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Framing climate change for effective communication: a systematic map

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Abstract

Climate change emerged as an issue of science, but its broad ranging impacts and potential mitigation strategies mean it is of significance to all people across sectors, interests, and nations. As a result, the traditional fact-centred way of communicating information about climate change is not necessarily the best strategy for engaging the full breadth of publics. In communication practice and scholarship, framing is an approach that emphasises certain attributes of an issue over others and as a consequence shapes how that issue is understood. This has led to the scholarly exploration of framing as a technique for tailoring climate change communication to engage diverse publics. Over the past two decades, research has examined a range of different frames for the communication of climate change, such as *Public health, National security* and *Economic prosperity/development*. With this literature now rapidly expanding, it is crucial to synthesise existing evidence so that future research efforts and climate communication interventions are best informed about the current knowledge-base and research gaps. This article presents this synthesis in the form of a systematic map. We systematically searched scholarly (Scopus and Web of Science) and grey literature databases for English-language climate change framing literature. All articles were screened at the title/abstract and full-text level, with included articles incorporated into a Microsoft (MS) Excel database. The information extracted from the literature included bibliometric, geographical and other data pertaining to study design and the climate change frames examined. Our systematic map includes 274 articles (281 studies). The most common frames appearing in this literature base (making up about 50% of the total) were *Scientific, Economic* and *Environmental*. Other frames such as *Public health, Disaster* and *Morality/ethics* appear to be gaining more scholarly attention in recent years. Almost half of the collected studies are from the United States but there is a growing trend of studies comparing climate change frames from other countries. Climate change frames are numerous and can have different efficacies depending upon country and social-political context. Research needs to be reflexive in its approach to understand the broader impact of framing in climate change communication and should continue to employ multi-national studies and explore climate change framing effects in under-researched nations to combat bias.

1. Background

Human-caused greenhouse gas (GHG) emissions have already caused a 1 °C rise in global temperature compared with pre-industrial times, which has resulted in more extreme weather events, sea level rise, and a range of impacts on people and valued natural and human systems (IPCC 2018). Despite these substantial negative consequences, concerted action to halt GHG emissions has been inadequate (Rogelj *et al* 2018, den Elzen *et al* 2019). In some countries, this has been attributed in part to widespread misunderstandings or rejection of climate change science (Hornsey *et al* 2016). Accordingly, effective communication

about the reality and significance of climate change has been identified as a crucial element of efforts to build broad engagement with climate change and its potential solutions (Bernstein and Hoffmann 2019). One promising aspect of effective communication is framing (Nisbet 2009).

Framing was first conceptualised by Goffman (1974) and since then, research on framing has been conducted in fields such as media studies, communication and psychology. As a result, the scholarship on framing has developed in parallel disciplines, leading to different approaches to research and understanding of frames (Scheufele and Iyengar 2014). Framing in communication broadly refers to the act of sense-making through emphasising certain aspects of a reality over others (Entman 1993, Chong and Druckman 2007, Schäfer and O'Neill 2017). In essence it is concerned not with *what* is being communicated but more with *how* it is being communicated (Scheufele and Iyengar 2014). Framing is a constructivist concept that can be used to help understand different social realities of climate change (Schäfer and O'Neill 2017). This can then allow more tailored communication, more relevant communication (Nisbet 2009), better conceptual boundary making, and clearer connections between concepts and understandings. Frames in communication can, according to Entman (1993, p.52), be thought of as having four explicit functions: 'diagnosing causes', 'defining problems', 'making moral judgements' and 'suggesting remedies'.

Media studies research has used methods such as content analysis in efforts to understand how news stories have framed climate change. The media provides a key conduit for access to scientific information (Funk *et al* 2017) and acts as an important source for awareness and knowledge of climate change (Schmidt *et al* 2013). Scholarly interest in analysing media representations of climate change began in the 1990s and reached a volume where synthesis studies were required to bring this knowledge together (Schäfer and Schlichting 2014). Research has now been conducted in more than 27 countries with synthesis studies such as Schmidt *et al* (2013) providing integrative perspectives on media representations of climate change. Such studies have also been conducted to understand the breadth of climate change media frames in the US (Bolsen and Shapiro 2018) and globally (Vu *et al* 2019). Some current findings highlight the dependence of climate change media frames on broader social and political systems (Vu *et al* 2019). Importantly, media studies can provide a perspective on how climate change is being framed in the public domain but cannot provide specific insight into which frames facilitate effective communication.

Experimental research following the traditions of psychology contributed to framing research by conducting experiments that collect empirical data on the effectiveness of frames (Fielding *et al* 2014).

Early studies explored the differences between climate change impact frames in positive versus negative terms (Morton *et al* 2011), not dissimilar to the seminal framing study by Tversky and Kahneman (1981) which explored consequences of different framings of risk. Research into alternative climate change frames such as *Public health* (which emphasises the health impacts of climate change) on attitudes and behavioural intentions toward climate change mitigation have also been an area of exploration (Myers *et al* 2012). While studies such as Myers *et al* (2012) and Maibach *et al* (2010) have found evidence for the efficacy of the Public health frame, others have found limited evidence (Walker *et al* 2018). More recent research has suggested that other factors such as politically-aligned attitudes (Zhou 2016) and the presence of 'counter-frames' (Mccright *et al* 2016) may override framing effects.

Complicating these diverse research areas and mixed findings is the range of ways that frames have been defined, studied, and evaluated. Scheufele and Iyengar (2014, p 6) noted that studies of framing were undermined by 'conceptual vagueness', leading to inconsistency between studies. While the interdisciplinary nature of framing research has offered value via the breadth of approaches, it has also resulted in a lack of coherence regarding understandings of how climate change can or should be framed. In this study, we attempt to bridge the disciplinary divide to gain a rich insight into the broad research area of climate change framing. Through adopting a systematic mapping methodology, we gather and categorise relevant articles, describe broad trends, and synthesise what climate change frames are being researched, and therefore identify the relevant evidence bases. Individual studies have shown that framing climate change has utility for effective communication, but what lacks is a broader view of the current research field to help make sense of the evidence base. This collation of evidence also allows us to highlight some gaps in knowledge and directions for future climate change framing research.

2. Methods/Design

We developed a systematic map (SM) of the climate change framing literature following the methodology proposed by the Collaboration for Environmental Evidence (CEE) (2018) and the Reporting Standards for Evidence Syntheses (ROSES) (Haddaway *et al* 2018). This approach systematically identifies and categorises literature associated with a specific topic, and as a result offers insights into the broad trends in the literature while reducing biases that can be present in traditional literature reviews (Collaboration for Environmental Evidence 2018). Such trends can include geographical biases regarding author and/or study location, the topic areas of focus, the methodological approaches used, and

other categorical factors relevant to the subject area. As a form of evidence synthesis, the SM provides a conceptual mapping of the literature, though it does not extend to undertaking meta-analysis of the data within the included studies. Rather, it highlights broad trends in the literature, the gaps in knowledge, and opportunities where meta-analyses and/or systematic reviews can be conducted.

This study was guided by an overarching research question drawing together more specific sub-questions:

- *What is the existing evidence base regarding climate change framing?*
  - * What frames have been examined in the literature?
  - * How are studies assessing these frames?
  - * What are the macro-level trends that shape the literature?
  - * What are the gaps in knowledge and priority areas for future research?

2.1. Search strategy

2.1.1. Scoping

Initial scoping involves testing search strategies and keyword strings in different databases to ensure appropriateness before systematic searching begins (Collaboration for Environmental Evidence 2018). Scoping for this SM involved testing different search strings in a number of databases to ascertain which databases would be most appropriate for literature collection. Supplementary table S1(a) (available online at stacks.iop.org/ERL/15/123002/mmedia) contains all searches conducted, including both scoping searches and literature collection searches. To ensure full transparency, the date, database searched, keyword string used, and results were recorded.

2.1.2. Keyword string

Development of the final keyword string began with a scoping search in Scopus and Web of Science to identify relevant literature using simple keywords such as ''*climate change' AND framing'*. The main purpose of this scoping stage was to identify some highly cited work on climate change framing and use keywords in those papers to develop our final keyword string. Eight relevant papers spanning a wide cross-section of the climate change framing literature (e.g. framing in the media and experiments testing frames) were identified. In addition to building the final keyword string, these papers also acted as an internal check when conducting the final literature searches. We refer this list of eight papers as the 'internal-check papers' and a table containing their citation information can be found in the supplementary materials (supplementary table S2). The internal-check papers list is not an exhaustive account of seminal work on climate change framing, but instead a

tool that enabled us to develop the final keyword string.

Keyword strings are search terms that are designed to yield as broad a range of relevant literature as possible, while limiting the number of irrelevant articles. Good practice for the development of keyword strings is to follow the Population, Intervention, Comparator and Outcome (PICO) design (James *et al* 2016), such that the search string specifies: population; intervention; comparison; and outcome. The search string was iteratively refined until all the internal-check papers appeared in the searches. This was checked in Scopus and Web of Science, and the inclusion of the internal-check papers in the search results suggested the searches were probing the relevant literature base. Some terms would not affect the presence of an internal-check paper but would balloon the search results. An example of this was using the term 'fram*' which would search terms such as frame, frames, framing, framings, framer, framed and framework. Framework is not an appropriate term describing this literature and the inclusion of it would cause the results to double in some cases, hence terms like this were excluded.

Many scoping keyword strings were explored for appropriateness, but the final literature search used only two substrings. These substrings were broad enough to collect a large amount (thousands) of relevant literature without ballooning the searches to an unmanageable number of results.

The keyword string used in this systematic map was:

> (''clim* chan*'' OR ''global warming'' OR ''global environmental change'' OR ''clim* variability'') AND (framing OR frame OR frame OR framed)

When necessary, the keyword string was altered for databases where the full string was not accepted or returned no results, for example grey literature searching (see section 2.1.3). Some databases required minor modifications to the search string (e.g. different Boolean functions), as such each keyword string used for every search was recoded and can be found in supplementary table S1(a) for scholarly literature and supplementary table S1(b) for grey literature.

2.1.3. Databases and searches

Academic literature was collected from the online Scopus database and the online literature searching tool Web of Science. Scopus has been identified as a database with one of the best coverages of social science literature (Norris and Oppenheim 2007). Literature citing the internal-check papers was also collected and added to the scholarly literature corpus.

Grey literature is a crucial component of a systematic study helping reduce publication bias which can affect the results of a systematic review or

map (Haddaway and Bayliss 2015, Collaboration for Environmental Evidence 2018). In this study, grey literature is defined as articles that have not been published in traditional commercial journals (Haddaway *et al* 2015). We included theses, book sections and reports in the present SM. The search engines used to collect grey literature were Bielefeld Academic Search Engine, Open Access Theses and Dissertations, Open Grey and Google Scholar (search strategies in supplementary table S1(b)).

In addition to grey literature databases we also searched organisational websites that may host relevant reports or other material. Organisational websites were identified through incognito/private searches in Google and DuckDuckGo search engines (supplementary table S3). Relevant organisations were included if they conducted their own research, published it only on their website (i.e. not a scholarly journal) and was on the topic of climate change framing, otherwise the organisation was excluded.

Due to language limitations only English language literature was searched for and retained. This was the case for both scholarly and grey literature.

2.2. Exported results
Search results were exported from most databases and online tools via the available export functions. Exported files were .ris files which were imported into reference management software Endnote and Mendeley. Literature results from searching on Open Grey were exported used a web scraper plugin (webscraper.io) in the Google Chrome web browser and then saved in an excel spreadsheet.

2.3. Duplicate removal
Due to literature being collected from multiple online tools, some articles were present in the research results multiple times. To remove duplicates, .ris files were imported into desktop reference manager End-Note X9 and the 'remove duplicates' automatic function was used. Multiple passes were required to remove all the duplicates present, and as a result, different matching criteria (e.g. title, journal title, authors etc.) were toggled on and off to capture all duplicates. Duplicate entries were reviewed manually prior to deletion to ensure that articles being deleted were in fact duplicates.

In some cases, duplicates were not clearly identifiable repeat entries of the same article, for example, when the same research was published as both conference proceedings and in a journal article. To address this, a final stage of duplicate removal involved searching for entries with the same title but with other bibliographic details differing (e.g. publication type and/or name) and assessing whether they were in fact the same study. We were guided by a hierarchy of article types where journal articles published with the same title as a conference proceeding were retained (and the latter removed). In cases where the journal

article was unavailable, then the conference proceeding with the latest date was retained.

2.4. Article screening and inclusion criteria
Screening was conducted at the title, abstract and full-text level (exclusions recorded with reasons in supplementary table S4) and the Population, pHenomenon and Outcome (PHO) (adapted from PICO/PECO, Collaboration for Environmental Evidence 2018) inclusion criteria are outlined in table 1. The article had to be from the body of scholarly or grey literature, and the article needed to focus specifically on the framing of climate change or global warming (i.e. not simply note framing as a tangential issue of interest). The focus needed to be on the framing of climate change as a 'political object' and not on climate adaptation or mitigation as these are slightly adjacent to our focus area. Finally, the article needed to be about communication frames (not frames in thought) and studies looking only at imagery (visual framing) were excluded unless they were combined with textual frames. The scholarly results went through two passes of full-text screening, this ensured the right articles (addressing our research question) were being included.

In terms of books, only relevant book sections were included and not entire books. Additionally, the book either needed to be available online or in physical form at the The Australian National University library. All search results were screened for the grey literature searches, except for Google Scholar where only the first 350 results were screened (following methods in Haddaway *et al* 2015). Forty-two organisational websites were searched using either their own website search functions or looking in relevant sections of the websites. Results were exported from 11 websites (see supplementary table S5), results were then screened for relevance at the full-text level.

2.5. Consistency checking
Screening consistency checking was conducted for the three authors (NB, WJG and RMC) to ensure that all were screening in line with each other. A random selection of 100 articles from the academic database (Web of Science and Scopus) was selected and screened by NB, WG and RC and then a kappa statistic was calculated. The kappa statistic is a means to check for consistency between reviewers, although there is currently no consensus around an 'adequate' level of agreement as noted by the Collaboration for Environmental Evidence (2018, section 6.3.4).

A first screening test was conducted, and the kappa statistics displayed 'moderate agreement' (Viera and Garrett 2005) and this was deemed insufficient by the authors (i.e. below 0.5) and a meeting was held to discuss the PHO criteria and adjust them as necessary. Following this, another screening test was conducted with a new sample and the kappa

Table 1. PHO elements for assessing inclusion/exclusion.

PHO element	Description	Inclusion criteria
Population	The body of climate change framing literature	Is it a defined piece of academic or grey literature?
pHenomenon	The issue of climate change	Is the article about climate change or global warming?
Outcome	The use of framing for communication of climate change	Is the article about how the issue of climate change or global warming is framed?

Table 2. Coding strategy used for collecting data from each study.

Code category	Data collected
Bibliographic	Title, author(s), year, journal, study methodology
Geographic	Location of first author, location of sample
Study specific	Type of data used, sample size, stimulus medium, sample type, sample segmentation, response variable(s)
Frames	Frames used in studies, Other frames, Extra dimensions

statistics were calculated and ranged from 0.65–0.85. This level of agreement between the first author and the other two authors was sufficient (ranged from 'substantial' to 'almost perfect' agreement (Viera and Garrett 2005 p362)) to continue and screening was then conducted by the first author. However, in cases of uncertainty, the authors came together to discuss and decided upon inclusion/exclusion of a specific article.

2.6. Data coding
The coding stage involved extracting from full-texts relevant details to address the research question and objectives. Each study (some articles had more than one) was given one row in an excel spreadsheet. Each variable was given one column in the same excel spreadsheet and then counts were completed in order to help map out the broad literature trends. Table 2 outlines the types of data extracted from the literature. As some articles include multiple studies, each study was considered separately.

2.7. Data quality and confidence
Reflecting standard practice for SM (James *et al* 2016, Collaboration for Environmental Evidence 2018), we specified the study type and grey/scholarly literature classification which can give some indication of quality, though we do not explicitly assess the quality of these articles as critical appraisal is only optional for systematic maps (James *et al* 2016).

3. Systematic map results

3.1. Search results and screening
Online database Scopus and online tool Web of Science were searched without any restrictions (e.g. language, study type or topic area) and returned 3977

(2000 downloaded due to download limit [3]) and 3381 results, respectively. Additionally, citation searching in Scopus was conducted to collect all scholarly publications citing the internal-check papers. The citation search returned 1869 results. Grey literature searching was conducted in Bielefeld Academic Search Engine (BASE), Open Access Theses & Dissertations (OATD), Google Scholar (GS), Open Grey (OG) and organisational searching in Google and DuckDuckGo search engines.
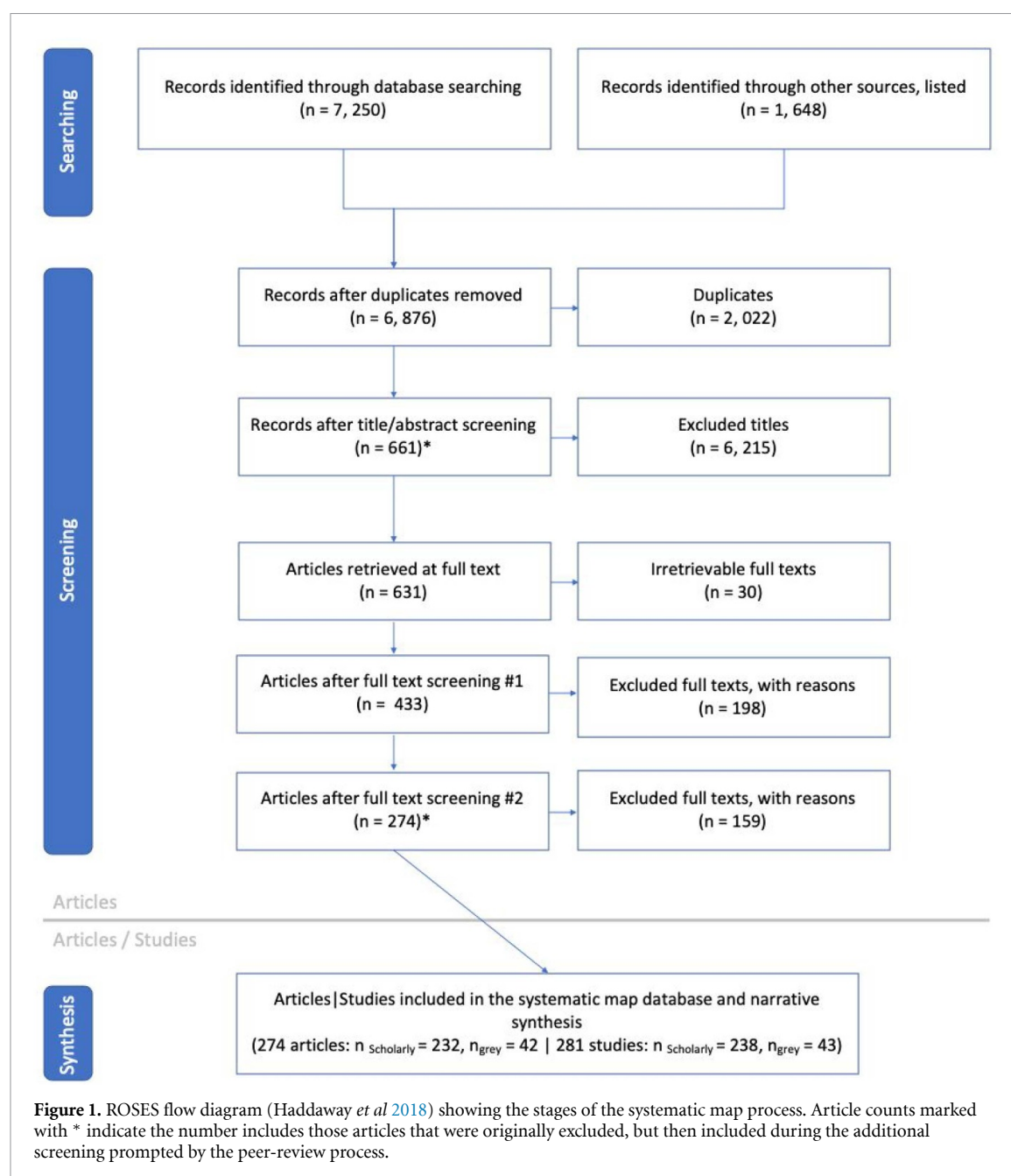
In total, 7250 articles were collected from the scholarly literature and 1648 from the grey literature . After the removal of 2022 duplicates across the combined databases, the number of articles remaining was 6876. The first stage of screening (at the title and abstract level) excluded 6215 articles. Full-text screening was completed in two passes: the first resulted in 198 being excluded the second pass saw another 159 excluded. Finally, 274 scholarly and grey articles (which included 281 studies) were included and coded into the systematic map. Due to there being no restrictions on the searching, some articles were picked up that are not published in scholarly journals, such as conference proceedings and book sections. In the systematic map these are considered grey literature but were collected during the scholarly searching. Figure 1 presents a summary of the search process and results.

During the peer-review process (and therefore following full-text screening), we revisited the title/abstract and full-text exclusion lists, prompted by comments from the reviewers. This resulted in the inclusion of an additional 13 articles (12 from the title/abstract exclusion list, and one from the full text exclusion list). All results were updated accordingly, though our headline conclusions were unchanged.

3.2. Dates, journals and study types
The earliest article on climate change framing was published in 1996. Publications on the topic became more frequent from about 2004 and peaked in 2017 (figure 2). Accordingly, most of the climate change framing literature has been published in the past 15 years. As literature collection was conducted in

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[3] Scopus will only allow viewing and downloading of the first 2000 results of a search.

Figure 1. ROSES flow diagram (Haddaway *et al* 2018) showing the stages of the systematic map process. Article counts marked with * indicate the number includes those articles that were originally excluded, but then included during the additional screening prompted by the peer-review process.

June of 2019, the number of articles for 2019 is an incomplete record.

The scholarly articles were published in 127 different scholarly journals (figure 3). While most of these journals published just one relevant article, seven journals published more than one-third of the total. These were Environmental Communication (n = 25), Global Environmental Change (n = 18), Public Understanding of Science (n = 11), Wiley Interdisciplinary Reviews (WIREs) Climate Change (n = 9), Climatic Change (n = 9), Science Communication (n = 7), and Environmental Education Research (n = 5). In total, 231 articles were published in commercial journals which made up the majority of the literature base. Theses (n = 19), book sections (n = 6), reports (n = 6), conference proceedings (n = 5), commentaries (n = 4), guides (n = 2) and

one working document made up the remaining 16% of the database.

The studies were categorised into four groups based on their methodologies: experimental; observational; discussion; and synthesis (figure 4). Experimental studies involved an intervention and primary data collection, observational studies analysed a phenomenon without intervention using secondary data, discussion studies were primarily theoretical without data collection and synthesis studies involved structured methodologies, like meta-analyses or systematic reviews. The most common study type was observational (n = 139, 49% of total studies). Of these observational studies, news media analysis was most prominent (n = 86, 61% of observational studies). Discussion (n = 74, 26% of total studies) was the second most common type of study. Experimental
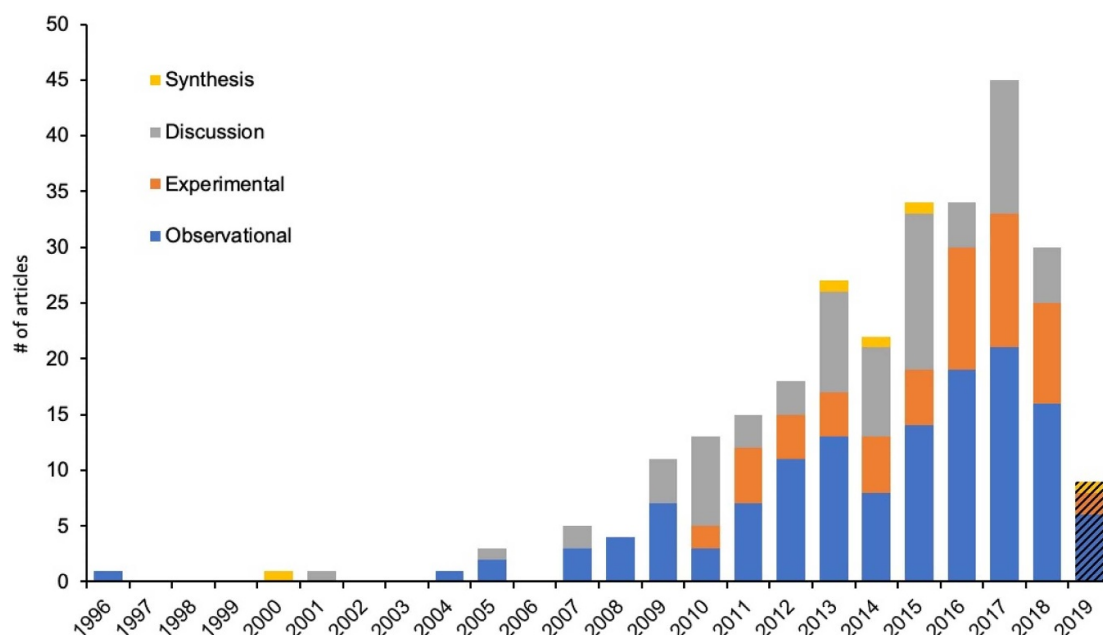
Figure 2. Publication dates for all articles (total n = 274), 2019 is textured as it does not contain all studies published in that year, i.e. 2019 is an incomplete record.
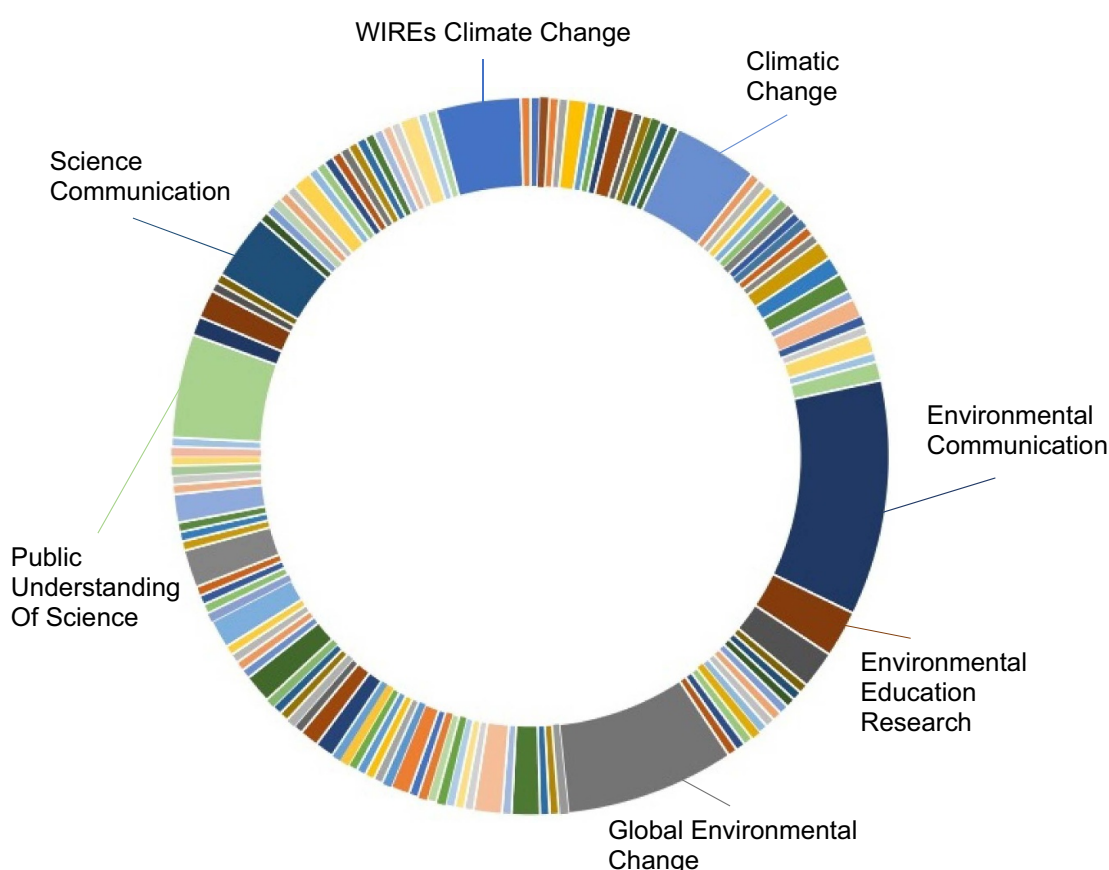
Figure 3. The seven most common journals for the scholarly literature.

(n = 63, 22% of total studies) and synthesis studies made up the remainder (n = 5, 2% of total studies). Overall, the most common type of framing study was an analysis of news media.

3.3. Geography
Geographic information was recorded in two variables (figure 5): the location of the first author, and the location of the sample used in the study (e.g.
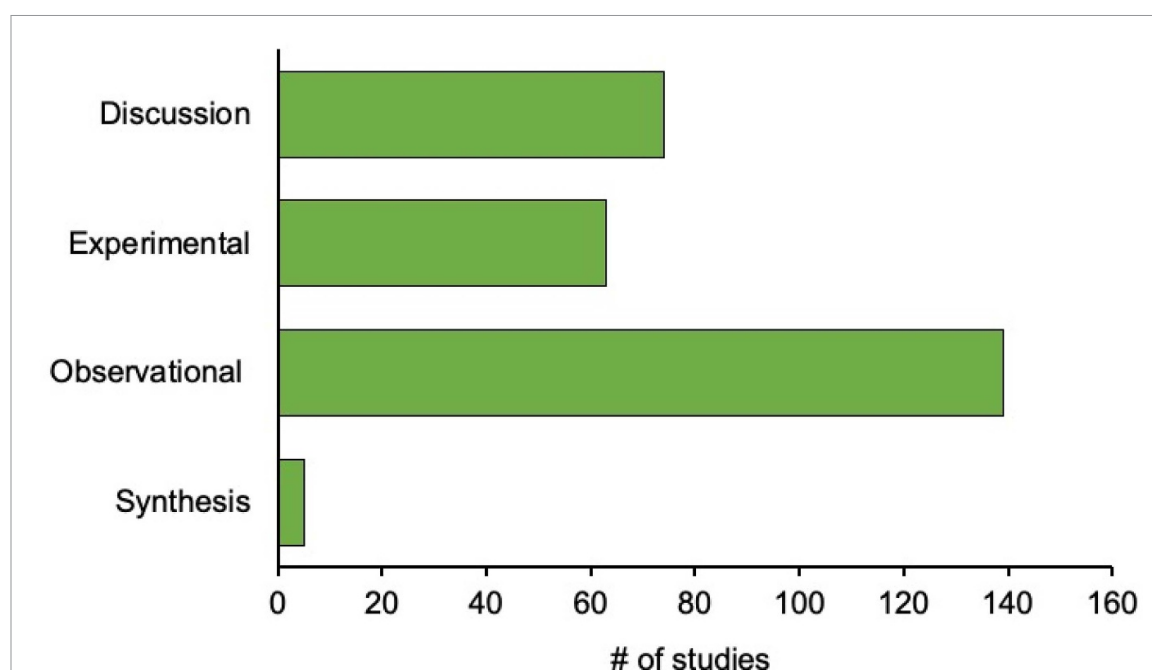
Figure 4. The count of studies (total n = 281) across four study type categories.

human participants, news articles). First author locations spanned 31 countries across six continents. Almost half (n = 112, 42% of total studies) of the studies were published with a first author from the United States. Next most common were the United Kingdom (n = 31, 12% of total studies) and Australia (n = 22, 8% of total studies).
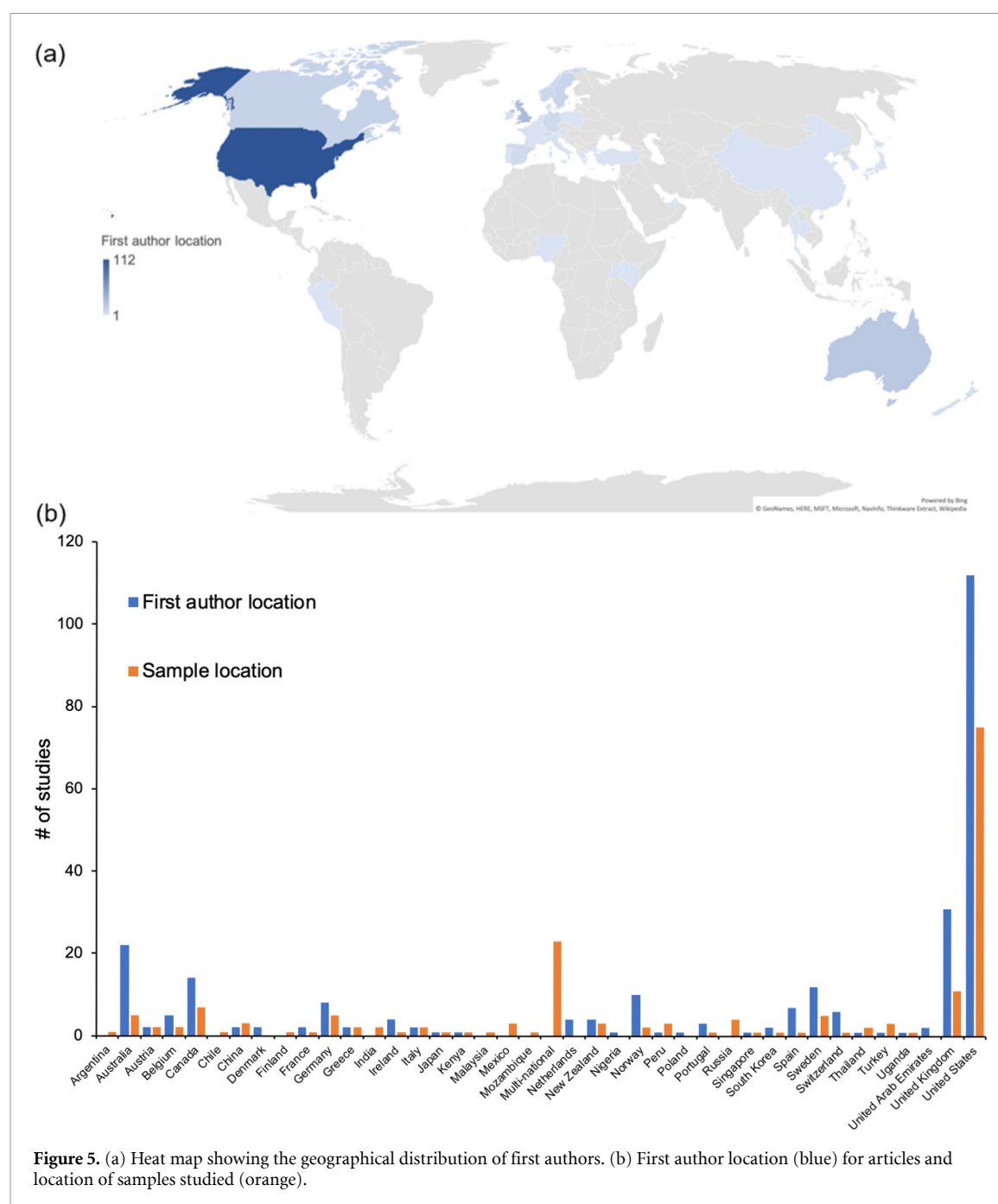
The sample location variable covered slightly more countries (35 in total), but also contained a number of studies with cross-national samples. The United States (n = 82, 40% of total sample locations) was the most common sample location, and the second most common sample location (multinational) involved samples from more than one country (n = 23, 11% of total sample locations). The United Kingdom (n = 12, 6% of total sample locations) was the third most common sample location followed by Canada (n = 7, 3% of total sample locations), Sweden (n = 6, 3% of total sample locations), Australia (n = 5, 3% of total sample locations) and Germany (n = 5, 3% of total sample locations). The rest of the countries had fewer than five studies each with samples from their respective countries and this comprised 32% of the total sample locations.

Multi-national samples began to appear in the literature in 2010, with generally two to three studies published per year, and peaked in 2016 with eight studies. The first author location of these studies reflects the overall trends with Europe (n = 12, 52% of total multi-national studies) and the United States (n = 5, 22% of total multi-national studies) being the most common. Most of the multi-national studies (n = 21, 91% of total multi-national studies) were published in commercial journals except for two which were within theses.

3.4. Frames

Frames were coded using the framing typology presented in Bolsen and Shapiro (2018), itself a synthesis of climate change frame typologies. Most frames mapped well onto this typology, however in some cases this typology was not broad enough to capture all frames identified in the literature. To address this, we extended the typology by including additional frames from Nisbet (2009). If the frames in a study were not captured by these two typologies, then they were added into an 'other' category. In some cases, additional frame codes were added based upon the frequency of frames appearing in the 'other' category. An example of this was the *Religious* frame, which can be thought of as a specific sub-set of the *Morality/Ethics* frame but appeared frequently enough that we felt it was useful to represent it in its own frame code. Some studies looked at only one frame while others included more than one, hence, the number of frames is greater than the number of total studies. Some studies focussed the use of the term 'climate change' itself. These studies generally looked at the effects of framing the issue as 'climate change' or 'global warming' or 'climate crisis/emergency'. These studies were included in the *Title framing* category.

The most common frame that occurred was the *Scientific* frame (n = 124, 17% of all frames), followed by the *Economic* (n = 97, 13% of all frames) and *Environmental* frames (n = 96, 13% of all frames). These three frames made up 43% of the total frames recorded. Frames were grouped using the four frame functions from Entman (1993) (diagnose causes; suggest remedies; make moral judgements; and define problems). The 'general' categories

Figure 5. (a) Heat map showing the geographical distribution of first authors. (b) First author location (blue) for articles and location of samples studied (orange).

(e.g. 'general causes', 'general remedies') were frames that used Entman's classification without use of one of the more specific frames categories (figure 6).
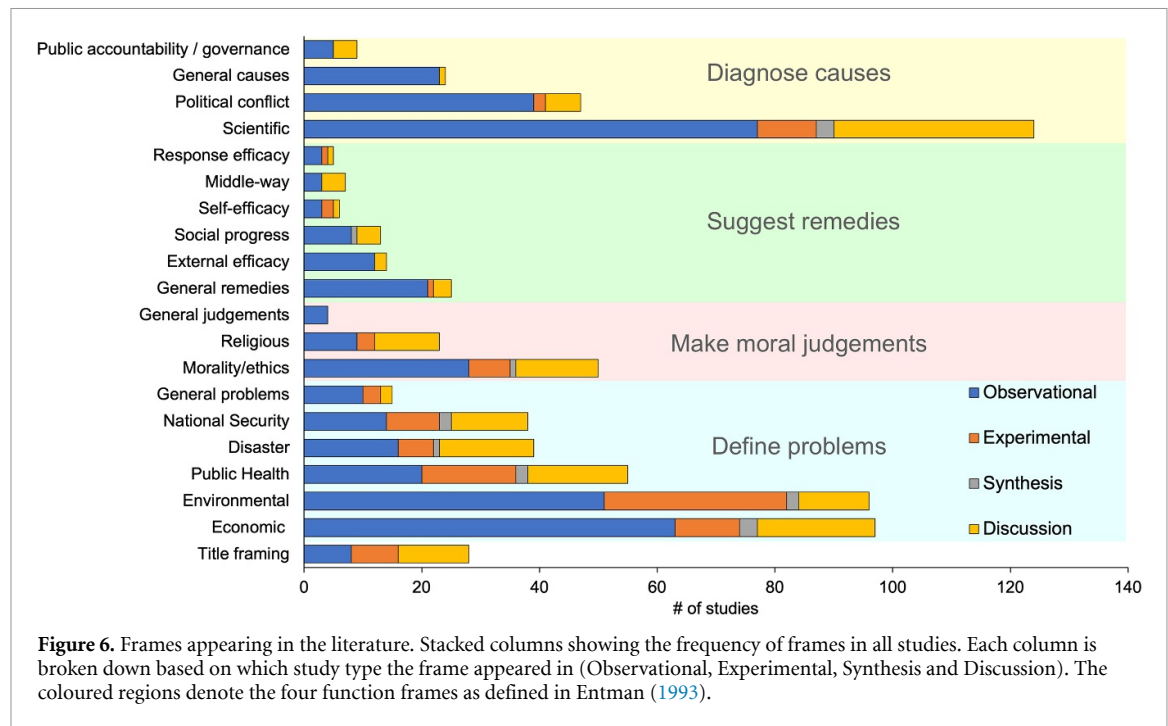
3.5. Trends in research per study types

3.5.1. Experimental studies

Among the experimental studies, the most commonly studied experimental frame was *Environmental* (n = 31, 28% of experimental studies) which emphasised the environmental impacts of climate change. The second most studied frame was *Public Health* (n = 16, 15% of experimental studies) and then *Economic* (n = 11, 10% of experimental studies). Other common frames were *Scientific* (n = 10, 9% of experimental studies), *National security* (n = 9, 8% of

experimental studies) and *Morality/Ethics* (n = 7, 6% of experimental studies). Of the 63 experimental studies, the main data collection method was a survey (n = 54, 97% of experimental studies). Two experimental studies used interviews (3% of experimental studies). A large proportion of studies used a participant sample between 101–500 people (n = 24, 39% of experimental studies), with the next most common being 1001–2000 (n = 10, 16% of experimental studies) and 1–100 (n = 10, 16% of experimental studies). Approximately half (n = 35, 56% of experimental studies) stated using a control frame when doing experiments.

For the experimental studies, the most common samples were non-nationally representative adults

Figure 6. Frames appearing in the literature. Stacked columns showing the frequency of frames in all studies. Each column is broken down based on which study type the frame appeared in (Observational, Experimental, Synthesis and Discussion). The coloured regions denote the four function frames as defined in Entman (1993).

(n = 24, 39% of experimental studies) and university students (n = 18, 29% of experimental studies). Nationally representative samples were used in six studies (10% of experimental studies). In terms of how the framing effects were analysed, the samples were most commonly analysed by comparing the results from the specific experimental groups used in the studies (n = 46, 61% of experimental studies) and then dividing the sample by and comparing between political views/stances (n = 18, 24% of experimental studies). Five studies used segmentation analysis to analyse framing effects, four US studies and one Australian study, together equalling 6% of the total experimental studies.

In terms of geography, the experimental studies were predominantly conducted with an American sample of people (n = 46, 73% of experimental studies). The remaining countries were relatively much lower with the United Kingdom and Australia being next most common with only four and three studies each, respectively.

The experimental studies all employed response (dependant) variables measuring frame effectiveness. Although the response variables were usually specific to an action (see 'Detailed description of response variables' column in the SM database), we grouped them to observe the broad trends. The most common response variable used related to personal or collective efficacy (n = 36, 26% of experimental studies) or acceptance of the reality of climate change (n = 36, 26% of experimental studies). Examples of these types of response variables are attitudes towards pro-environmental behaviours, likelihood of taking collective action and intended political action, and also belief in climate change/global warming or belief in a consensus on climate change. The

other categories related to beliefs/attitudes regarding impacts/risks (n = 22, 16% of experimental studies), governmental action (n = 21, 15% of experimental studies), solutions (n = 2, 1% of experimental studies) and others (n = 19, 14% of experimental studies).

3.5.2. Observational studies

As the observational studies made up slightly more than half of the entire literature base, the frames for these are representative of the general totals: *Scientific* (n = 77, 18% of observational studies), *Economic* (n = 63, 15% of observational studies) and *Environmental* (n = 51, 12% of observational studies). Other common frames examined in observational studies were *Political conflict* (n = 39, 9% of observational studies), *Morality/Ethics* (n = 28, 7% of observational studies), *National Security* (n = 14, 3% of observational studies) and *External efficacy* (n = 12, 3% of observational studies). The most common type of observational study was analysis of the news media (n = 86, 61% of observational studies) with the second being mixed studies that analysed multiple data sources, such as news media, political documents or other online sources.

3.5.3. Discussion studies

Among discussion studies, the most common frames were *Scientific* (n = 34, 19% of discussion studies), *Economic* (n = 20, 11% of discussion studies) and *Disaster* (n = 16, 9% of discussion studies), which goes further than the impacts frames and describes climate change as apocalyptic or a catastrophe. Other studied frames were *Public health* (n = 17, 10% of discussion studies) and *Environmental* (n = 12, 7% of discussion studies). *Title framing* (n = 12, 7% of

discussion studies) was the next most examined in the discussion studies.

3.5.4. Synthesis studies

The synthesis studies are not very numerous (n = 5, 2% of total) compared with the other study types. The same trend of frames can be seen in this study type with *Scientific* (n = 3, 20% of synthesis studies), *Economic* (n = 3, 20% of synthesis studies), *Environmental* (n = 2, 13% of synthesis studies), *Public health* (n = 2, 13% of synthesis studies) and *National Security* (n = 2, 13% of synthesis studies) being the most prominent.

3.6. Extra dimensions of frames (how the frames were framed)

Frames in the typology can be used as ways to frame climate change, but most frames can also be communicated in various dimensions. An example of this is that the *Economic* frame can refer to either economic opportunities or costs of climate change. Similarly, the *Environmental* frame may discuss distant or local environmental impacts. Hence, we make the distinction between the core frames and the extra dimensions that can be applied to frames such as positive/negative or local/distant. These details can add extra dimensions of complexity when seeking to understand the efficacy of a frame. Hence, we have kept them separate to the frames themselves in order to not confuse the findings.

Forty-five studies applied extra dimensions to the frames. Of these the most common was distance (n = 26, 46% of multi-national studies). This involved applying a distance dimension (either geographic or social) to a frame. The second most common was valence (n = 11, 19% of multi-national studies) which is about applying a positive or negative aspect to the frame. Like with the addition of distance, this frame can be positive or negative when talking about climate change impacts.

3.7. Visualising the findings: EviAtlas output

To enhance the usability of this SM we have included an EviAtlas-compatible version of our map (Haddaway *et al* 2019). This is an interactive interface that plots the studies from this SM along with their associated data and could be of use to researchers and also climate change communication practitioners. The supplementary file 'EviAtlas_Framing climate change for effective communication_Badullovich-Grant-Colvin.csv' can be uploaded to https://estech.shinyapps.io/eviatlas/ where the entire SM can be visualised and the user can toggle different variables on and off to explore the trends in our SM.

4. Discussion

We have used a systematic mapping methodology to capture and collate the existing research on climate change framing. Through searching multiple scholarly and grey literature databases and repositories, 274 articles (281 studies) were included in the final SM. Climate change can be framed in many different ways (Nisbet 2009), and we have shown that framing research has examined a wide collection of these frames. Our SM shows that *Scientific, Economic* and *Environmental* frames are the most studied among the many climate change frames. Climate change has historically been seen (and arguably still is seen) as a scientific and environmental issue that has major implications, with one of those being impacts on economies. This encapsulates one of the predominant discourses of climate change (Pascoe *et al* 2019) and we see these being the major themes (or in this case, frames) in this literature base.

While these three frames have been the most studied in the literature, there has still been considerable attention given to frames such as *Morality/ethics, Political conflict, Public health, Disaster* and *National security. Religious* is a frame that can fall under *Morality/ethics* as it is a moral system that can be used for making judgement on climate change and motivating action. However, we have separated *Religious* as it is a relatively recent addition in the literature (peaking around 2016/2017) but has had some scholarly interest (Hayhoe *et al* 2019, Hempel and Smith 2019). Studies on other frames such as *Public health* have been occurring more frequently in the literature compared with emerging frames such as *Religious*. Accordingly, although the typology from Bolsen and Shapiro (2018) and Nisbet (2009) offers value for organising the dominant frames present in the literature, there are still gaps in our knowledge on the efficacy of alternative frames for climate change. These alternative frames provide opportunities for future research to further explore these understandings, and our SM has suggested a modified typology of climate change frames, building on those presented by Bolsen and Shapiro (2018) and Nisbet (2009), as summarised in figure 7, cross-tabulated against study location.

The most common study type identified in the literature corpus was observational, which analysed a phenomenon without direct intervention. The majority of these observational studies were analyses of frames used in the news media, meaning our data suggests that knowledge of extant climate change frames comes predominantly from the news media. Given many people get their scientific information from the news (e.g. Funk *et al* 2017), it is crucial we understand what frames are being used and where. This means we can track frames that are widely accessible and potentially affect understandings of climate change. By understanding what frames exist in the media, we can have a better idea of where to direct research efforts for understanding frame effectiveness and consequences. However, while news media analyses can inform us about what frames exist, they

	Title framing	Define problems						Moral judgements			Suggest remedies						Diagnose causes			
		Disaster	Economic	Environmental	National security	Public health	General	Morality/ethics	Religious	General	Response efficacy	External efficacy	Social progress	Self-efficacy	Middle-way	General	Scientific	Political conflict	Public accountability / governance	General
Africa				1										1			1			1
Asia		3	5	8	1	1						1	1				4	2		2
Asia/Europe	1		1	2	1			1									2	1		
Australia			3	3				1				1					4	1		
Europe		6	10	20	1	3	1	5	1	1	2	1	1		1	2	24	11	1	6
Europe/Asia		1	1	1								1					4	2		
North America	11	4	26	32	18	25	7	16	11	2	2	3	1	3		9	21	7	2	4
South America		1	8	6		1		1				2				2	6	5		1
Zealandia			3	2		1		2					2			1	2	1		
Multi-national	2	5	11	5	1	3	3	5		1	2	2	1	2		6	12	9	1	6

Figure 7. Density map of where the different frames have been studied. The continents represent the locations of the samples in the studies, not the location of the first author. Europe/Asia refers to countries such as Russia and Asia/Europe refers to countries such as Turkey.

generally cannot speak directly to how these frames affect social perceptions of climate change.

The second most common study type was discussion, which did not utilise primary data and generally provided a perspective or theoretical argument on climate change framing. What such studies can do is provide broader perspectives, drawing on different research to understand the bigger picture. Though they do not provide novel data, they can still contribute novel perspectives which help to set the direction for future research efforts. Due to study design, we suggest the experimental studies present the most appropriate type for use in full systematic reviews or meta-analyses. This would allow measured framing effects to be put together to determine if any net framing effects exist. However, care would need to be taken to ensure studies are being synthesised in the right way with the appropriate response variables. Additionally, future studies should consider which response variables are used to measure frame effectiveness. We noted a number of studies examining perceptions or attitudes to climate change. This is a critical aspect in developing a broad picture of climate change communication, though perceptions do not necessary translate into meaningful action (Leviston *et al* 2015). Future studies could consider prioritising behaviour-related response variables (Steg 2018). Understanding what motivates behaviour change and action on a personal and collective level will strengthen climate change communication outcomes.

Almost 50% of all studies identified in this systematic map are from the United States; with about 75% of the experimental studies being conducted in the US. This means our understanding of climate change framing effectiveness is largely coming from one specific socio-political context. Given the high levels of political polarisation on climate change in the US (Hornsey *et al* 2018, Bolsen and Shapiro 2018) it may be no surprise that efforts to understand framing in psychology have been focused in this region. However, it is worth cautioning that while these studies are relatively numerous in the US, the lessons learned may not be directly translatable to other countries. The US is unique in the way that climate change beliefs are strongly tied to ideology more than in many other countries (although Australia is a close second to the US) (Hornsey *et al* 2018, Nurse and Grant 2019). This highlights the significance of the social, cultural, and political context in which climate change is an object of communication, and as such frame effectiveness is likely to have a strong geographic dimension (Shih and Lin 2017, Zhang *et al* 2018). A more nuanced understanding of effective climate change framing would be achieved through more studies in underrepresented countries and, as others have called for, more multi-national comparison studies (Schäfer and O'Neill 2017). Encouragingly, we find this to be a prominent emerging trend in this literature. More than 20 multi-national studies were documented in the observational category, and these emerged from 2012, remaining fairly consistent in frequency in subsequent years with an anomalously high year in 2016. However, the majority of these multi-national studies are observational and hence we are yet to see this trend extend to experimental studies.

Framing research needs to be reflexive in its approach to understand how to frame the issue of climate change. Previous work has noted the

importance of values, beliefs and worldviews with respect to climate change engagement (Corner *et al* 2014). Hence, simply communicating the facts is generally insufficient in achieving positive communication outcomes (Corner *et al* 2015). Framing could be better understood within a two-way communication context (Stilgoe *et al* 2014), where the goal is not to persuade, but to open up productive dialogue. This builds on the call for framing in science communication more generally to be focused on opening up two-way communication (Scheufele 2014), and reflects recent research that has emphasised the importance of conversation for understanding of climate change (Goldberg *et al* 2019).

Our study highlights a strong tendency in the literature towards understanding unidirectional communication (in the media and experiments) whereas in reality, competing climate change frames exist together and in two-way communication contexts (Chong and Druckman 2007, Nisbet *et al* 2013). Limiting our understanding of effective framing to mostly unidirectional experimental studies or news media analyses—important as they are for understanding the framing puzzle—will not provide a full exploration of the social complexity of the role of framing in effective climate change communication. Future research could consider explorations into how framing can affect conversation, whether it can be used a tool to depolarise views, or better promote behaviour change.

This SM can act as useful tool for practitioners to probe the knowledge base and could facilitate more discussion between researchers and practitioners. We encourage the use of the SM database, available as an Excel file in the supplementary information, to support future research on climate change framing. Additionally, framing research needs to recognise the evolving nature of frame effectiveness and the power that different approaches such as qualitative methods can bring in terms of complementing existing research in efforts toward achieving a multi-dimensional understanding (Scheufele and Iyengar 2014, Schäfer and O'Neill 2017). Being reflexive in the approach to framing research, but also with regard to what constitutes effective framing is critical. It will enable us to develop a deeper understanding of productive climate change framing in communication. While there are valid questions about the efficacy of framing as a central strategy for effective communication (Nisbet 2019), we believe there is value to be gained from continued research in this field. This systematic map is a first step at bringing coherence to the evidence base, identifying the gaps and providing a way forward by focusing on synthesised understandings grounded in specific socio-political contexts.

4.1. Limitations

This systematic mapping project sought to collect all the relevant literature on climate change framing,

however there are some important limitations that we have outlined below in the interest of full transparency. Only English language articles were included which means our database is also skewed towards English speaking countries. This could be redressed by future updates on this systematic map involving a team of investigators that includes speakers of a range of languages, thereby accessing different literatures. Meanwhile, the term framing itself has a history of debate in the academic literature (Ardevol-Abreu 2015) and some studies may use different terms such as metaphors, themes or topics (e.g. Flusberg *et al* 2017, which explored the role of metaphorical framing). However, we only used variations of 'framing' which was the most prevalent term in the internal-check papers, and hence likely to be the most common in the literature base of interest (see section 2.1.3 for our keyword string). Additionally, including alternative terms would have complicated our approach as mixing different concepts would risk losing the nuanced understanding we can gain from examining framing specifically. Some papers may discuss framing but do not use these terms in the title or abstract and therefore this literature would be more difficult to pick up. This highlights the importance of using consistent terms when conducting framing research.

We adapted our search approach to capture all the relevant scholarly and grey literature, although there is always the chance that articles have been missed. Importantly, our searches revealed the presence of related literature outside of our focus area (e.g. visual framing or framing of related issues like air quality), and these were not included in our final SM. Defining the area of interest is important for putting boundaries on the literature searching (as mentioned earlier). Future studies can build on these limitations by exploring other related areas of climate change framing in mitigation; policy; and adaptation framing and also the role of imagery or visual framing. Finally, some articles were inaccessible, however, this number was only ∼3% of the entire database and hence, unlikely to affect the overall trends in our SM. As mentioned in the methods section, comments and suggestions during the peer-review stage prompted us to perform an additional screening pass on the excluded literature. This resulted in some extra articles being included, although it did not significantly change the key findings we drew from the SM.

A final point worth discussing concerns the methodology adopted for this systematic map. As mentioned above, systematic evidence syntheses present advantages through reducing biases, and scoping research areas, as was the aim of this study (James *et al* 2016, Haddaway *et al* 2016). However, while framing has seen rich discussion and theoretical development in different academic fields, it also suffers from vagueness and sometimes fuzzy definitional boundaries (Entman 1993, Scheufele and Iyengar 2014). This

presents a challenge as this type of methodology requires hard boundaries to be put on searching and inclusion criteria (see Collaboration for Environmental Evidence 2018). We encourage future primary research and evidence synthesis to ask new questions of the literature base and look to our included and excluded literature as a starting point for questions that differ from that which we explored in this SM. Literature excluded from this study offer value and utility for different research questions and explorations. Our study presents a first attempt at scoping the climate change framing literature, and we have been able to characterise the broad trends and general shape of the literature base. This paper does not present the final word on this climate change framing, but instead presents an important step in incorporating some systematic approaches and integrated evidence synthesis.

4.2. Conclusions

Framing is a way to emphasise certain aspects of reality over others, as a result shaping the ways in which that reality is understood. This means framing is a central aspect of communication, which is considered as a key area for helping gain public support for climate change solutions (Bernstein and Hoffmann 2019). We have used a systematic map methodology to search for scholarly and grey literature on the topic of climate change framing. After screening 6876 articles, we identified 281 relevant studies which have been included in the final database. After exploring some of the broad literature trends we believe this SM has made three key contributions.

First, we have characterised the types of studies within our literature corpus and found that the majority of studies are observational in nature with a large component of those being analyses of news media. However, there is also a considerable amount of experimental research which aims to empirically test the effectiveness of frames. These two types of studies are complementary as the former can identify the frames being used in the public domain and the latter can provide evidence on how climate change can be framed to engage different publics.

The second important finding of our research is that almost 50% of our understanding of climate change framing comes from the US. As effective science communication is dependent on factors such as political context (Scheufele 2014) and the values (Corner *et al* 2014) of different publics, it is important to recognise when lessons can be applied to the context of another country, and when they cannot. Situating insights about effectiveness of framing within the relevant geographical and cultural context is essential (Vu *et al* 2019). Likewise, conducting framing research that probes more understudied countries and/or utilises cross-national comparison

should be a priority for future research. We have confirmed that this is starting to become more common in this literature which is a sign that a shift may be occurring.

The final important contribution made by this systematic map is the identification of literature within the broad climate change framing literature corpus that are suited for deeper synthesis and analysis. For example, our systematic map has organised the literature by a range of variables, particularly including important factors such as study type and geography. Other scholars can use this map to conveniently identify sub-groups within the climate change framing literature for meta-analysis or systematic reviews. However, in this regard we note the importance of bounding deeper syntheses within the relevant socio-political context. New understandings will be accurate and meaningful only when the evidence base and the context of interest are appropriately aligned (i.e. insights from the US should inform understandings about the US, but not necessarily other nations with a different social and cultural context) (Hornsey *et al* 2018, Vu *et al* 2019). We suggest this SM can act as a reference tool, where studies can be filtered by country and the relevant literature can be identified in order to contribute to new, context-specific synthesised understandings. As such, we encourage other researchers and practitioners to make use of our SM database, available in the supplementary information.

We have shown that framing is still an area of scholarly interest and presents some areas of future development. Future research could embrace this diversity in study types and adopt both quantitative and qualitative research methods to help understand framing in these different contexts. Furthermore, framing should not be thought of only as a way of enhancing climate change messages, but also a way of opening up productive dialogue with publics of different values or socio-political standpoints (Scheufele 2018). That would then position framing as a useful strategy in many different unidirectional and multidirectional communication scenarios. Framing can be used to connect with different publics on climate change, but ought to be followed up with productive and thoughtful dialogue which takes into account varying values, beliefs, ideologies, and identities (Corner *et al* 2014). It is this reflexive approach to framing (and framing research) that presents a promising future direction in productively opening up the conversation on climate change and extending on the extant knowledge base outlined in this systematic map.

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Data availability statement

All data that support the findings of this study are included within the article (and any supplementary information files).

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