents mentioning keywords. The difference is that **Figure 5** considers all words mentioned at least 300 times in each dataset, and plots them according to their OLS coefficients. Words that exhibit strongly positive or negative trajectories are highlighted.

At the level of specific words, **Figure 5** points toward some of the same results that **Figure 4** highlight. Namely, “climate\_change”, “community,” “food,” “social,” and “justice” all fall in the top right quadrant, indicated that their frequencies are increasing in both datasets. The word “policy” is also increasing in both datasets, suggesting that both groups are increasingly interested in government action. The only other quadrant with a significant number of words is the top left, where terms are increasing EM but decreasing in ESSA. Interestingly, we find words like “measure” and “value,” possibly suggesting that while environmental social scientists may be moving toward more-heavily qualitative as opposed to quantitative studies, environmental activists are increasingly interested in quantifying their efforts and impacts. “Oil” and “gasoline” are decreasing in EM and staying relatively constant in ESSA, while “energy” is increasing in ESSA but staying constant in EM. Taken together, these trends reveal that while both communities may be increasingly focusing on certain topics, they are coming to it from different directions: environmental social scientists from quantitative studies “measuring”

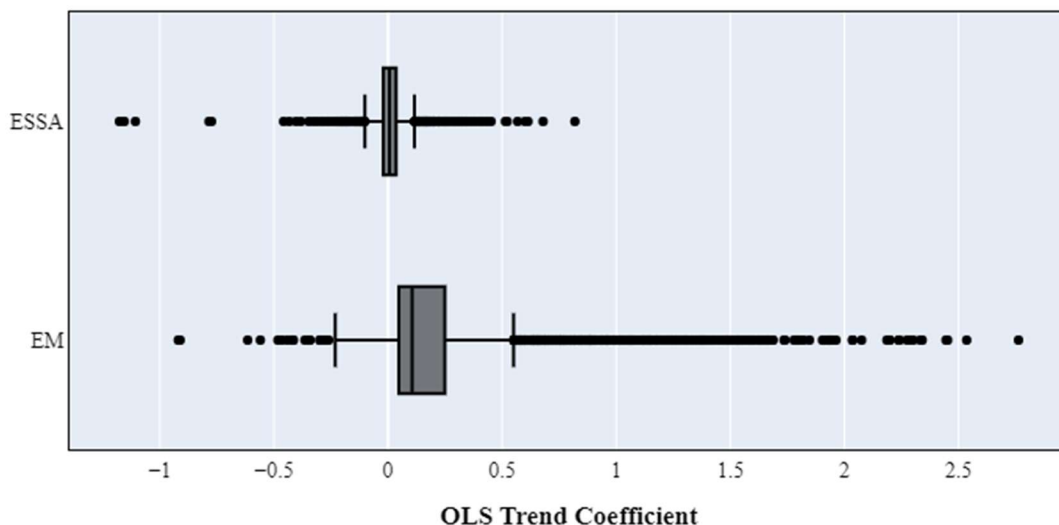
“concentrations” of likely toxic chemicals and pollutants, and environmental activists from a focus on fossil fuel depletion (“gas” and “oil”).

**Figure 5. Trajectories of Terms in EM and ESSA**



At a broader level, the shape displayed in **Figure 5** is puzzling. Why do the environmental magazines have so few words with negative trajectories? Is it possible that they simply do not prune their language as diligently as the social scientists? Part of the answer is that **Figure 5** can only show words occurring repeatedly in both datasets, so some words with negative trends are excluded because they do not appear enough in ESSA. However, **Figure 6** below shows that this is not the fully story, showing boxplot distributions of coefficients for all words with at least 300 uses in the given dataset, regardless of use in the other dataset. The EM coefficients are clearly skewed positive, while the ESSA coefficients are nicely balanced around zero. This may be an area for future research.

**Figure 6. Distribution of Term Appearance Trajectories (OLS)**



For a final perspective on RQ1 and the evolution of environmental activism and environmental social science, topic modeling can provide useful insight. As mentioned in the previous section, a manual iterative process led to the selection of nine topics in the EM dataset and seven in the ESSA dataset. The top-10 words in each topic, as well the titles of five documents most associated with each topic, can be found in the appendix, **Figures A-5** through **A-8**. Below are the topic labels that were manually assigned based on those top words and top documents.

**EM:** *Climate Change, Community, Economy, Food, Fossil Fuels, Knowledge, Politics, Renewables, and Urbanism*

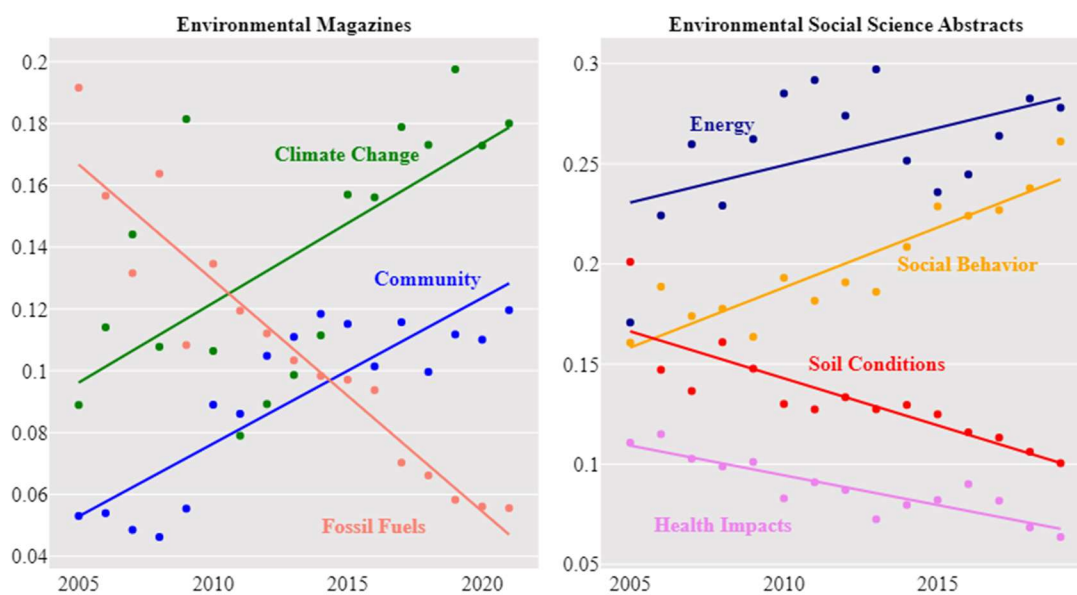
**ESSA:** *Airborne Pollution, Chemical Exposure, Energy, Health Impacts, Hydrological Modeling, Social Behavior, and Soil Conditions*

The topic models produce document-topic loadings, which sum to one for each document and represent the share of that document that is estimated to have been generated by each topic. For example, an EM article with high loadings for *Renewables* and *Politics* would be very likely deal with those two topics. In fact, a search across the dataset for articles that meet this criterion

turned up a Grist article from 2007 titled “Sen. Domenici tried again to boost loan guarantees for nuclear power plants.”

One way to use topic models to assess change over time is to aggregate the average topic loadings across all documents annually. This is what is done in **Figure 7**, separately for the EM and ESSA datasets. Note that to keep these charts readable, only topics exhibiting a significant positive or negative trend are included. As shown, the environmental magazines are moving away from coverage of fossil fuels and toward coverage of climate change and community. Environmental social science is moving away from hydrological modeling and chemical exposure, and toward energy and social behavior. The upward trends in community (EM) and social behavior (ESSA) exhibit the increasing alignment of activists and social scientists in the space of environmental knowledge production.

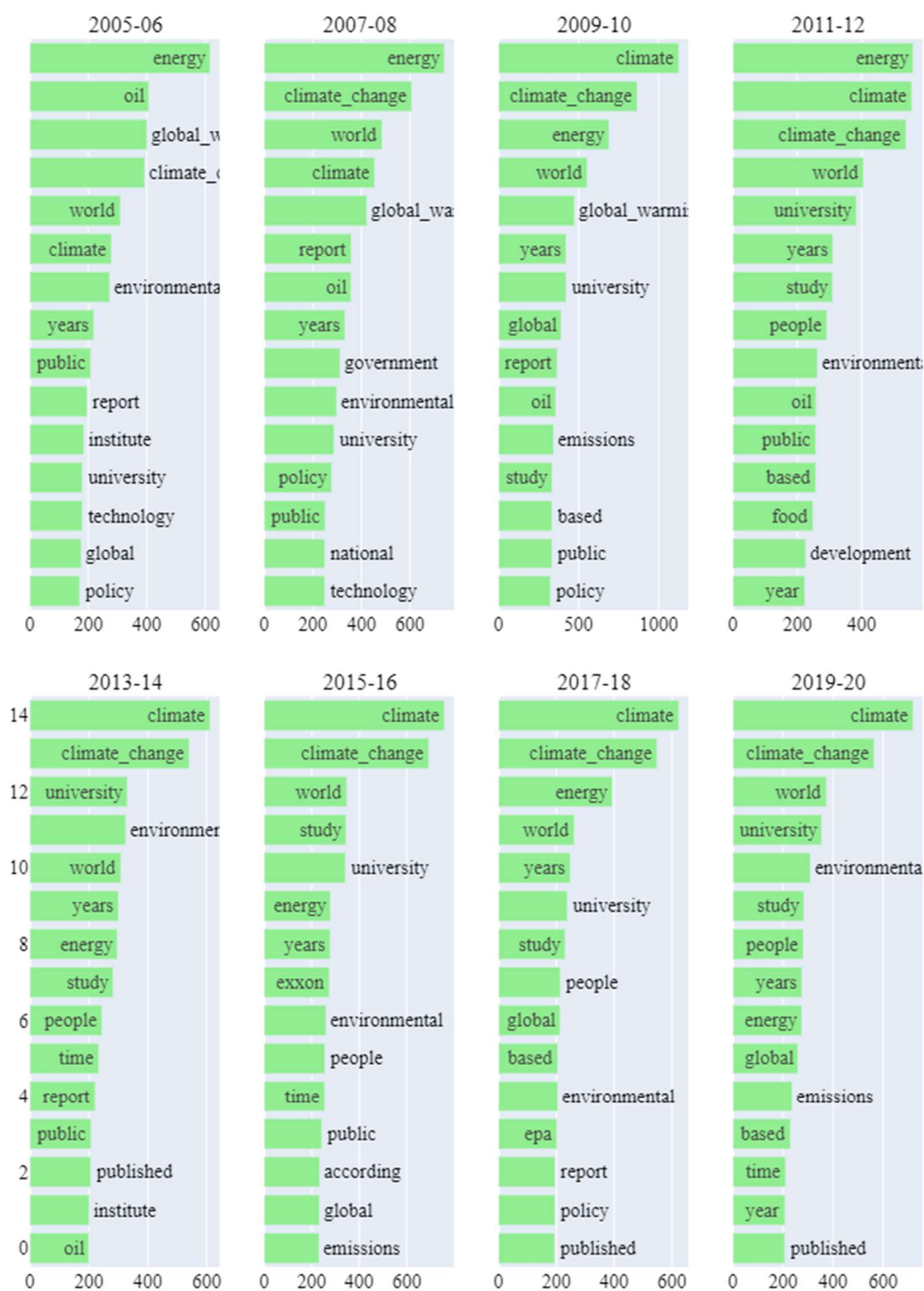
**Figure 7. Average Annual Document-Topic Loadings**



A separate goal of this research, apart from characterizing the evolution of environmental activism and environmental social science (RQ1), is to explore the ways these two communities refer to and rely on one another (RQ2). The first major finding is that **the most common references to research or science by environmental activists are related to energy and climate change**, with the former losing ground to the latter over the course of the timeframe considered. This trend is observed in **Figure 8**, which plots the most common words appearing in sentences with “research,” “science,” “scientist,” or “scientific.” Words related to energy appear at the top of the lists in the earlier time periods but give way to climate change related words after 2007-08.

Because Resilience.org had been The Energy Bulletin until 2012, the same analysis was performed with all articles from that source excluded, to determine whether the noticed pattern was entirely driven by this rebranding. The pattern persists, albeit less starkly. The figure resulting from that sensitivity analysis can be found in the appendix, as **Figure A-8**. In addition, a corresponding analysis was performed with the ESSA dataset, looking at words that co-occur with “activism,” “activist,” “environmentalism,” and “environmentalist,” but no strong patterns emerged that warranted significant discussion. The figure from this analysis can also be found in the appendix, as **Figure A-9**.

**Figure 8. Words Co-occurring with Science in EM**



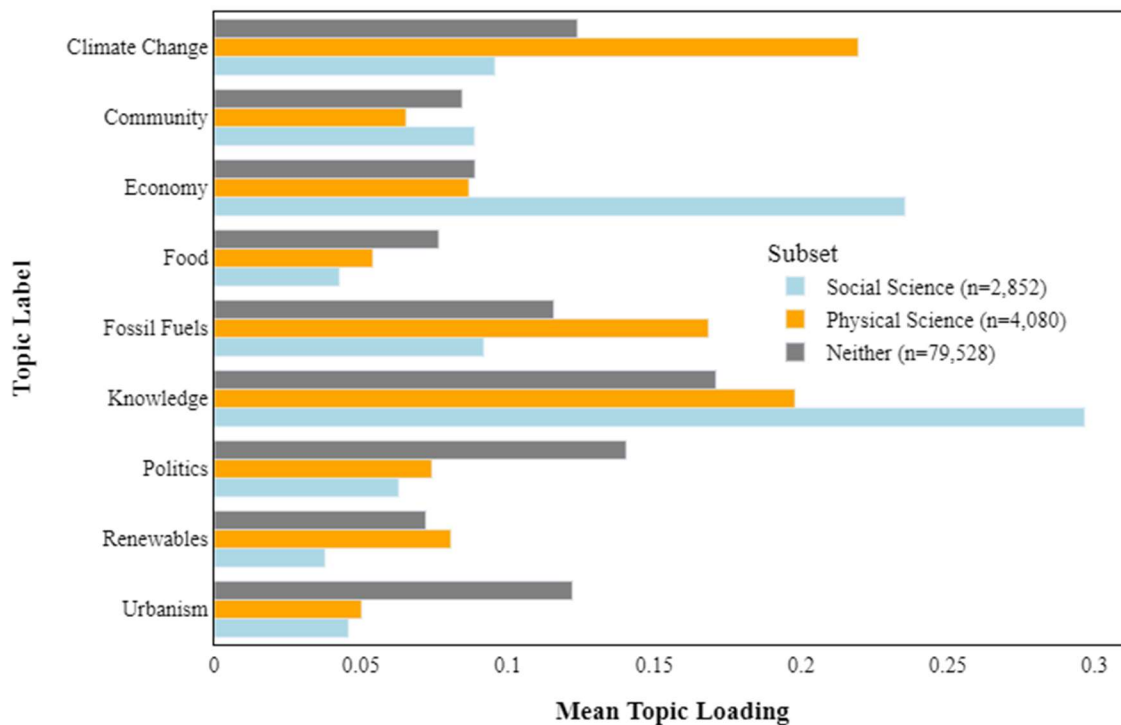
For another perspective on how environmental scientists and environmental activists refer to one another, the LDA topic models discussed earlier can be recycled. The method involves two steps: (1) identify subsets of each dataset that are relevant to the research question, and (2) compare patterns in the document-topic loadings between those subsets. To begin with the EM dataset, relevant subsets are those articles that refer to social science versus physical science. This is a useful distinction because the focus of this research project is environmental social science, and the previous analysis used very general words referring to any science or research. Detecting patterns between how environmentalists refer to social vs. physical science will offer clues for how social scientists can better engage with and support this community.

To create subsets looking at physical vs. social science, keyword lists were generated. Any article mentioning one or more of the keywords shown below was categorized into the corresponding subset. There were a small number of articles (338) that were thus included in both subsets.

**Social science:** *anthropology, economics, political science, psychology, social science, sociology.*

**Physical science:** *atmospheric science, chemistry, climate science, earth science, geology, meteorology, physics, physical science.*

The results are shown in **Figure 10**, below. As perhaps would be expected, the authors of EM articles refer to physical science more than social science when discussing climate change, fossil fuels, and renewables. On the other hand, there is a clear tendency for articles mentioning social science to be discussing the economy, community, and the “knowledge” topic.

**Figure 10. EM Subset Topic Loadings**

The “knowledge” topic is admittedly the least descriptive and most vague label, so it will be useful here to add some description of the kinds of concepts that fall into this topic. The top words are *think, know, thing, way, go, way, world, right*, but the real key to understanding this topic is not the words, but the articles. Among the articles that the model says were generated nearly exclusively from this topic are: a philosophical argument about human nature, a post about the difference in style and effort needed between writing blogs posts and writing fiction, a review of a book that outlines appropriate Christian responses to impending environmental and civilizational collapse, a how-to guide for science communication, and a musing on the importance of narrative in the construction of reality.<sup>2</sup> This may sound like a jumble, but all these

<sup>2</sup> Titles, dates, authors, and links for these examples can be found in the appendix, **Figure A-11**.

have in common a reflective sense of thinking about how we make sense of ourselves and our situation. Perhaps it would have been more helpful to label it the “epistemology” topic.

The fact that social science is referenced in work dealing not only with very tangible concepts like economy and community, but also in those that dig into the deep, philosophical questions, should be a promising sign for the potential of environmental social science. Both practical and theoretical social scientific work can have synergies with environmental activism.

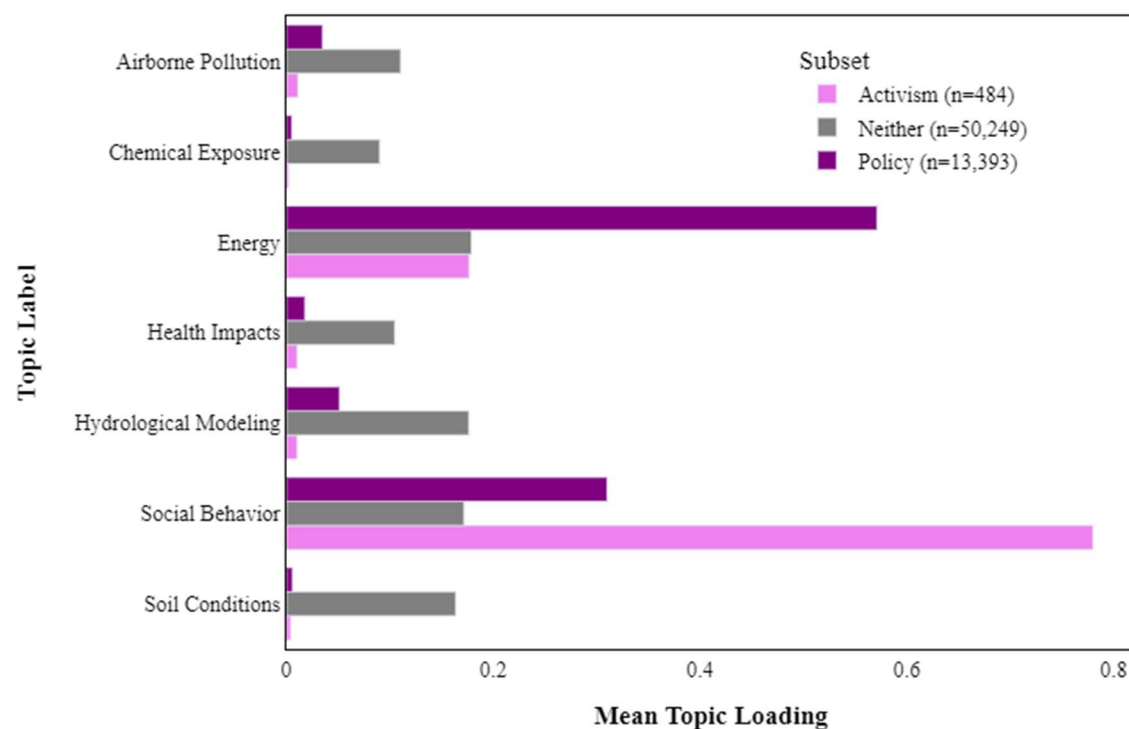
In the ESSA dataset, subsets were determined based on whether the abstracts mentioned words related to activism or government policy. This is a useful distinction for RQ2b, because the patterns with which environmental social scientists refer to activism can be better analyzed in opposition to a different group. Policymakers, like activists, can serve many roles to social scientists; they can be the subjects of inquiry, the intended audience, or the inspiration for the research. Keywords identifying these subsets are listed below, followed by the figure.

- **Activism:** *Activism, activist, environmentalism, environmentalist*
- **Policy:** *Policy, policymaker, government*

A couple of notable insights can be gleaned from **Figure 11**. First, abstracts that refer to either activism or policy do not tend to be the same abstracts that deal with airborne pollution, chemical exposure, health impacts, hydrological modeling, or soil conditions. This leaves the social behavior topic and the energy topic, both of which are likely to have high document-topic loadings given that the abstract mentions either activism or policy. Activism is more related to social behavior, and policy is more related to energy. This suggests that environmental social scientists who are working on topics that are commonly associated with generic social science (i.e., social behavior) recognize that their work has a potential audience in the activist community. Given that the social behavior topic has been expanding (see **Figure 7**), perhaps the

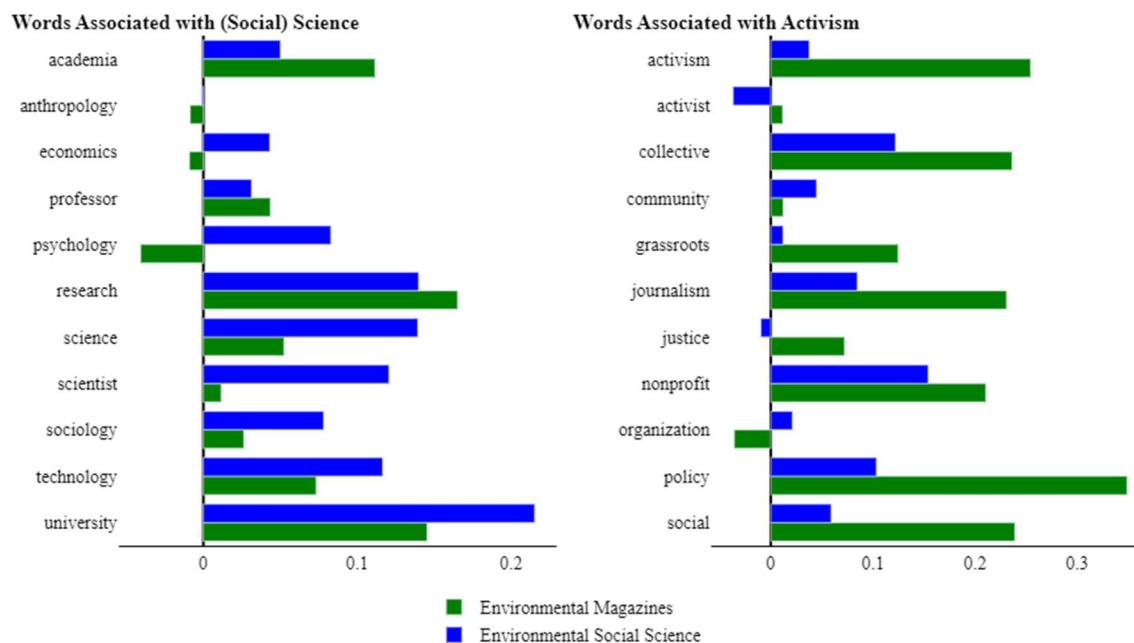
opportunities for mutually beneficial interaction between the two communities studied in this research could expand as well.

**Figure 11. ESSA Subset Topic Loadings**



The final approach to RQ2 uses word embeddings. As described in the Methods section, a skip-gram word2vec model is implemented separately on each dataset, encoding each word as a 100-dimensional vector. Within each model, a dimension is calculated spanning between the vectors representing *sustainable/sustainability* and *unsustainable/unsustainability*, and vectors representing various words are projected onto that dimension. If the projection falls closer to the “sustainable” side, it is an indication that the discursive community considers that word to be more sustainable than not. The results of this analysis are displayed in **Figure 12**, below. The x-axis runs from unsustainable (-1) to sustainable (+1).

**Figure 12. Word Embedding Projections onto Sustainability Axis**



The first result to notice is that the EM projections are more favorable to activism-related words than the ESSA dataset, and the opposite is true for science-related words. Said differently, each community thinks its own activities are more valuable for sustainability. If this result can be trusted, it reflects a certain hubris held by each community, which may prevent stifle productive collaboration. Another interesting finding reflected in **Figure 12** is that more general or conceptual terms tend to be seen as more sustainable by the alternative community than more specific or practical terms. For example, the EM dataset views *research*, *university*, and *academia* as more sustainable than specific social science disciplines (*sociology*, *economics*, and *anthropology*) and individuals (*professor*, *scientist*). Likewise, the ESSA dataset views *activism* as more sustainable than *activist*. It is possible that this reflects a general openness to the idea of the other community, but an inexperience with direct collaboration or interaction with specific individuals.

## VI. DISCUSSION

This research has considered two primary questions. The first deals with the evolution of environmental activism and environmental social science in recent years. As we have seen, environmental activism has sharpened its focus on climate change, community-building, and social justice, paying somewhat less attention to fossil fuel depletion. Environmental social scientists have increased their efforts in studying social behavior, expanding beyond studies of chemical exposure and health impacts of pollution. These trends should be complementary and mutually reinforcing, as environmentalists gain knowledge about what works for sustainable social change, and social scientists gain access to an important and fascinating set of social dynamics that should provide fertile ground for research.

There are a few examples of this kind of mutually beneficial interaction between science and activism, the likes of which this research is intended to bolster. One comes from Elinor Ostrom, the first woman to win the Nobel Prize in Economics. Ostrom's work bucked existing economic theory regarding the "tragedy of the commons" and empirically developed eight principles for effectively managing common resources. Her research relied on hundreds of case studies with actual community groups around the world, and the scientific knowledge she produced in this effort continues to be extremely useful for environmentalists (Nordman, 2021; Ostrom, 1990, 2009).

Another example of beneficial collaboration between activists and scientists comes Richard Heinberg, the activist, author, and Senior Fellow at Post Carbon Institute, who in 2016 published a book on renewable energy coauthored with David Fridley, a staff scientist who studies energy policy at Lawrence Berkeley National Laboratory. The book, *Our Renewable Future*, can be held as an example of the kind of work that is possible when activists and social

scientists collaborate, and it has been a useful tool for environmentalists seeking to understand the energy predicament (Heinberg & Fridley, 2016).

While offering novel analysis and insights, this research does suffer from some limitations, and examining these can point toward directions for future work. First, it is difficult to assess the representativeness of the sample of environmental magazines for capturing the relevant discussions in the environmental movement over time. It is possible that these sources have increased in importance as activism integrates more fully with online community building through recent years. Other forums that could be investigated would include social media, which would have the advantage of capturing direct conversation and debate within the environmental movement, albeit with less nuance than is found in the dataset used in this study. Moving the opposite direction, toward more detail and more nuance, future research could computationally explore books and book reviews in the environmental space.

A second limitation has to do with the methods used. Given that topic modeling relies on the selection of an appropriate number of topics and the subsequent labeling of those topics, it would be beneficial to discuss these manual decisions with a team of thoughtful researchers, and to explore the implications of alternative choices more fully. The results from the word embedding method employed, while interesting, entirely rely on word co-occurrence patterns to establish attitudes. The insights should be validated, perhaps through interviews or surveys that measure attitudes towards the perceived contributions to sustainability of different communities.

## VII. CONCLUSION

When learning about environmental issues, one often stands in fearful awe of not only the scale of human domination over nature, but also by the inertia of human systems. Our inability to pull back, to avoid doing irreparable harm, is at times hard to understand. Understanding our social systems and how to change them will be key to mitigating the cascading environmental crises of the 21<sup>st</sup> century. This is the research project taken on by the growing field of environmental social science, and it coincides directly with knowledge that has evolved naturally in the environmental activist community over the last several decades. Increased collaboration between these two communities will be necessary to accelerate the pace of the transition to sustainability.

This research project has attempted to show, using computational analysis of text data, that the space for potential collaboration is already large and continues to grow, as environmental social science and environmental activism converge on issues like climate change, social justice, and community-based solutions. I can only hope that this work contributes in a small way to the swelling wave of knowledge produced with sustainability and healthy societies in mind.

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## APPENDIX

**Figure A-1. Common Authors in EM Dataset**

<b>Author</b>	<b>Most Common Publication</b>	<b>Number of Articles</b>	<b>Description</b>
<b>Roddy Scheer</b>	EMagazine	574	Journalist and photographer specializing in environmental issues. ( <a href="https://roddyscheer.com/about-roddy-scheer/">https://roddyscheer.com/about-roddy-scheer/</a> )
<b>Brita Belli</b>	EMagazine	191	Author of <u><a href="https://emagazine.com/author/bbelli/">The Autism Puzzle: Connecting the Dots Between Environmental Toxins and Rising Autism Rates</a></u> ( <a href="https://emagazine.com/author/bbelli/">https://emagazine.com/author/bbelli/</a> )
<b>Doug Moss</b>	EMagazine	130	Founding Editor/Publisher, E/The Environmental Magazine & its syndicated column, EarthTalk. Owner, Douglas Forms & Printing. Musician/Composer & Activist ( <a href="https://twitter.com/doug111352?lang=en">https://twitter.com/doug111352?lang=en</a> )
<b>Lindsey Blomberg</b>	EMagazine	114	Description not available.
<b>Jim Motavalli</b>	EMagazine	31	Jim Motavalli is passionate about the environment, cars, and music. He is a regular contributor to <i>The New York Times</i> , <i>Barron's</i> , <i>New York City Jazz Record</i> , Environmental Defense Fund's <i>Solutions</i> , MediaVillage and Wharton School reports. ( <a href="https://www.jimmotavalli.com/">https://www.jimmotavalli.com/</a> )
<b>David Roberts</b>	Grist	3,114	I run a newsletter called Volts, about clean energy & politics. ( <a href="https://twitter.com/drvolts">https://twitter.com/drvolts</a> )
<b>Jess Zimmerman</b>	Grist	1,001	I'm an editor at Quirk Books and a freelance writer of essays, fiction, and prose poetry. I was previously the editor-in-chief of Electric Literature, the founding editor of Archipelago, and a contributing editor for The Establishment. I'm the author of <i>Women and Other Monsters</i> (Beacon, 2021) and the coauthor of <i>Basic Witches</i> (Quirk, 2017). I've also been an opinion columnist (at the Guardian) a journalist (at FactCheck.org), a news writer (at Grist), and a teacher of rhetorical writing. I live in Philadelphia. ( <a href="http://www.jesszimmerman.com/about.html">http://www.jesszimmerman.com/about.html</a> )
<b>Sarah Laskow</b>	Grist	899	My stories are rooted in history and science, and I write often about plants, the politics of the environment and energy, cities, food, transportation, books, libraries, and medieval culture. ( <a href="https://www.sarahlaskow.com/">https://www.sarahlaskow.com/</a> )
<b>Joseph Romm</b>	Grist	806	Romm is a physicist and climate expert who writes what has been called the indispensable blog on climate change. ( <a href="https://www.climateone.org/people/joe-romm">https://www.climateone.org/people/joe-romm</a> )
<b>Kate Sheppard</b>	Grist	645	Kate Sheppard was previously Grist's political reporter. She now covers energy and the environment for The Huffington Post. ( <a href="https://grist.org/author/kate-sheppard/page/278/">https://grist.org/author/kate-sheppard/page/278/</a> )
<b>Stacy Feldman</b>	Inside ClimateNews	174	Stacy Feldman is a co-founder of InsideClimate News, where she served as executive editor from 2015 to 2020. She's part of the 2020-21 Class of Ted Scripps Fellows in Environmental Journalism. ( <a href="https://www.greenbiz.com/stacy-feldman">https://www.greenbiz.com/stacy-feldman</a> )

<b>Phil McKenna</b>	Inside ClimateNews	132	Phil McKenna is a Boston-based reporter for Inside Climate News. Before joining ICN in 2016, he was a freelance writer covering energy and the environment for publications including The New York Times, Smithsonian, Audubon and WIRED. ( <a href="https://insideclimatenews.org/profile/phil-mckenna/">https://insideclimatenews.org/profile/phil-mckenna/</a> )
<b>Marianne Lavelle</b>	Inside ClimateNews	128	Marianne Lavelle is a reporter for Inside Climate News. She has covered environment, science, law, and business in Washington, D.C. for more than two decades. ( <a href="https://insideclimatenews.org/profile/marianne-lavelle/">https://insideclimatenews.org/profile/marianne-lavelle/</a> )
<b>Bob Berwyn</b>	Inside ClimateNews	117	Bob Berwyn an Austria-based reporter who has covered climate science and international climate policy for more than a decade. ( <a href="https://insideclimatenews.org/profile/bob-berwyn/">https://insideclimatenews.org/profile/bob-berwyn/</a> )
<b>David Hasemyer</b>	Inside ClimateNews	103	Inside Climate News reporter David Hasemyer is from the red rock country of Southeastern Utah where he grew up and learned to appreciate the importance responsible stewardship of the environment. He is co-author of the Dilbit Disaster: Inside the Biggest Oil Spill You've Never Heard Of, which won the 2013 Pulitzer Prize for National Reporting, and co-authored the 2016 Pulitzer Prize finalist series "Exxon: The Road Not Taken." ( <a href="https://insideclimatenews.org/profile/david-hasemyer/">https://insideclimatenews.org/profile/david-hasemyer/</a> )
<b>Tom Whipple</b>	Resilience	669	Tom Whipple is one of the most highly respected analysts of peak oil issues in the United States. A retired 30-year CIA analyst who has been following the peak oil story since 1999, Tom is the editor of the long-running Energy Bulletin (formerly "Peak Oil News" and "Peak Oil Review"). ( <a href="https://www.postcarbon.org/our-people/tom-whipple/">https://www.postcarbon.org/our-people/tom-whipple/</a> )
<b>Kurt Cobb</b>	Resilience	343	Kurt Cobb is a freelance writer and communications consultant who writes frequently about energy and environment. ( <a href="https://www.resilience.org/resilience-author/kurt-cobb/">https://www.resilience.org/resilience-author/kurt-cobb/</a> )
<b>John Michael Greer</b>	Resilience	261	John Michael Greer is a widely read author and blogger whose work focuses on the overlaps between ecology, spirituality, and the future of industrial society. He served twelve years as Grand Archdruid of the Ancient Order of Druids in America, and currently heads the Druidical Order of the Golden Dawn. ( <a href="https://www.resilience.org/resilience-author/john-michael-greer/">https://www.resilience.org/resilience-author/john-michael-greer/</a> )
<b>Rob Hopkins</b>	Resilience	250	Rob Hopkins is a cofounder of Transition Town Totnes and Transition Network, and the author of The Transition Handbook, The Transition Companion, The Power of Just Doing Stuff, 21 Stories of Transition and most recently, From What Is to What If: unleashing the power of imagination to create the future we want. ( <a href="https://www.resilience.org/resilience-author/rob-hopkins/">https://www.resilience.org/resilience-author/rob-hopkins/</a> )
<b>Richard Heinberg</b>	Resilience	194	Richard is Senior Fellow of Post Carbon Institute, and is regarded as one of the world's foremost advocates for a shift away from our current reliance on fossil fuels. ( <a href="https://www.postcarbon.org/our-people/richard-heinberg/">https://www.postcarbon.org/our-people/richard-heinberg/</a> )

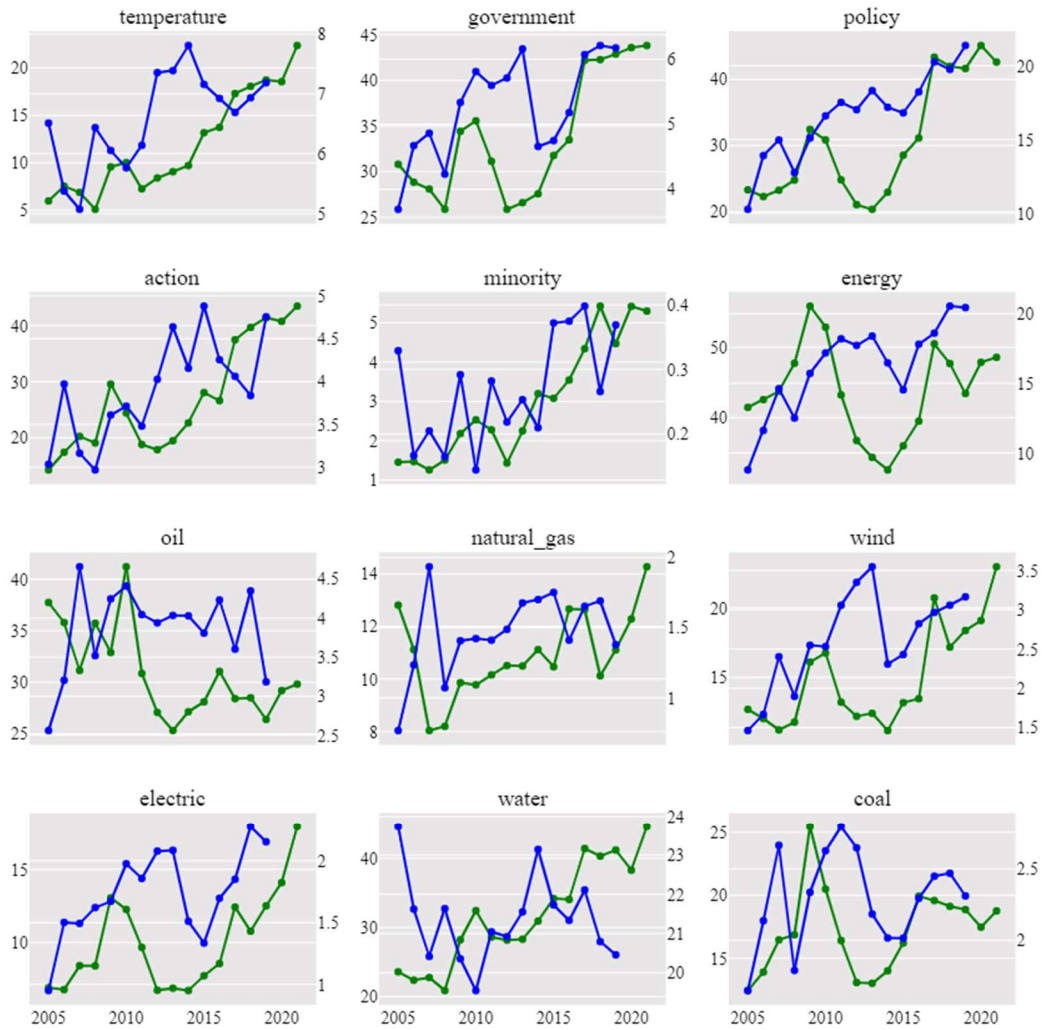
**Figure A-2. List of Journals Included in ESSA Dataset**

<i>Antipode</i>	<i>Environmental Values</i>
<i>Area</i>	<i>Geoforum</i>
<i>Cultural Geographies</i>	<i>Global Environmental Politics</i>
<i>Disasters</i>	<i>Human Ecology</i>
<i>Ecological Economics</i>	<i>International Regional Science Review</i>
<i>Ecology And Society</i>	<i>Journal Of Environmental Economics And Management</i>
<i>Energy &amp; Environment</i>	<i>Land Economics</i>
<i>Energy Policy</i>	<i>Natural Resources Forum</i>
<i>Energy Research &amp; Social Science</i>	<i>Organization &amp; Environment</i>
<i>Environment And Behavior</i>	<i>Papers In Regional Science</i>
<i>Environment And Urbanization</i>	<i>Population And Environment</i>
<i>Environmental Health Perspectives</i>	<i>Progress In Human Geography</i>
<i>Environmental Research Letters</i>	<i>Review Of Environmental Economics And Policy</i>
<i>Environmental Research Letters</i>	<i>Society &amp; Natural Resources</i>
<i>Environmental Science &amp; Technology</i>	<i>Water Resources Research</i>

**Figure A-3. N-gram list**

<b>N-gram Type</b>	<b>List</b>
<b>Bigrams</b>	'climate change', 'global warming', 'united states', 'peak oil', 'natural gas', 'new york', 'fossil fuels', 'fossil_fuel', 'renewable energy', 'clean energy', 'oil production', 'greenhouse gas', 'long term', 'carbon dioxide', 'power plants', 'economic growth', 'energy efficiency', 'nuclear power', 'tar sands', 'crude oil', 'greenhouse gases', 'white house', 'cap_trade', '\$_barrel', 'saudi arabia', 'public health', 'natural resources', 'san francisco', 'barrels_day', 'federal government', 'solar panels', 'year_old', 'middle east', 'air pollution', 'short term', 'solar power', 'clean air', 'coal fired', 'sea_level', 'los angeles', 'climate crisis', 'power plant', 'carbon tax', 'keystone_xl', 'united_nations', 'shale_gas', 'drinking_water', 'food production', 'north america', 'climate science', 'developing countries', 'low income', 'sierra club', 'solar energy'
<b>Trigrams</b>	'new_york_times', 'new_york_city', 'environmental_protection_agency', 'sea_level_rise', 'clean_air_act', 'green_new_deal', 'international_energy_agency', 'wall_street_journal', 'world_war_ii', 'keystone_xl_pipeline', 'clean_power_plan', 'energy_information_administration', 'center_american_progress', 'carbon_capture_storage', 'george_w_bush', 'nuclear_power_plants', 'post_carbon_institute', 'clean_water_act', 'los_angeles_times', 'occupy_wall_street', 'national_academy_sciences', 'union_concerned_scientists', 'new_york_state', 'american_petroleum_institute', 'u.s_department_energy', 'national_wildlife_refuge', 'environmental_defense_fund', 'paris climate agreement', 'steady state economy', 'dakota access pipeline'
<b>Quadgrams</b>	'intergovernmental_panel_climate_change', 'natural_resources_defense_council', 'coal fired power plants', 'national oceanic atmospheric administration'

**Figure A-4. Additional Keyword Frequency Plots**



**Figure A-5. Top Words in Each Topic in ESSA Topic Model**

<b>Social Behavior</b>	<b>Hydrological Modeling</b>	<b>Health Impacts</b>	<b>Soil Conditions</b>	<b>Airborne Pollution</b>	<b>Energy</b>	<b>Chemical Exposure</b>
social	model	exposure	surface	increase	energy	organic
research	water	study	high	emission	policy	compound
community	datum	concentration	result	high	emission	water
study	flow	effect	soil	concentration	cost	acid
paper	result	associate	concentration	temperature	result	study
process	time	health	water	change	use	sample
environmental	base	high	study	source	increase	treatment
management	scale	result	increase	forest	impact	product
local	method	level	rate	area	electricity	concentration
practice	estimate	risk	ph	region	study	chemical

**Figure A-6. Topic Document Titles in Each Topic in ESSA Topic Model**

<b><i>Social Behavior</i></b>	
-	Applying the system viability framework for cross-scalar governance of nested social-ecological systems in the Guiana Shield, South America
-	A Typology of Indigenous Engagement in Australian Environmental Management: Implications for Knowledge Integration and Social-ecological System Sustainability
-	Connecting knowledge with action through coproductive capacities: adaptive governance and connectivity conservation
-	Social-ecological enabling conditions for payments for ecosystem services
-	How to build science-action partnerships for local land-use planning and management: lessons from Durban, South Africa
<b><i>Hydrological Modeling</i></b>	
-	On mapping fracture networks onto continuum
-	Storage-dependent drainable porosity for complex hillslopes
-	Impact of scale/resolution on evapotranspiration from Landsat and MODIS images
-	Fill and Spill Hillslope Runoff Representation With a Richards Equation-Based Model
-	Wavelet-based multiscale performance analysis: An approach to assess and improve hydrological models
<b><i>Health Impacts</i></b>	
-	Effects of Aryl Hydrocarbon Receptor Deficiency on PCB-77-Induced Impairment of Glucose Homeostasis during Weight Loss in Male and Female Obese Mice
-	Micronuclei in Cord Blood Lymphocytes and Associations with Biomarkers of Exposure to Carcinogens and Hormonally Active Factors, Gene Polymorphisms, and Gene Expression: The NewGeneris Cohort

- Maternal and Cord Blood Manganese Concentrations and Early Childhood Neurodevelopment among Residents near a Mining-Impacted Superfund Site
- Blood and Urinary Bisphenol A Concentrations in Children, Adults, and Pregnant Women from China: Partitioning between Blood and Urine and Maternal and Fetal Cord Blood
- Effects of Di(2-ethylhexyl) Phthalate (DEHP) on Female Fertility and Adipogenesis in C3H/N Mice

### ***Soil Conditions***

- Coprecipitation of arsenate with metal oxides: Nature, mineralogy, and reactivity of aluminum precipitates
- Formation and dissolution of single and mixed Zn and Ni precipitates in soil: Evidence from column experiments and extended X-ray absorption fine structure spectroscopy
- In situ Fenton reagent generated from TiO<sub>2</sub>/Cu<sub>2</sub>O composite film: A new way to utilize TiO<sub>2</sub> under visible light irradiation
- Interaction forces between colloids and protein-coated surfaces measured using an atomic force microscope
- Aggregation kinetics of kaolinite-fulvic acid colloids as affected by the sorption of Cu and Pb

### ***Airborne Pollution***

- Warmer spring conditions increase annual methane emissions from a boreal peat landscape with sporadic permafrost
- Recent warming in Greenland in a long-term instrumental (1881-2012) climatic context: I. Evaluation of surface air temperature records
- Climate Change and Mercury Accumulation in Canadian High and Subarctic Lakes
- Identifying sources and biomagnification of persistent organic contaminants in biota from mountain streams of southwestern British Columbia, Canada
- Global Biogeochemical Implications of Mercury Discharges from Rivers and Sediment Burial

### ***Energy***

- Electricity dependency and CO<sub>2</sub> emissions from heating in the Swedish building sector – Current trends in conflict with governmental policy?
- Perspectives on implementing energy efficiency in existing Swedish detached houses
- Global analysis of the techno-economic potential of renewable energy hybrid systems on small islands
- Oil consumption and CO<sub>2</sub> emissions in China's road transport: current status, future trends, and policy implications
- Role of energy efficiency standards in reducing CO<sub>2</sub> emissions in Germany: An assessment with TIMES

### ***Chemical Exposure***

- Radiolysis Studies on the Destruction of Microcystin-LR in Aqueous Solution by Hydroxyl Radicals
- Evaluation of perfluorooctane surfactants in a wastewater treatment system and in a commercial surface protection product
- Ozonation of carbamazepine in drinking water: Identification and kinetic study of major oxidation products
- Photochemically Induced Bound Residue Formation of Carbamazepine with Dissolved Organic Matter
- Characterization of Unknown Brominated Disinfection Byproducts during Chlorination Using Ultrahigh Resolution Mass Spectrometry

**Figure A-7. Top Words in Each Topic in EM Topic Model**

Renewables	Knowledge	Community	Food	Politics	Fossil Fuels	Economy	Urbanism	Climate Change
Energy	think	community	food	state	oil	policy	city	climate
solar	know	work	farmer	water	energy	economy	car	climate_change
power	thing	tree	farm	bill	company	economic	green	emission
wind	go	water	organic	environmental	price	job	bike	carbon
electricity	way	food	eat	epa	gas	need	home	percent
cost	world	local	crop	coal	industry	cost	day	global_warming
technology	right	grow	agriculture	obama	china	market	get	country
plant	ve	good	meat	president	coal	money	good	report
use	good	way	corn	republican	percent	system	go	scientist
coal	get	plant	grow	group	world	tax	work	greenhouse_gas

**Figure A-8. Top Document Titles in Each Topic in EM Topic Model****Renewables**

- How (Not) to Run a Modern Society on Solar and Wind Power Alone
- Enabling wind, sun to be our main power supplies
- Enabling Wind, Sun To Be Our Main Power Supplies: Quest for Storage — “Holy Grail” of New Energy Economy — Nears Goal
- Believe it
- Efficiency is the key

**Knowledge**

- Human Nature
- About that novel
- Review: “Let Us Be Human: Christianity for a Collapsing Culture”
- Now More than Ever, Scientists Need to Communicate Better. Here’s How.
- The unfathomable universe

**Community**

- Creating a cottage garden
- Transition Essentials: No.1 – Food
- Sticking to the plot: A celebration of permaculture allotment projects
- Hard to stomach: How a fresh clam feast got the best of me
- An Orchard from a Single Tree

**Food**

- U.K. organic milk better for you than conventional, thanks to cows’ grass-based diet
- While global GMO acreage surges, herbicide-resistant weeds thrive
- For first time, GM soybeans may be losing favor among farmers
- Low doses of BPA are worse for you than high doses
- U.K. government says organic, free-range eggs have ‘significantly’ less salmonella

**Politics**

- Semana del 27/5/12
- Semana del 19/11/2006
- Samana del 12/11/06
- Semana del 14/01/2007
- Semana del 03/12/2006

**Fossil Fuels**

- Trends in world oil supply/consumption and net exports/imports
- What the new 2011 EIA oil supply data shows
- World Oil Production Forecast – Update November 2009
- Good forecasts/bad forecasts: how does the US DOE/EIA come out?
- Peak Oil Review – Dec 1

**Economy**

- The Grexit Proposal
- In Search of a Sane Economy
- The Financial Times is Right – Labour’s Ownership Funds will Transfer Wealth and Power
- Common questions about economic sharing
- Racial Inequality Is Hollowing Out America’s Middle Class

**Urbanism**

- Papa wheelie: Is there one dad bike to rule them all?
- Peer-to-peer bike rentals are more principle than profit
- Umbra on biking with kids
- Uber and Lyft admit they’re terrible for traffic, finally
- Bikeshare rolls into Chi-Town, spreading transportation bliss

**Climate Change**

- State of the climate: Summer 2021 sets new high for average land temperature
- Factcheck: Climate Models have not ‘Exaggerated’ Global Warming
- Explainer: Will global warming ‘stop’ as soon as net-zero emissions are reached?
- UNEP: Net-zero pledges provide an ‘opening’ to close growing emissions ‘gap’
- “Clouds Appear to Be Big, Bad Player in Global Warming” — an amplifying feedback

Figure A-9. Words Co-occurring with Science in EM, Excluding Resilience.org

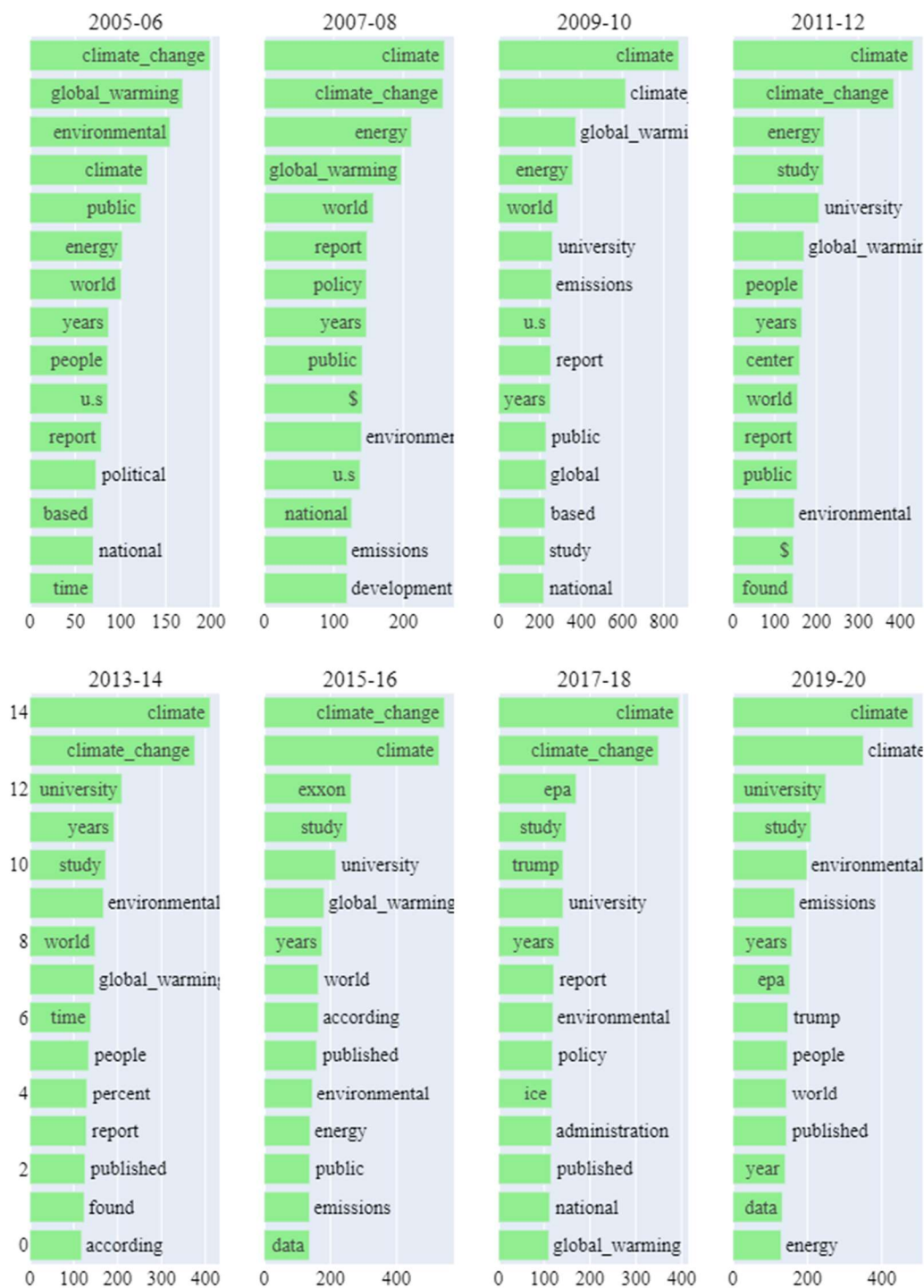


Figure A-10. Words Co-occurring with Activism in ESSA



**Figure A-11. Examples of EM Articles in the “Knowledge” Topic**

<b>Title</b>	<b>Author</b>	<b>Date</b>	<b>Source</b>	<b>Link</b>
Resources for a better future: Human Nature	Eleanor Finley	June 11, 2020	Resilience.org	<a href="https://www.resilience.org/stories/2020-06-11/human-nature/">https://www.resilience.org/stories/2020-06-11/human-nature/</a>
About That Novel	David Roberts	September 8, 2014	Grist.org	<a href="https://grist.org/article/about-that-novel/">https://grist.org/article/about-that-novel/</a>
Review: “Let Us Be Human: Christianity for a Collapsing Culture”	Roy Smith	March 8, 2012	Resilience.org	<a href="https://www.resilience.org/stories/2012-03-08/review-let-us-be-human-sam-charles-norton/">https://www.resilience.org/stories/2012-03-08/review-let-us-be-human-sam-charles-norton/</a>
Now More than Ever, Scientists Need to Communicate Better. Here’s How.	Randy Olson	July 23, 2018	Resilience.org	<a href="https://www.resilience.org/stories/2018-07-23/now-more-than-ever-scientists-need-to-communicate-better-heres-how/">https://www.resilience.org/stories/2018-07-23/now-more-than-ever-scientists-need-to-communicate-better-heres-how/</a>
The unfathomable universe	Kurt Cobb	July 26, 2009	Resilience.org	<a href="https://www.resilience.org/stories/2009-07-26/unfathomable-universe/">https://www.resilience.org/stories/2009-07-26/unfathomable-universe/</a>