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# Community Resilience Planning: What New Methods Reveal About the Formation and Transformation of a Field

Jonathan Tollefson[1,2] | Scott Frickel[1] | Christina Gore[3] | Jennifer Helgeson[3]

[1]Department of Sociology, Brown University, Providence, Rhode Island, USA | [2]Department of Sociology, University of Chicago, Chicago, Illinois, USA | [3]Applied Economics Office, Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, Maryland, USA

**Correspondence:** Jonathan Tollefson (tollefson@uchicago.edu)

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## ABSTRACT

Community resilience planning (CRP) research encompasses diverse disciplinary foci, ranging from ecological and socio-political to engineering studies, and employs a range of analytic scales and methodologies. Despite the rise of integrative approaches to studying increasingly complex risks faced by communities—in particular, the growing, and often inequitable, impacts of climate and weather stressors and extremes—CRP remains a fragmented field of study and practice. This paper provides a broad map of the CRP field over the last 25 years, linking bibliometric methods with novel, network-based, multi-level approaches to computational text analysis. Despite trends toward interdisciplinary and transdisciplinary research, our analysis demonstrates that the CRP field consists of divergent bodies of research, characteristic of disciplinary siloing. At the same time, new approaches to computational text analysis provide innovative ways to understand the epistemic and social links across subfields, revealing patterns of connectivity that traditional citation-based bibliometric methods cannot access. Results indicate that the development and maturation of CRP are characterized in part by a longitudinal transformation in research methods and by a shift in substantive questions that CRP researchers are asking. These findings suggest that thematic and credit-based structures operate in tandem to produce complex webs of interconnection across the disciplinary domains that have historically constituted the field.

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## 1 | Introduction

This systematic review maps the field of community resilience planning (CRP) research since its emergence in the early 2000s, with a focus on whether its epistemic and social structures facilitate or constrain interdisciplinary knowledge and collaboration. Community resilience planning is an applied field of research concerned with the capacity of communities and regions "to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions" (McAllister 2015). CRP researchers have documented how increasing intensification, frequencies, and shifting baselines of climate-induced hazards, often combined with historical socioeconomic inequities and political marginalization, variously challenge impacted communities' ability to recover from hazard events while planning and preparing for the next ones (Ernst et al. 2023; Singh et al. 2023). In this context, some have described community resilience as a "national imperative" (Ge et al. 2023; National Academies of Sciences, Engineering, and Medicine (NASEM) et al. 2012), adding scientific and moral urgency to the question of whether and how CRP knowledge circulates across and beyond the field's own collaborative networks.

Community resilience planning has its roots in the early 1970s, as ecologists increasingly turned their attention to the behavior of ecological populations in response to disturbance. Resilience ecologists were primarily concerned with the ability of a system to return to equilibrium following external shocks: to "absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973, 17). Resilience did not imply stability, as a "system can be very resilient and still fluctuate greatly;" as such, early resilience frameworks understood ecosystem management as an open-ended project, and emphasized the importance of multi-scalar and heterogenous approaches in measuring, modeling, and managing ecosystems to support long-term resilience (Holling 1973, 17, 18). These core perspectives informed the application of resilience concepts to the relationship between social and ecological systems (Carpenter et al. 2001; Folke 2006), in the context of growing attention to the dynamic nature of system equilibria and long-term processes of system change (Holling 1996). Community resilience planning research, in turn, initially emerged from a synthesis between socio-ecological perspectives on resilience frameworks alongside research and policy attention to natural hazards, with a sustained focus on understanding, planning for, and adapting to emerging climate risks (Klein et al. 2003; Norris et al. 2008; Alexander 2013; Tollefson et al. Forthcoming). Resilience remains a central organizing concept for research on how communities withstand, adapt to, and recover from stressors, shocks, and disruptions. The present study targets research that draws on resilience concepts in order to understand the development of theoretical and applied research rooted in this specific conceptual framework.

Anchored by a series of Congressional funding efforts,[1] today CRP encompasses diverse disciplinary foci, ranging from ecological and sociopolitical research to engineering studies, and employs a range of analytic scales and methodologies. The field accommodates basic, applied, and community-driven approaches with support from a range of academic and other institutions, including universities, government agencies and planning boards, and private research organizations (e.g., First Street Foundation), as well as community and grassroots groups. Even so, CRP remains "unsettled" as an organizational field (Fligstein and McAdam 2012). There is variation across core concept definitions such as "community" (Moteff 2012; Humphreys 2019; National Academies of Sciences, Engineering, and Medicine et al. 2019) and "resilience" (Quinlan et al. 2016). Further, there is topical fragmentation (Fan and Lyu 2021), leaving the field in need of conceptual integration (Berkes and Ross 2013; Ge et al. 2023; Norris et al. 2008; Kirmayer et al. 2009) and strategies for translating scholarly research into action-based implementation (Clavin et al. 2023). Resilience frameworks are increasingly leveraged to understand a wide array of socio-ecological processes across the natural and social sciences (Brand and Jax 2007), raising important questions about the conceptual organization of CRP research; its structure and historical development; and what the rapid transformation of the field, since its initial emergence in the early 2000s, reveals about new trajectories in CRP research going forward.

Even as researchers have incorporated socio-environmental interactions into various dimensions of the resilience concept, evidence is emerging that the growth of community resilience as a local and national imperative was associated with solidification of the "engineering resilience" perspective—a policy-level approach to resilience planning that emphasizes "bouncing back to a previous 'normal' condition," rather than adapting to emergent risks (Lambrou and Loukaitou-Sideris 2022, 811). In a systematic analysis of resilience plans in US cities, Lambrou and Loukaitou-Sideris (2022, 827) find that engineering perspectives dominate city-level resilience plans, thereby "emphasizing a return to a previous state, normalizing risk, and eschewing (admittedly more difficult) opportunities for alternative and more just transformative potentials." Understanding how knowledge circulates across the field's diverse research areas thus has important implications for how communities plan for extreme events and climate hazards.

Our aim in this systematic review is to identify the dominant ideas shaping CRP's historical development and to examine the circulation of those ideas in relation to the research collaborations that generate the field's substantive knowledge. To do so, we analyse a bibliometric text corpus consisting of 2331 CRP studies published in academic journals. Building on systematic approaches to analyse large-scale text corpora (e.g., Lesnikowski et al. 2019), we employ a novel computational platform (Hannud Abdo et al. 2022) that allows researchers access to the fine-grain discursive structure of research fields at multiple levels by analysing relationships between topics (i.e., clusters of co-occurring words) and domains (i.e., clusters of topically-related articles). By studying how thematic domains are organized in relation to one another, how domains intersect with the social organization of the field, and how these relationships change over time, we can assess whether the field's structure facilitates or impedes knowledge generation, while also providing a high-level conceptual map of the development of CRP research over time.

## 2 | Data and Methods

### 2.1 | Data

Data for this study were generated from the Clarivate *Web of Science Core Collection* publication database, which indexes published research from approximately 34,000 academic journals and is a widely used data source for bibliometric analysis (Birkle et al. 2020; Visser et al. 2021). We conducted an "all fields" search across all available years to maximize the inclusion of publications representing the CRP field. We developed our search strategy through a reflexive process, iteratively refining the search string to capture the extended interdisciplinary breadth of the field while limiting the inclusion of extraneous publications. Because a general search for the terms "community," "resilience," and "planning" captures several parallel but unrelated literatures, including research in the mental health and psychology fields, we ultimately narrow our search strategy to target research on CRP in the context of natural hazards and vulnerability. We target the term "resilience," specifically, to capture research rooted in the synthesis of ecological and socio-environmental concepts outlined in the prior section.

$$\text{ALL} = (\text{communit}^*) \text{ AND ALL} = (\text{resilien}^*) \text{ AND ALL} = (\text{planning}) \text{ AND } (\text{ALL} = (\text{vulnerab}^*) \text{ OR ALL} = (\text{hazard}^*))$$

This search strategy returned a total of 2331 English-language research documents published from 1996 through the first quarter of 2023. Research articles make up 92% of the sample, which also contains review papers (6%), proceedings (1%), and commentaries and other material (1%). We include the latter publication types because prior research shows that reviews and editorial commentaries can be important communication strategies for framing and legitimating emergent interdisciplinary fields (Frickel 2004; McGreavy et al. 2013).

While our analysis begins in 1996, corresponding to the earliest publication identified by the selected search strategy, community resilience planning began to emerge as a distinct field of research during the 2008–2017 period, when annual publication counts first started to increase at a sustained rate. A second phase of field development began in 2018 with an exponential increase in publication rates, a productivity boom that produced nearly three quarters of the sampled documents.

Sampled documents appear in 644 different academic journals, with nearly two-thirds of these journals (58%) contributing just a single article to the corpus. Three journals with broad, transdisciplinary approaches—*International Journal of Disaster Risk Reduction* (est. 2012), *Sustainability* (est. 2009), and *Natural Hazards* (est. 1988)—form a nucleus that together accounts for 16% of total publications, suggesting a nascent organizational structure of publication.

## 2.2 | Methods

Our analysis takes advantage of the *Sashimi* toolset (Hannud Abdo et al. 2022), a new computational methodology that uses network-based text analysis methods to analyse the thematic organization of large-scale text corpora. *Sashimi* draws on Stochastic Block Modeling approaches to map the lexical structure of text documents and link text content with additional document-level metadata. We employ a local instance of the *Sashimi* Python module (https://gitlab.com/solstag/sashimi/) using computational resources provided by the Center for Computation and Visualization at Brown University.

The network analysis functions of the *Sashimi* toolset also allow us to link text analysis of article abstracts to information on publication dates and cited references. Specifically, we undertake (1) a thematic analysis to understand the epistemic structure of the field and (2) a temporal analysis to understand the evolution of the epistemic structure of the field over time. Then, (3) we join our thematic analysis with a multilevel network analysis of cited references to understand the relationship between the field's epistemic structure and its social organization.

### 2.2.1 | Thematic Analysis

We begin with a "domain-topic" analysis of article abstracts. The *Sashimi* approach to domain-topic analysis begins by identifying a mutually exclusive set of conceptual topics (see Figure 1, right panel). Much like traditional topic modeling approaches (cf. Murakami et al. 2017), topics are defined as mutually exclusive groups of terms that co-occur within abstracts across the corpus. Due to the rich nature of the source data, topics reflect coherent and consistent concepts. One representative topic, for instance, consists of the terms "indicators," "dimensions," and "measure," among other less frequent terms, and thus captures concepts related to measurement and indicators. Documents, in turn, can be understood through their relative connectivity to specific thematic topics, with the distribution of those topics characterizing the main theme(s) of an article. After terms are partitioned into mutually exclusive topics, the topics are then organized into a nested hierarchy ranging from the concrete to the abstract, with lower-level topics clustered within a decreasing number of higher-level topic groups. This hierarchical structure is generated as a Bayesian Stochastic Block Model (SBM), a graph clustering approach that forms the basis for the *Sashimi* domain-topic methodology (Peixoto 2014).

Domains, meanwhile, are groups of documents that are clustered according to the distribution of document-level topics, such that documents that draw on a similar set of topics occupy the same domain (see Figure 1, left panel). Like topics, domains are subsequently clustered into a multilevel hierarchy using an SBM approach. At the lowest, most specific level (Level 1), domains are defined by the topic terms that distinguish them from other Level 1 domains. For instance, a Level 1 domain that we label "healthcare" (see Table 2, next section) is defined primarily by the topic terms "health" and "care," while also drawing from topics related to disease and disability. Higher-level domain groups (Level 2, Level 3, etc.) are defined by the thematic commonalities shared across their constitutive sub-domains (see Hannud Abdo et al. 2022, 996, 997): The "healthcare" domain, for instance, joins with domains related to pandemics, public health, health in extreme events, recovery plans, psychological health, and mortality to form a Level 2 domain group capturing public health research, broadly defined (see Table 2, next section).

This hierarchical, nested domain structure makes it possible to understand the convergences between distinct research areas at multiple levels of granularity, as well as the key divisions between research clusters across multiple levels. In this way, domain-topic analysis allows us to understand the epistemic structure of a corpus on a hierarchical axis, revealing links between domains based on the clustering results at more abstract levels, in addition to mapping the field across a horizontal domain space at a given level of abstraction. The network architecture of the multilevel domain-topic structure thus affords a three-dimensional view of the data in a way that is unique from other approaches to computational text analysis.

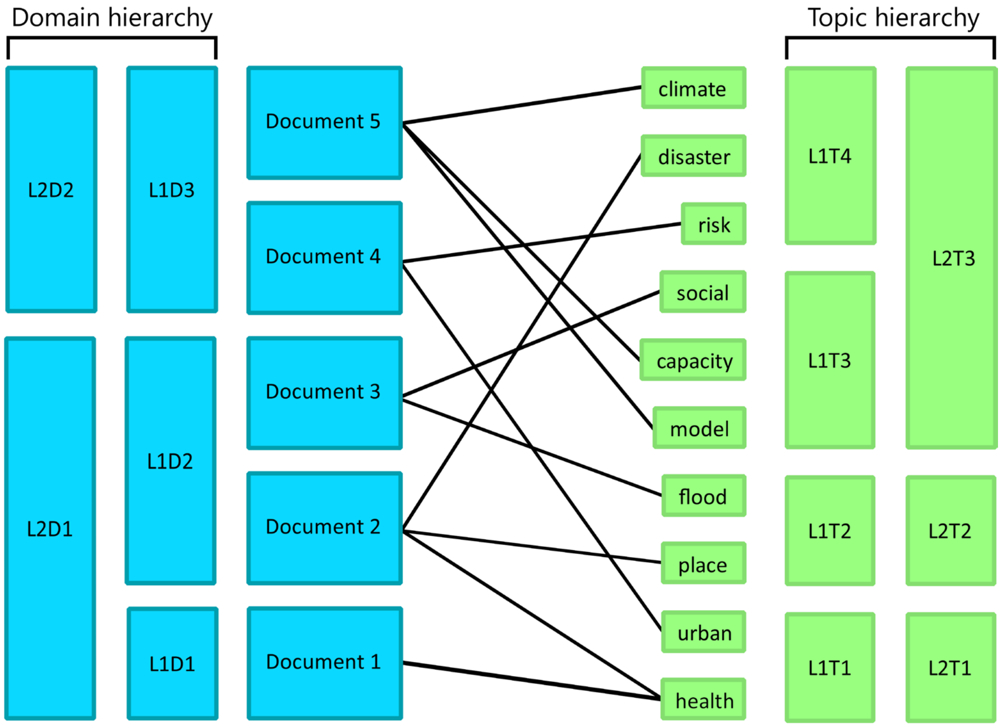


**FIGURE 1** | Example illustrating a multilevel domain-topic structure. In this example, specific domains and topics are labeled according to their position in the nested domain or topic hierarchy (Level 1, Level 2, or Level 3, referenced as L1, L2, or L3), alongside a unique number distinguishing them from other units at the same level. The result is a compound label: "L1D0" for Domain 0 at Level 1, for instance, or "L2T4" for Topic 4 at Level 2. Domain labels within the same level of the hierarchical structure are used to distinguish between mutually exclusive domains but hold no intrinsic ordinal meaning. See also Hannud Abdo et al. (2022).

**TABLE 1** | *Sashimi* hyperparameters.

| Parameter | Specification | Details |
|---|---|---|
| *N*-grams | 3 | *N*-grams permitted, up to $N=3$. |
| Stop word approach | Topic | Stop words retained in input text data. The *Sashimi* SBM approach clusters stop words in a single topic, which is then removed from analysis. |
| Min. blocks | Free | Number of blocks allowed to vary freely. Blocks at each level inferred from input data (Hannud Abdo et al. 2022, 995). |
| Max. blocks | Free | Number of blocks allowed to vary freely. Blocks at each level inferred from input data (Hannud Abdo et al. 2022, 995). |
| Block levels | Free | Number of levels allowed to vary freely. Hierarchical structure inferred from input data. |

Because SBM is based on a Markov Chain Monte Carlo approach and therefore contains inherent randomness, we ran 30 separate models and selected the iteration with the lowest entropy score, following advice from *Sashimi* developers (see Hannud Abdo et al. 2022; Breucker et al. 2016). Entropy scores are computed using negative log likelihood, a standard model heuristic. Stochastic Block Model hyperparameters were defined according to Table 1.

### 2.2.2 | Linking Thematic Analysis to Temporal Change and Citation Structures

Subsequent parts of our analysis seek to understand the temporal and social organization of the CRP corpus in relation to the epistemic structures revealed by the domain-topic analysis. To do so, we draw on the network functions of the *Sashimi* toolset to model additional multilevel clusters of two distinct document-level variables. This approach holds fixed the initial domain-topic structure outlined above while fitting the SBM to additional document-level metadata, an approach that *Sashimi* developers call a "domain-chained" model (Hannud Abdo et al. 2022, 993).

First, we introduce publication date as an additional "chained" variable to identify temporal variance in the field's epistemic structure. This approach clusters document publication dates according to their distribution across thematic domains. Examining the network connectivity between domains and publication date clusters allows us to understand how the epistemic structure of the corpus changed as the field developed over time.

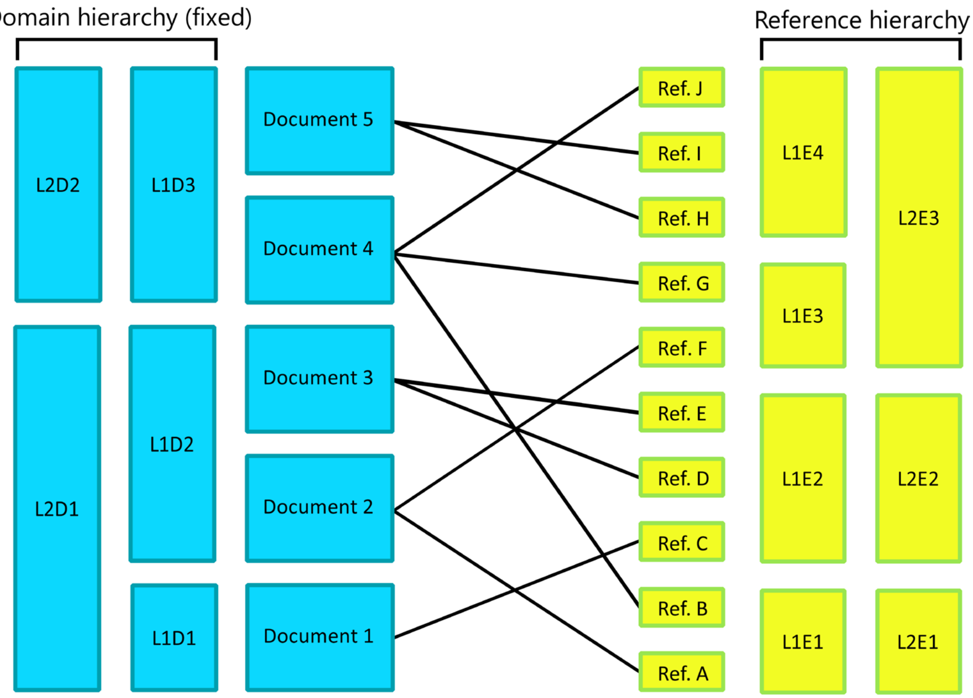


**FIGURE 2** | Example illustrating a multilevel domain-chained structure for cited references. Domains are held fixed while reference clusters are allowed to vary to best fit references to the domain-topic structure. Like domains and topics, reference clusters in this example are identified with a compound label denoting their position in the hierarchy (L1, L2, etc.) as well as a unique label distinguishing them from other clusters at the same level (L1E1 for citation cluster 1 at Level 1, for instance). The same process is applied to infer temporal clusters. See also Hannud Abdo et al. (2022).

Next, we chain the domain-topic model to the 108,856 unique references cited by articles in the corpus. This analysis produces clusters of cited references partitioned according to their distribution across the domain-topic network, allowing us to analyse the links between the epistemic and social structures of the field at multiple levels of abstraction (see Figure 2, right panel). This approach is particularly useful for revealing the social-epistemic structure of newly developing and highly interdisciplinary fields, like CRP, whose social organization reflects the rapid diffusion of attention to mutually shared questions or substantive foci (Parker and Hackett 2012), rather than longstanding normative conventions and canonical literatures characteristic of more established disciplinary fields (e.g., Mullins 1972).

## 3 | Results

### 3.1 | Thematic Analysis

We evaluate the epistemic structure of the CRP field using a domain-topic analysis of article abstracts, which provides a detailed thematic map of how the field's discourse is organized across multiple levels. Evaluating a domain-topic model for the CRP corpus produced an initial list of 67 unique topics, consisting of groups of terms clustered according to their co-occurrence across research documents. Subsequently, the corpus was partitioned into a multilevel domain structure based on the distribution of topics among research documents. The result is a thematic map made up of 61 mutually exclusive Level 1 domains, consisting of research documents that share a topical focus. These 61 Level 1 domains are in turn clustered within 10 Level 2 domain groups, which are themselves partitioned across two Level 3 clusters: one Level 3 group focusing on impact modeling, and a second Level 3 group lacking a modeling focus. This split across impact modeling themes represents the broadest and most abstract thematic division in the field, and is a key finding we return to throughout the following sections. In our results, the common elements defining mid-level Level 2 domain groups represent distinct thematic research areas, while the base Level 1 domains represent narrow subareas within the broader domain landscape. That granularity, however, also limits their usefulness: because Level 1 domains are defined by a highly specific set of thematic commonalities, the thematic characteristics and temporal trajectories of individual domains reveal little about the development of the field as a whole. For this reason, we focus most of our attention on Level 2 domain groups, as they provide a useful balance between the highly specific Level 1 subareas and the highly abstract Level 3 division. The thematic areas that make up this mid-level structure provide a base of understanding for our subsequent analysis of temporal changes in the field, as well as our final analysis of the relationship between the epistemic structure and social organization of CRP research. We additionally return to several Level 1 domains in the final results section.

Table 2 reports the full domain structure revealed by the analysis. For Level 1 domains, we assign domain labels based on the specific topic terms that define a given domain (data available on request). For Level 2 and 3 domain groups, labels are assigned based on the topic terms that are common across their lower-level domains, as well as the substantive content of those constitutive research areas. Due to the nested nature

**TABLE 2** | Multilevel domain structure. Domain labels (e.g., "public health") assigned by authors based on constitutive publications (for L1 domains) and constitutive sub-domains (for L2 and L3 domain groups).

| ***L3 domain group*: Common terms*** | ***L2 domain group*: Common terms*** | **Constitutive L1 domains** |
|---|---|---|
| *Non-modeling domains* | *Public health*: health; pandemic; women | Pandemic |
| | | Public health |
| | | Healthcare |
| | | Extreme events and health |
| | | Recovery plans |
| | | Psychological |
| | | Mortality |
| | *Natural hazards*: natural; analysis; results | Hazards and plans |
| | | Risk and risk perception |
| | | Flood risk assessment |
| | | Resilience indicators |
| | | Energy |
| | | Urban sustainability |
| | | Vulnerability indices |
| | | Recovery and housing |
| | | Earthquakes |
| | | Building performance and damage |
| | | Local governance, risk reduction |
| | | Flood |
| | | Supply chain, territorial imbalances |
| | | Preparedness and perception |
| | | Urban reconstruction after disaster |
| | | Tsunami |
| | *Ecosystem changes*: changes | Water |
| | | Fisheries |
| | | Rivers, extreme events |
| | | Forest, adaptation, national priorities |
| | | Species |
| | | Forest |
| | | Coral, marine |
| | *Infrastructure and localities*: infrastructure | Infrastructure |
| | | Local adaptation |
| | | Community research, heritage, tourism |
| | | Coastal |

(Continues)

**TABLE 2** | (Continued)

| *L3 domain group*: Common terms* | *L2 domain group*: Common terms* | Constitutive L1 domains |
|---|---|---|
| | *Climate change strategies*: climate; change; agricultural | Adaptation and resources |
| | | Coastal impacts |
| | | Vulnerability indices |
| | | Flooding, extreme events |
| | | Socio-eco. Resilience and sustainability |
| | | Farmers and production |
| | | Adaptation and indigenous knowledge |
| | | Fire, wildfire |
| | | Adaptation stakeholders |
| | | Household livelihoods, food |
| | *Healthcare*: healthcare; violence; young | Hiv |
| | | Place |
| | | Solidarity |
| *Impact modeling*: time; model; area | *Future impacts*: region; future; impacts | Health, climate |
| | | Heat |
| | | Development, resource |
| | | Livestock, husbandry, reindeer |
| | | Aquifer and watershed modeling |
| | | Whales, forecasts |
| | *Policy*: policies; manage; parcels | Modeling building performance |
| | | Governance, policy, actors, discourse |
| | *Located/area*: located; area; areas | Evacuation |
| | | Adaptive capacity |
| | | Landslides |
| | | Debris, susceptibility |
| | *Ecosystems and biodiversity*: ecosystem; diversity; functional | Functional, ecosystem, landscape |
| | | Vegetation and soil |

*Selected topic terms that are common across the various sub-domains that make up a given domain group. Level 2 and 3 domain groups are assigned labels according to these common terms in addition to the specific foci of constitutive sub-domains.

of the analysis, research areas should be interpreted according to their position in the multilevel domain hierarchy: The research areas nested within the Level 3 *impact modeling* group, for instance, are understood to carry a common modeling focus, alongside the specific characteristics that distinguish different lower-level domains from one another.

The prevalence of Level 2 domain groups across the corpus maps the relative importance of different research areas within the CRP field. As Figure 3 reveals, *natural hazards* represents the most prevalent domain group, accounting for 32% of the corpus. Smaller thematic domains include *infrastructure and localities* (20%), *climate change strategies* (16%), two health-related domain groups (*healthcare* and *public health*; 11% in total), and *ecosystem changes* (9%).

Finally, we identify four Level 2 domain groups related to modeling, measurement, and impacts, which together constitute about 12% of the documents overall. These four Level 2 groups are separated from the rest of the corpus within a distinct Level 3 domain group (*impact modeling*). The *impact modeling* group consists of a wide range of substantive research areas linked by a shared focus on modeling, measurement, and impact. Though the *impact modeling* domains make up a relatively small

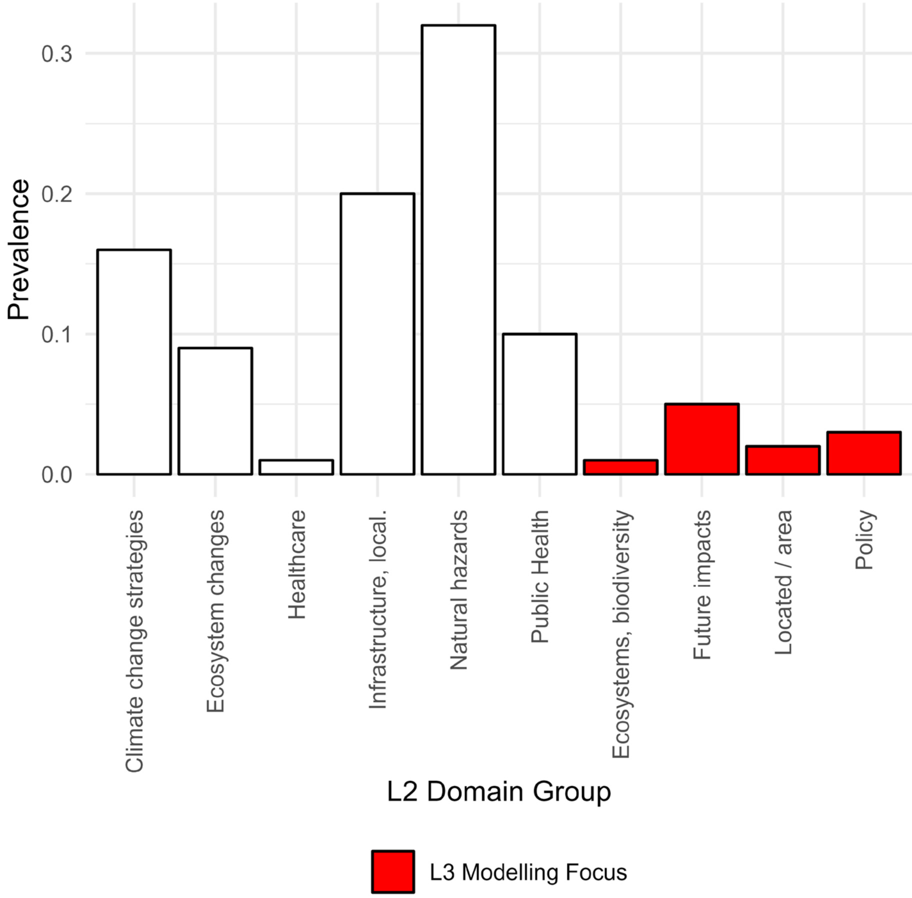


**FIGURE 3** | Level 2 domain groups, prevalence across full CRP corpus. Prevalence measured as the proportion of documents within the full corpus contained by that domain. Note that only two domains are present at Level 3: One Level 3 group (*impact modeling*) clusters domains with a specific focus on modeling future impacts; the other Level 3 group contains all remaining Level 2 domains without a modeling focus. Level 2 domains shaded in red should therefore be interpreted as these themes relate to impact modeling (e.g., *the local and areal dimensions of impact modeling*).

proportion of the entire corpus, this Level 3 split between *impact modeling* domains and the rest of the field represents the fundamental thematic division in CRP research.

## 3.2 | Temporal Analysis

To understand the temporal development of the field's epistemic structure, we use a domain-chained modeling approach to cluster publication dates by their network connectivity to the thematic domains evaluated above. This analysis reveals a key thematic split between 2015 and 2016, corresponding to the period of exponential growth in the field that began in the latter half of the 2010s. We evaluate change over time using the relative prevalence of domains in 2016–2023 compared to the 1996–2015 period (see Equation 1).

$$\text{Relative Prevalence} = \frac{\left(\frac{\text{Documents in domain, 2016–2023}}{\text{Total documents in corpus, 2016–2023}}\right)}{\left(\frac{\text{Documents in domain, 1996–2015}}{\text{Total documents in corpus, 1996–2015}}\right)} \quad (1)$$

Relative prevalence of a domain within the 2016–2023 period compared to 1996–2015. A relative prevalence of 2 indicates that a particular domain is twice as common in the latter period compared to 1996–2015; conversely, a relative prevalence of 0.5 means that a domain is half as common between 2016 and 2023 compared to the earlier period.

Figure 4 displays the relative prevalence of Level 2 domain groups in the 2016–2023 cluster compared to the earlier period. Notably, the core *natural hazards* domain group emerges as the only mid-level research area that remains a consistent and significant presence in the field over time, contributing about a third of the research documents across both periodized clusters, even as the field grew exponentially in the post-2016 period. In contrast, other domain groups exhibit significant temporal variation. Research on *public health* and *infrastructure and localities* both grew by about 20% as CRP expanded after 2016. At the same time, the prevalence of basic research on ecosystems changes and natural resource industries (*ecosystem changes*) and the *climate change strategies* group declined significantly, by about 50% and 20%, respectively (the small *healthcare* domain group, which contains just 17 research documents in total, declined by about 50% as well).

The most dramatic temporal shift is the growth of domains related to modeling, measurement, and impacts. Though it accounted for a relatively small portion of the field during its initial formation in the early 2000s, the Level 3 *impact modeling* group is nearly

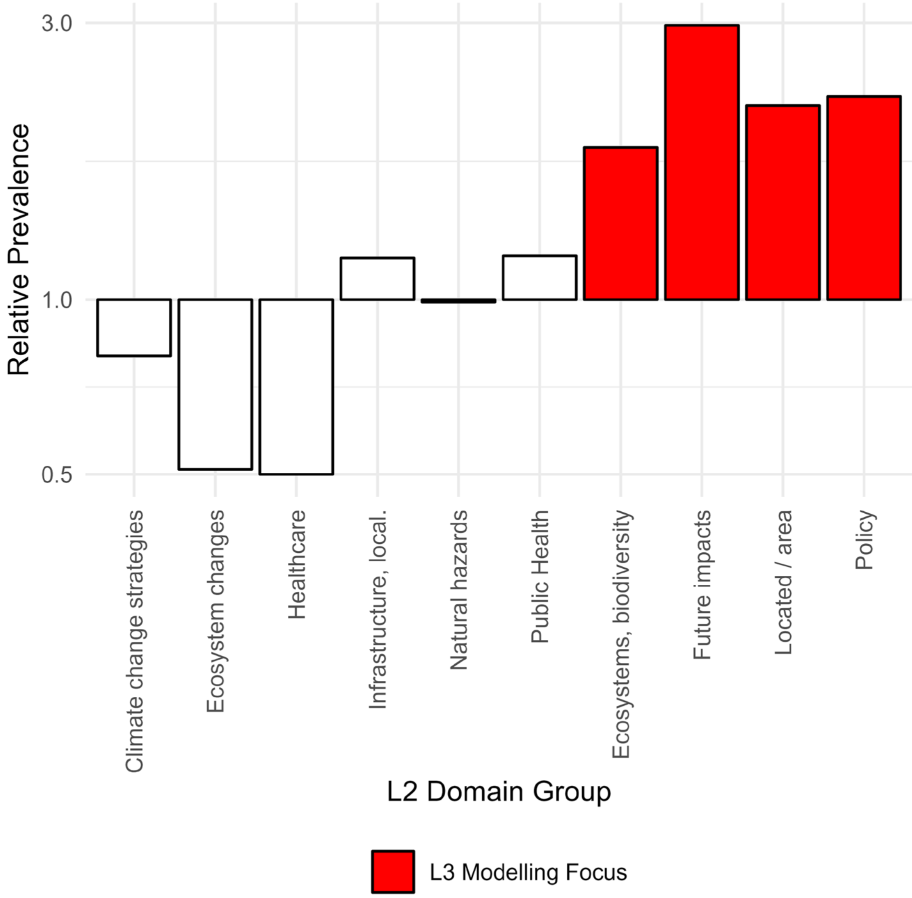


**FIGURE 4** | Relative prevalence of Level 2 domain groups in 2016–2023 compared to the 1996–2015 period. Relative prevalence calculated according to Equation (1). Note that only two domains are present at Level 3. One Level 3 group (*impact modeling*) clusters domains with a specific focus on modeling future impacts; the other Level 3 group contains all remaining Level 2 domains without a modeling focus. Level 2 domains shaded in red should therefore be interpreted as these themes relate to impact modeling (e.g., *the local and areal dimensions of impact modeling*).

2.5 times more prevalent during the recent expansion in community resilience research compared to the pre-2016 period. Thus, the thematic evolution of CRP maps onto the most abstract division in the epistemic structure of the field, as CRP research has increasingly shifted toward an impact modeling focus over time.

### 3.3 | Social Organization of CRP Research

As represented by the domain-topic analysis, CRP has emerged as a diverse array of research areas with significant temporal variability. Aside from the consistent and strong presence of natural hazards research, we observe relatively little thematic convergence. Instead, we find evidence for a growing disciplinary and methodological divide between *impact modeling* domains and an older body of research that lacks a modeling focus. The question thus remains: To what degree is the community resilience field held together by a shared literature? Where does the field converge based on its formal, citation-based social organization—and where does it diverge? To answer these questions, we constructed an additional domain-chained model focusing on the 108,856 unique references cited across the CRP corpus.

This approach clusters cited references according to their connectivity with the thematic domains analysed above, revealing pathways for the interdisciplinary transmission of CRP knowledge. Analysing the formal links between the epistemic structure (via thematic domains) and social organization (via co-citation clusters) of the field has the potential to reveal emerging connections across disciplines—connections that may be obscured by an approach that focuses on text analysis or citation network approaches alone.[2]

The domain-chained analysis of cited references produced 35 unique Level 1 citation clusters grouped into 18 Level 2 cluster groups; these Level 2 groups, in turn, are organized into nine clusters at Level 3. The large number of references cited across the corpus provides abundant material for our network clustering analysis, leading to significant differentiation at Level 3. For this reason, we primarily focus on these higher-order citation clusters, as they allow us to examine broad trends across the field.

Figure 5 outlines the patterns we observe in the distribution of the nine Level 3 clusters, along with a description of their connectivity to different thematic domains. We rely on two related measures to assess connectivity patterns across the corpus. The first is the standard deviation (SD) of the connectivity between each Level 3 citation cluster and the 62 Level 1 thematic domains, calculated using a modified version of the relative

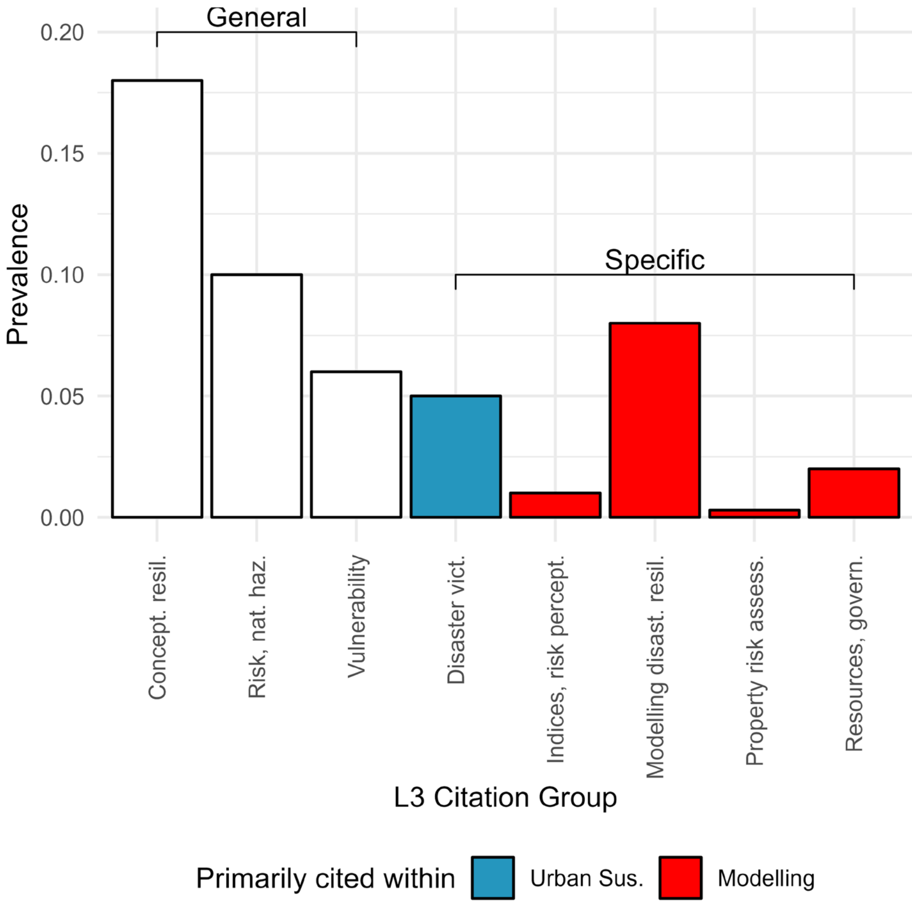


**FIGURE 5** | Relative prevalence of L3 citation clusters. "General" and "specific" connectivity patterns coded according to information presented in Table S1. Four citation clusters are primarily cited within L1 domains related to modeling and measurement. One ("disaster victims") is primarily cited within the *urban sustainability* domain.

prevalence metric outlined above. The second measure is the proportion of the Level 1 domains that display zero connectivity to a given Level 3 citation cluster. Together, these two metrics reveal the distribution of Level 3 citation clusters across the epistemic structure of the corpus: High SD and a high zero connectivity rate indicate that a citation cluster is disproportionately cited in some domains while appearing only rarely in others (coded as a "specific" connectivity pattern in Figure 5; see Table S1, for SD and rates of zero connectivity). Conversely, low SD and a low zero connectivity rate indicate that the citations within a given Level 3 cluster are distributed widely and evenly across the thematic domains (coded as a "general" connectivity pattern in Figure 5).

### 3.3.1 | High-Level Divisions in the Social Organization of CRP Research

Citation analysis reveals several high-level divisions in the social organization of CRP research. Five Level 3 citation clusters exhibit strong connectivity to a narrow range of thematic domains while escaping the attention of domains outside their specific area. Four of these clusters ("modeling for disaster resilience;" "indices and risk perception;" "resources and governance;" "property risk assessment") are primarily cited within the growing *impact modeling* domains, while the fifth ("disaster victims") is primarily cited in research about urban sustainability. Of these, two clusters ("resources and governance;" "property risk assessment") are cited within modeling domains alone.

At Level 3, the growing thematic domains related to *impact modeling* and *urban sustainability* tend to reference literature that is almost completely invisible to the rest of the corpus, relying heavily on relatively narrow citation clusters. Citation analysis reveals that the social organization of CRP thus reflects the thematic divisions outlined in the previous sections, as a series of narrow citation groups define an equally narrow range of thematic subject areas, yet are rarely—if ever—cited in CRP more generally. The convergence of thematic domains and citation clusters suggests that impact modeling research may represent a distinct disciplinary silo within a broadly interdisciplinary field, an important point we return to in the discussion.

### 3.3.2 | General Patterns of Interdisciplinary Connectivity

What, then, holds the field together? Despite the emergence of the high-level divisions outlined above, we also observe three Level 3 citation clusters that are linked to a wide array of thematic domains. Rather than defining particular thematic subareas, these clusters draw important links across the various domains of the field. We hypothesize that these field-spanning citation clusters are particularly important to the structural coherence and identity of CRP overall.

Three Level 3 citation clusters exhibit general connectivity to a range of thematic domains, accounting for 34% of the total cited references. The first, "conceptualizing resilience," is the strongest linking cluster, exhibiting positive, non-zero connectivity to every domain across the corpus. "Conceptualizing resilience" contains many of the most widely cited references across the corpus, including work by Cutter et al. (2008), Norris et al. (2008), Adger (2006), Folke (2006), and Smit and Wandel (2006), as well as Holling's foundational 1973 paper. Together, the articles comprising "conceptualizing resilience" form a core citation cluster that links divergent domains across the field, representing a set of ideas that circulate widely across CRP. This includes the various modeling domains—a significant finding, given that the *impact modeling* domains draw on topics and citation clusters that are generally absent from the wider corpus.

"Conceptualizing resilience" is less common among modeling domains, however, appearing about half as often as in domains outside the modeling group. "Conceptualizing resilience" is also disproportionately associated with declining research areas, including the Level 1 domains *local adaptation* (which saw an 11% relative decline between the two temporal clusters), *socio-ecological resilience and sustainability* (44% relative decline), *adaptation stakeholders* (54%), and *forest, adaptation, and national priorities* (66%).[3] The decline in thematic domains that prominently feature the core "conceptualizing resilience" cluster, alongside the relatively low importance of that cluster within the ascendant modeling domains, suggests that CRP is shifting away from the literatures that formed the core of its initial formation in the early 2000s. The patterns observed in "conceptualizing resilience" are repeated across the two remaining generally-cited clusters ("vulnerability and risk" and "natural hazards") as well, with some variation in their specific thematic links.

#### 3.3.3 | Granular Patterns of Interdisciplinary Connectivity

Linking thematic and citation analysis reveals more granular patterns of interdisciplinary connectivity, as well. In addition to the field-spanning clusters outlined above, we also observe a range of small-scale links across disciplinary and methodological boundaries, driven primarily by substantive connections rather than by a shared theoretical literature. To map these more granular patterns, we turn our attention to the relationship between Level 3 citation clusters and the 61 Level 1 thematic domains that make up the most granular level of the field's epistemic structure.

The "modeling for disaster resilience" citation cluster clearly displays this form of low-level interdisciplinary connectivity. "Modeling for disaster resilience" is primarily cited within a narrow Level 1 modeling domain (*modeling building performance*), yet it is also widely cited in *building performance and damage* and *infrastructure*, a pair of closely related Level 1 domains that fall outside of the modeling field. In this way, "modeling for disaster resilience" forms an important point of intersection for research on building performance and infrastructure within and outside of the *impact modeling* domain group, representing one of the few social links between modeling studies and other thematic domains.

We observe similar inter-thematic connections with the "indices and risk perception" citation cluster, which links two Level 1 sub-domains of the *impact modeling* literature (*landslides* and *adaptive capacity*) with several domains that fall outside of the narrow scope of *impact modeling*, including a small subset of the *climate change* and *natural hazards* domain groups (*climate adaptation; vulnerability indices; earthquakes; resilience indicators; floods;* and *risk perception*). Thus, granular cross-citation links draw important social connections across the *impact modeling* divide. This emergent pattern of interdisciplinary knowledge exchange is likely to accelerate as the modeling literature moves closer to the centre of the field.

## 4 | Discussion and Conclusion

Community resilience planning has seen accelerated growth over the last two decades, expanding significantly beyond its conceptual and substantive origins at the intersection of ecology, ecosystem management, and social-environmental relations. Building on a consistent core of natural hazards and climate change research, we find that the field has gradually shifted to accommodate a growing focus on applied disciplines, particularly related to infrastructure and public health. To a still greater degree, we find that CRP is increasingly driven by a substantive and methodological focus on research that develops, discusses, references, or takes advantage of high-level measurement and modeling approaches. The rapid ascent of modeling literatures is joined by a fundamental division between research with and without a modeling focus. This split is replicated in the thematic content of research articles as well as the circulation of credit across the field: research that forefronts modeling approaches speaks a different language—and cites a different literature—than the main body of CRP.

Community resilience planning thus remains an unsettled field, even as the need for enhanced community resilience demands an integrated response from policymakers, practitioners, and researchers. We introduce novel methods that help resolve this misalignment, revealing how disciplinary and interdisciplinary processes are concurrently shaping the production of CRP knowledge (Adams and Light 2014). Our findings show that emerging structures of interconnection in CRP are forming through granular cross-citation linkages between new modeling domains and core areas of traditional research. This cross-pollination is driven primarily by specific substantive connections between closely related domains that fall on opposite sides of the modeling divide. These findings suggest that interdisciplinary integration may be accomplished at a more granular level, taking place within substantive subfields rather than across the broader CRP space.

As climate and weather hazards, disasters, and extreme events grow in prevalence, severity, and complexity, it becomes imperative that the knowledge produced by the field circulates efficiently and widely. Identifying nodes of interdisciplinary integration thus suggests several avenues for coordinating research and policy efforts to effectively understand and respond to increasingly complex threats to communities. As a practical response, researchers may begin targeting the granular research areas that link across divisions in the field to understand the structural and strategic conditions enabling these new and unexpected forms of interdisciplinarity. Building from these points of interconnection may facilitate interdisciplinary communication in a way that adapts to ongoing changes in the social-epistemic structure of the field. Funders and policymakers can similarly target efforts for interdisciplinary integration in places that are already starting to emerge.

The line of inquiry introduced here can also contribute to a theoretical understanding of disciplinary and interdisciplinary processes that constitute research fields more broadly. Though interdisciplinarity has long been touted as a panacea for the theory-driven knowledge generated by disciplines (e.g., Klein 1996), a growing number of empirical studies cast doubt on the aspirational claims of interdisciplinarity proponents, noting the academic risks and penalties associated with interdisciplinary scholarship (Leahey et al. 2017), power imbalances that reinforce disciplinary hierarchies within interdisciplinary settings (Frickel et al. 2016), and the potential for interdisciplinary practice to exacerbate tendencies toward specialization and fragmentation (e.g., Jacobs 2014). Moreover, as Adams and Light (2014) have shown, some fields are constituted through concurrent disciplinary and interdisciplinary processes that are inherently uneven and shape the power dynamics operating within the field. This, in turn, can impact whether and how ideas circulate and how knowledge from the field is or is not implemented in applied settings—a finding that has direct implications for CRP, where valuable, targeted research can help communities plan and respond more effectively.

Methodologically, the present paper highlights the utility of multilevel approaches for mapping the evolution of research fields over time. Because patterns of interdisciplinary interconnectivity form a relatively weak signal compared to the strong intradisciplinary ties that define CRP's distinct subfields, such patterns, as revealed here, would likely be overlooked in studies using conventional bibliometric methods. Multilevel text analysis methodologies capture how field development is shaped by highly granular discursive processes; citation-based methods, meanwhile, capture the development of a research field through the circulation of credit and credibility. Integrating text-based methodologies alongside a formal analysis of citation structures allows for a direct comparison between these two distinct dimensions of field development, as research networks are constituted and reconstituted through the intersection of epistemic and social processes of field formation.

Together, our findings suggest that CRP research is undergoing a substantive and structural transition. A substantive turn to research focused on modeling approaches is joined by a growing epistemic and social gap between modeling research and the main body of the field. At the same time, we identify low-level structures of interdisciplinarity that persist despite growing disciplinary divisions. We expect that these transitions are still ongoing. Further research may investigate the durability of these emerging disciplinary and interdisciplinary structures as the field continues to develop, especially within the context of policy and funding shifts. The present study serves as a useful baseline for future research on the development of applied research fields in the context of accelerated regulatory capture (cf. Carpenter and Moss 2013). Further research, which we are beginning to explore, may also look to understand the relationship between CRP research and policy to understand how scholarly research shapes policy production; feedback mechanisms across the research-policy nexus; and how the policy process reshapes and recontextualizes scholarly research at the municipal, regional, and national scale.

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### Author Contributions

**Jonathan Tollefson:** conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), software (equal), validation (equal), visualization (equal), writing – original draft (equal), writing – review and editing (equal). **Scott Frickel:** conceptualization (equal), data curation (equal), funding acquisition (equal), investigation (equal), project administration (equal), resources (equal), supervision (equal), validation (equal), writing – original draft (equal), writing – review and editing (equal). **Christina Gore:** conceptualization (equal), data curation (equal), investigation (equal), validation (equal), writing – original draft (equal), writing – review and editing (equal). **Jennifer Helgeson:** conceptualization (equal), data curation (equal), funding acquisition (equal), investigation (equal), project administration (equal), resources (equal), supervision (equal), validation (equal), writing – original draft (equal), writing – review and editing (equal).


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### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The data that supports the findings of this study are available in the manuscript and also on reasonable request from the corresponding author.

### Related WIREs Articles

Resilience implications of policy responses to climate change

The dynamics of vulnerability: why adapting to climate variability will not always prepare us for climate change

Frontiers in data analytics for adaptation research: Topic modeling

Adaptation and resilience: responding to a changing climate

### Endnotes

[1] In the U.S., these efforts began with the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 and are ongoing through the Disaster Recovery Reform Act (DRRA) of 2018.

[2] Co-citation analyses rely solely on co-citation frequency to construct network connections (e.g., Small 1973). By highlighting these strong, frequent, and often discipline-specific co-occurrences, co-citation analyses may reify disciplinary boundaries when applied to newly emergent, interdisciplinary fields. Co-citation frequency may bear little relation to an emerging field's epistemic structure, while obfuscating the connections across fields that are more likely to be characterized by thematic overlap than co-citation frequency.

[3] "Conceptualizing resilience" is also disproportionately cited in the Level 1 domain *adaptation and indigenous knowledge*, a research area that accounts for a greater proportion of the CRP field over time. The rise of this domain likely reflects a general increase in research on Indigenous knowledge and sovereignty across fields (see Bohensky and Maru 2011; Nikolakis et al. 2024).

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** wcc70015-sup-0001-supinfo.docx.