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Scientists, censorship, and suppression: A combined comparative-processual analysis of U.S. cases involving chemical and climate change expertise

David J. Hess

Department of Sociology, Vanderbilt University, Nashville, Tennessee, USA

Correspondence
David J. Hess, Department of Sociology, Vanderbilt University, PMB 351811, Nashville, TN 37235-1811, USA.
Email: david.j.hess@vanderbilt.edu

Abstract

Although scientific research is often crucial for efforts to achieve improved environmental regulation for industrial products and processes, scientists who document or publicize research on possible risks can face suppression or censorship by industry, government, and other actors. This study contributes to the sociology of science by examining the challenges and responses of environmental scientists in the U.S. in two research areas: toxic chemicals and climate change. Drawing on comparative and processual methods applied to a small-N, unique data set of cases, the study conducts formal coding of variables for contextual conditions and four general categories of the suppression sequence: triggering circumstances and actions, suppression actions, responses, and outcomes. The first stage of the analysis identifies significant relationships between contextual conditions and the suppression sequence, such as the different forms of suppression that government employees and university professors face. The second stage identifies three composite processual sequences: employment risk for government scientists, records attacks for both government and university scientists, and reputation attacks on university scientists. Together, the two types of analysis advance research by identifying novel relationships in a more systematic way than is accomplished with the standard approach of one or a few cases. The approach also examines the benefits of a mode of comparative analysis that can be more readily connected with theory testing via process tracing at the case level. The practical issue of responding to suppression or censorship is considered, which could be of value to environmental scientists and their partners.

KEYWORDS
climate science, environment, expertise, science, suppression, toxics

1 | INTRODUCTION

Industries have long shown concern with scientific research that could lead to greater public awareness of risks from toxic exposure (Markowitz & Rosner, 2013; Michaels, 2008). Furthermore, as awareness of climate change increased, industrial attempts to obstruct research that could trigger regulatory oversight increasingly have included the fossil-fuel industry, which has funded research to discredit climate science (Brulle, 2014, 2023). In addition to attempts to undermine unwanted science, industrial actors have also funded political parties and candidates that oppose more stringent environmental regulation, and they have contributed to political polarization (Carmichael et al., 2017; McCright et al., 2014). When such candidates occupy government positions, they tend to show a record of censorship of environmental science and suppression of environmental scientists (e.g., Environmental Data and Governance Initiative, 2024; Sabin Center for Climate Change Law, 2024; Shulman, 2008).

Within this field of research in the sociology of science, an important area involves what is often called the suppression of science, scientists, and intellectual dissent (Delborne, 2016; Martin et al., 1986). Although the term “censorship” is commonly used, suppression is used here as a broader term that includes more diverse mechanisms. Suppression of scientists occurs when their research runs contrary to a powerful vested interest such as that of an industrial or government actor. These actors have various goals, including discrediting scientists' research, preventing scientists from conducting or publicizing their research, or creating a “chilling effect” for other researchers (Kempner, 2008). Typical means of suppression include organizational orders to avoid speaking publicly about specified research of knowledge, threats that the scientist will lose employment or funding, litigation and misconduct investigations, and public attacks on research methods or ethics. This study also understands suppression as a process that includes a triggering circumstance or event, actions by suppressing agents, responses by scientists and their allies, and outcomes.

This study makes theoretical, empirical, and methodological contributions to the field. First, it synthesizes the main approaches in the literature to bring together structural-institutional and agency-oriented frameworks. Second, the study suggests a way forward for the suppression studies literature, which is largely based on analyses of one or a few cases, and instead it uses a systematic comparative analysis of a unique data set to identify new empirical associations and pathways of sequences of suppression and outcomes. Third, the study provides a general methodological contribution that attends to some of the challenges of standard small-N comparative analyses, including working with large numbers of variables. It combines bivariate analyses of many potential relationships with the case-level analysis that shows how the variables appear together in composite processual sequences.

2 | LITERATURE REVIEW

This section reviews two main sociological approaches to the study of dissent and suppression in science, with research questions formulated from both approaches.

2.1 | Structural and institutional approaches

Structural and institutional approaches often begin with the capitalist form of modern industrial societies, which enables a high degree of influence of industrial actors on the government, civil society, higher education, and other fields and institutional sectors. In sociological research on dissent and suppression, these approaches are associated with the political sociology of science (Moore et al., 2011). This subfield of the sociology of science often draws attention to the matrix of industry, government, and civil society and social movements and the institutional and field structures in which actors are embedded.

With respect to industry, incumbent actors generally do not want to see publicity for research that could trigger regulatory responses, market loss for products, or potential liability (Martin et al., 1986; Michaels, 2008). Similar concerns can be found across industries. For example, there are consistent patterns of industrial control over research on scientific risk, and some cases of suppression of scientists, for both the chemical industry with respect to the exposure of toxic chemicals and the fossil-fuel industry with respect to climate change (Kuehn, 2004; Mann, 2012; Martin, 1996; Schneider, 2009; Vallianatos & Jenkins, 2014). Likewise, there is a pattern of industrial influence across spatial scale. At national or international levels, attempts to control science and media narratives can occur when scientists enter the public sphere. Examples of how scientists become targets include providing independent research in the form of testimony to government bodies (the courts, legislatures, and executive branch officials), forming policy advocacy organizations, making contributions to international decision-making processes (such as the United Nations Framework on Climate Change), and providing commentaries and analyses in the media (Mann, 2012; Moore, 2008). Scientists can also encounter suppression when working at a grassroots level with communities that are facing environmental justice challenges, and when contributing to networks of activists and advocates that seek to develop citizen-led research (Allen, 2018; Arancibia, 2016; Brown, 2007).

Industrial influence also extends to political parties and nongovernmental organizations, which in turn can contribute to the suppression of scientists. In most modern societies, industrial actors often capture related regulatory agencies, and they lobby elected officials for policies that involve under-regulation of potential public risks (Michaels, 2008). Their efforts to obstruct or weaken regulation have contributed to a broader pattern of neoliberal globalization in which scientific research is embedded (Moore et al., 2011). Where scientific research is used to guide regulation, industrial influence can be subtle, such as when agencies form epistemic preferences for methods and standards that tend to produce industry-aligned results (Henry et al., 2021; Suryanarayanan & Kleinman, 2016). Where political polarization affects issue areas, elected officials simply attack science that conflicts with industrial interests, and the traditional relationship of scientific advising and policy development breaks down (Hess, 2014; Schneider, 2009). A contributing factor to the epistemic rift between scientific advice and policy decisions includes inconsistent research advice from think tanks funded by corporations, such as think tanks that provide research on climate science and mitigation (Bonds, 2016; Brulle, 2014).

Some scientific issues, notably climate change, have also become highly polarized across political parties and ideologies (Smith et al., 2024). Populist right-wing parties are generally opposed to climate mitigation policy, whereas other issues, such as the regulation of chemicals, are sometimes more in the public health area (e.g., lead, asbestos), and they can be a basis for reduced polarization. Because of the relationship between the Republican Party in the U.S. and anti-environmental views, suppression can be more frequent or severe under Republican-controlled administrations (Gelbspan, 2005; Shulman, 2008). During the Trump administration of

2017–2020, there was extensive suppression of government data, as documented by the Environmental Data and Governance Initiative (2024), and suppression of scientists, as documented by the Sabin Center for Climate Change Law (2024).

Universities sometimes also engage in suppression of scientists whose work runs counter to their political or industrial funding priorities (Martin, 1999). Increasing concern with global competitiveness has motivated both governments and industry to invest in university-based research that can contribute to innovation. Government policies that strengthened intellectual property rights and university offices of technology transfer have facilitated the "asymmetrical" convergence of university research and industry research and development (Moore et al., 2011; Vallas & Kleinman, 2008). The focus on metrics of researcher evaluation based on external funding, coupled with direct funding by corporations and associated foundations, have contributed to the emergence of what Slaughter and Rhoades (2004) termed academic capitalism. Academic tenure may provide some protections, such as job security, for scientists who become targets of suppression, but they still face other forms of suppression from inside or outside the university, such as loss of funding or reputation attacks.

There is also research on countervailing trends to industrial influence on scientists, governments, and universities, and much of this work connects the sociology of science with the political sociology of social movements. In addition to founding scientist-led advocacy organizations (e.g., Moore, 2008), scientists also have founded new research fields to address environmental risk and problems (e.g., Frickel, 2004). Scientists sometimes work as advisors to advocacy, community, and social movement organizations (Arancibia, 2016; Frickel & Arancibia, 2022) and with citizen-science networks (Kimura & Kinchy, 2019). Scientists can also engage in "shadow mobilizations" that operate alongside social movements but are less visible to powerful industrial actors (Frickel et al., 2015). Conversely, social movement and civil society organizations, and sympathetic members of the press, sometimes also support scientists who are facing suppression (Delborne, 2016).

Another area of research in the structural and institutional dimensions of suppression is the effects of industrial and political priorities on access that public interest advocacy groups have to research that could strengthen their claims of a need for remediation or policy change. In the U.S., industrial pressure has led to the defunding of independent government research for various types of environmental risks, such as for the chemical and toxics area (Vallianatos & Jenkins, 2014). The defunding of research fields contributes to "undone science," or a situation where communities and civil society organizations look for supporting research and find instead absences of knowledge or contested research fields (Hess, 2016). Furthermore, even when science is completed, it may remain "unseen science" or unavailable to the public because of industry influence (Richter et al., 2018).

In summary, the background literature on structural and institutional conditions provides a basis for defining variables that could affect different aspects of suppression processes. For example, the institutional location of the scientist and of the suppressing agent could be associated with different forms of suppression. Likewise, more indirect structural conditions that affect the dominance of neoliberal and anti-regulatory ideology in the state, or a general trend toward polarization, could also affect the level and types of suppression. Thus, the first two research questions examine possible evidence for associations with these factors:

1. Are there systematic patterns that associate suppression with the institutional location of the scientist (i.e., in government or in industry, or in different research fields) and with the elements of a suppression process as defined above? Based on background reading of the literature, the study begins with the hypothesis that suppression may be greater for climate scientists than those in the chemical or toxics fields and for government scientists than for university-based scientists. This expectation is because of the high political polarization on climate policy in the U.S. as noted above and the likelihood that universities are more insulated from political interference.

2. Likewise, are variables linked to broader structural conditions associated with differences in suppression? Based on the background literature, the expectation is that suppression may be different or more severe after 2001, when political polarization became increasingly evident, and during periods when a Republican is president.

2.2 | Strategic action perspectives

The second approach to the study of intellectual suppression focuses on the strategy and tactics of the suppressing agent and suppressed scientists. This approach falls under the general category of strategy in sociology and other social sciences (e.g., Hess, 2019; King & Jasper, 2022). Scientists facing suppression must decide first if their goal is to fight the suppression or acquiesce to it, and this study will focus on the former type of case.

In numerous publications, Martin and colleagues have discussed the strategic dimension of suppression processes for both suppressing and suppressed actors (e.g., Martin et al., 1986; Martin, 2017; Shir-Raz et al., 2022). For suppressing actors, common tactics include censorship, employment or funding loss (or threats), reputation attacks and misconduct allegations, litigation, and records attacks. In turn, scientists who are facing suppression and wish to resist it have used tactics such as gaining the support of colleagues, journalists, government officials, and nongovernmental organizations, and they have also responded by engaging in defenses of their methods and of misconduct charges. They sometimes also respond with counter-litigation, and their supporters (especially in government) may launch investigations into the suppression.

Some of the research has resulted in hypotheses about what kinds of responses from scientists are effective. For example, one finding is that official channels (internal appeal processes, litigation in courts) can be time-consuming, expensive, and ineffective for the scientist (Martin, 2017). Using official channels can include responding to technical arguments and finding colleagues who have replicated the scientist's work, or what Delborne has termed "agonistic science" (Delborne, 2008). An alternative set of tactics, "mobilizing support" and "dissident science," involves finding a broader range of colleagues and gaining media attention (Delborne, 2008; Martin, 2017). However, the more public approach to resisting suppression can also cause the scientist to be labeled as an activist, which can lead to reputation damage. Consequently, it may be more effective to have a group of supporters lead the challenge, and the formation of a coalition of allies can become important.

The study of strategic action in relationship to outcomes is so complicated that one may be tempted to leave the project entirely to the analysis of complex turns of events in cases. Instead, this study analyzes the cases to develop composite groups of processual sequences that appear in the data set. These sequences include the relevant contextual conditions, triggering circumstances, suppressing actions, responses, and outcomes. Thus, this part of the analysis addresses the following research question:

3. To what extent can the set of cases be grouped into composite categories of processual sequences that suggest a common chain of events that leads to a related outcome? This study begins with the expectation that there are common groups of processual sequences and that the analysis of structural and institutional conditions can help to identify them.

3 | METHOD

3.1 | General description

The combined method of this study addresses challenges that confront case study analysis both for the specific problem of the suppression of scientists and intellectuals and more generally in sociology and the social sciences. First, because case study research is time intensive, it tends to be limited to a small number of cases. Second, the detailed analysis of cases can be very sensitive and often involves the risk of writing about personal reputations and cases that involve litigation. Thus, it is important to consider a method that can avoid some of the risks that can occur in some areas of case-study research. Third, case study methods do not provide a good basis for identifying general patterns (Frickel et al., 2022). However, quantitative methods for this type of project are limited because there are no general data sets available, the number of well-documented cases is small, the resources required to develop a large-N data set from interviews are prohibitive, and historical cases may only be accessible through documents.

Thus, the starting point for this project is in the tradition of small-N, comparative studies as a middle-ground between the case study method and multivariate analysis. In the social sciences, qualitative comparative analysis (QCA) or analytic induction (Ragin, 2014, 2023) provides an important way of thinking about and conducting rigorous, small-N analysis. This study addresses two challenges that have emerged with such an approach. First, a set of cases can involve many possible independent variables or conditions (even more than there are cases), and a researcher faces the challenge of selecting variables, which is accomplished largely based on theoretical reasons derived from the background literature. Furthermore, sometimes the formal comparative algorithm results in multiple prime implicants, which again must be selected on theoretical grounds or background knowledge. Thus, there is potential for bias based on the selection criteria (Marx et al., 2014).

Rather than pre-selecting a small number of variables on theoretical grounds, this study adopts a more exploratory approach by beginning with a relatively large number of possible bivariate relationships based on the literature described above (in the final analysis, 13 condition or independent variables and 25 outcome or dependent variables). It then identifies the subset of stronger associations using bivariate analysis. Although the selection of this large set of possible relationships is still guided by theoretical considerations, using a relatively large set of bivariate relationships derived from the background literature provides a way to identify potential surprises and to counter possible bias.

Second, formal comparative analysis produces recipes or strings of conditions associated with an outcome. The conjunctural approach is valuable because it allows the researcher to produce insights similar to those of multivariate analysis but for small-N data sets. However, this approach does not provide insight into the sequences that link conditions to outcomes. In other words, the model of causal inference is based on finding associations or recipes of variables that are linked to an outcome: X_1, X_2, and X_3 are associated (or not) with outcome Y. This model of causality is shared by both quantitative and Boolean or QCA approaches. In contrast, this study uses an associational model of causality (through the first step of bivariate analyses) in combination with an alternative model of causal inference that draws on the process tracing literature.

This sequential or processual approach conceives of causality as a chain of events: event A leads to event B leads to event C (Beach & Pedersen, 2013). Like all methods, this approach also has limitations, such as the potential for the chains to omit crucial steps in the process. However, it provides an alternative way to think about complex relationships between multiple variables and outcomes by developing scenarios of sequential processes. The method also addresses a general concern in comparative methods with temporality and the need to link comparative analysis to case-level analysis (Marx et al., 2014; Schneider & Wagemann, 2012, p. 268). Formal qualitative analysis with the reduction of variables via theoretical selection and Boolean operations provides an important and valuable perspective, but the condensed recipes of relatively necessary-and-sufficient variables do not necessarily provide clear guidance for sequential processes at the case level (Bengtsson & Ruonavaara, 2017; Bennett & Checkel, 2015). Thus, there is room for integrating a complementary approach based on identifying shared pathways or sequences of events.

Attention to the combined use of comparative analysis and processual analysis can be defended on two grounds. On practical grounds, the delineation of processual sequences is important for scientists who want to understand, in effect, what "story" they are in and to develop a strategy for responding to suppression. On more philosophical grounds, this approach does not restrict the understanding of causality to a regularity or associational view. In addition, causality can be approached as a sequence or chain of conditions and events (mechanistic) that can also potentially be tested at the case level through process tracing (Beach & Pedersen, 2013). The two-step analysis used here also contributes to the challenge for comparative process tracing, and case study work in general, of enabling the efficient use of resources at the case level (Bennett et al., 2019; Schimmelfenning, 2015). Although this study does not test composite sequences and associated theories through detailed case study analysis, it does identify and explore a specific methodological approach that increases confidence in associations and that identifies sequential relationships.

3.2 | Inclusion criteria and data sources

The space and time range for cases is the U.S. from 1981 to 2016. The period starts after the main structure of modern environmental legislation was in place, when the Reagan administration came to power and initiated a shift from a period of relatively bipartisan support for environmental legislation. The time range ends in 2016, prior to the inauguration of President Trump, whose administration introduced a different level of government suppression.

A "scientist" is defined as a natural scientist, toxicologist, public health researcher, or engineer (that is, not a social scientist or attorney). Skeptics and industry-funded scientists can also experience suppression, but they are not included in this data set. To be included, a case must involve a scientist, in the chemical-toxics or climate field, who engages in research, experiences suppression, and resists it. All elements of an episode (contextual conditions, triggering circumstances, suppressive actions, responses, and outcome) had to be available in the sources for a case to be included.

Because there is no single available data set of the suppression of U.S. scientists, cases that met the inclusion criteria were identified through an iterative process that included sources from Google Scholar and Scopus searches using various keywords associated with censorship or suppression. Other sources of possible cases came from websites on whistleblowers, sources that emerged as the research progressed, and several general books and articles that provided discussions of multiple cases. Some of the preliminary research on climate scientists was also produced by a team of student researchers.

When a case was identified that met the criteria, sources were consulted until the limit of availability or saturation was reached. The following sources were favored: a first-hand account written by the scientist(s) involved; work by a social scientist or scientist; and work published in peer-reviewed journals, reputable news organizations, or established trade or university presses. The sum of sources across episodes was 207. Because some sources had information relevant to more than one episode, the sum of unique sources was 167.

3.3 | Coding and analytic strategy

The unit of analysis is an episode, and each episode was coded for the variables described in Tables 1 and 2. Most episodes were for a single scientist, and most scientists had a single episode. A few cases included multiple scientists or multiple episodes for one scientist. The latter were usually spaced apart by at least 5–10 years.

A total of 44 episodes of suppression met the inclusion criteria. They were split evenly between the chemical risk and climate risk areas of research. Many of the cases involved well-known scientists and cases (e.g., David Lewis, Herbert Needleman, Melvin Reuber, and Steve Wing for the chemical-toxics group and James Hansen, Michael Mann, and Benjamin Santer for the climate group). To ensure confidentiality of cases that can involve reputations and often contentious claims, the names of the scientists are withheld. Fifty variables were coded in the preliminary analysis, but not all were used in the final analysis ($50 \times 44 = 2200$ observations).

A code of 1 was given for presence of the variable at least once in an episode and 0 if not present. In some episodes, there was more than one occurrence of a variable (such as multiple NGOs that supported the scientist), but a binary code was deemed more accurate because an ordinal variable would generate distortions across the

TABLE 1 Condition variables: Structural and institutional.

Variable name	N	Definition
Structural condition		
Republican president	21	1 if a Republican is president
Presidential administration	10, 9, 11, 14	4 variables, one for Reagan-Bush, Clinton, GW Bush, Obama
After 2000	25	1 if the episode occurs primarily after 2000
Chemical research	22	1 if chemical or toxic pollution risk research
Climate research	22	1 if climate science research
Institutional position suppressed actor		
University tenured	17	1 if tenured position in a university
University untenured	4	1 if non-tenured position in a university
Government	22	1 if government position
Independent	3	1 if at an independent institute, foundation, or other organization
Institutional position of suppressing actor		
Industry	12	1 if an industrial organization or associated scientists or public relations firms
Government	24	1 if a government actor
University	2	1 if university administration
Other	16	1 if another actor, usually a conservative NGO
Total episodes	44	

data set. Summaries or quotations from the sources were recorded in a document that also justified the coding decisions.

Table 1 defines the variables for condition variables (structural and institutional). It shows a roughly even split for party of the president, time period, and industry. Most of the scientists were in government positions or tenured university positions, but two other employment categories were coded.

Coding categories for outcome variables (triggering events, suppressive actions, and responses) were drawn from the background literature and modified iteratively as the analysis of cases proceeded. (See Table 2). Final outcomes of the episodes were also coded (turned over records or not, positive or negative outcome on investigation or litigation, and positive or negative outcome on employment or funding). These and the suppressing actor categories were used to assist the second step of the analysis.

With respect to the analytic strategy, bivariate analyses were conducted for the first two research questions. An associational matrix of all variables was examined using phi (the binary equivalent to Pearson's r) to identify strength and direction of associations. Analyses were conducted of the five independent variables of interest (chemical research, government employment, university tenured employment, president's party, and time period). Fisher's exact tests were conducted in R Studio for the five variables for all triggering events ($N = 5$), suppression types ($N = 11$), and responses ($N = 10$).

For the third research question, the results of the first analysis were used to group episodes into composite processual sequences as defined above. Although there is some “reduction” or merging of variables within the five elements of the set, the approach also maintains the full sequence rather than reducing the five elements via Boolean operations.

TABLE 2 Outcome variables: Triggering events, suppressive actions, and responses.

Code	N	Description
Triggering event type		
Media	29	1 if media coverage of the scientist
Policy change	11	1 if policy or rule change in government, such as with a change of administrations
Research publication	21	1 if publication or conference presentation of research
Testimony	5	1 if testimony event before a government unit, including courts
Whistleblower	8	1 if public denunciation of corruption or related activity
Suppressive action		
Censorship	15	1 if the workplace prevents the scientist from speaking to the media, publishing research without edits, or otherwise restricts public communications
Employment	18	1 if threat of or actual employment loss, demotion, or dismissal
Funding	4	1 if threat of or actual loss of funding
Investigation	17	1 if investigations into allegations of misconduct; can include beginnings of investigations or threats to do so
Litigation	9	1 if threat of litigation or actual litigation for criminal or civil charges
Methods	17	1 if criticism of methods by industry- or ideology-affiliated scientists; can include studies by industry scientists with opposing results
Misconduct	22	1 if allegations of scientific misconduct
Negative press	18	1 if media attacks on the scientist, focus on reputation or methods or both
Personal safety	10	1 if threats to personal safety or perceptions of threats, including threatening emails and phone calls
Records	12	1 if demands for records and data by suppressing actor or affiliated actors; includes hacking of records but not records turned over during internal investigations
Higher suppression	19	1 if high suppression defined as at least two of the following: employment, funding, investigation, litigation, personal safety, records
Response to suppression		
Censorship contest	6	1 if scientist rejects attempted censorship and pursues dissemination of the research or interview against the organizational order or request
Government supporters	15	1 if support from government officials
Defensive investigation	13	1 if investigation launched by the suppressed scientist or others in support of the suppressed scientist
Defensive litigation	11	1 if litigation launched by the suppressed scientist or others in support of the suppressed scientist
Local supporters	13	1 if local support from colleagues, students, and employees
Methods defense	12	1 if methods defense
Misconduct defense	10	1 if defense against misconduct allegations, generally in the context of an investigation or litigation against the scientist

(Continues)

TABLE 2 (Continued)

Code	N	Description
NGO supporters	14	1 if NGO support
Other scientists confirming studies	6	1 if other scientists confirm the research claims and these confirmations appear in the reports of the scientist's defense
Other scientists support	16	1 if other scientists (outside the workplace organization) or professional associations support the scientist
Positive press	24	1 if supportive press coverage of the scientist

3.4 | Limitations

In addition to the limitations described above for the inclusion and exclusion criteria, there are several additional limitations. First, this data set is exhaustive within the inclusion criteria, but it is not necessarily representative of a larger universe of cases in the U.S. or across countries, or for cases across disciplines. Many cases may not be recorded in the existing literature, and the patterns of less prominent cases may be different, especially if scientists did not resist the suppression. Second, although *p* values are used in addition to phi values to give an indication of the stronger associations, type 1 errors could occur for *p* values close to but under 0.05. However, this concern is less important considering that the goal is more to identify the stronger associations within the scope of the data set. Third, where a case was selected for inclusion, the data are limited by what is reported in the sources. Cases were selected that had good quality sources and information on the main types of suppression and response. This approach is much more resource efficient than an interview-based project, and it can include historical cases for which actors are deceased; however, the approach is less complete.

Overall, the analysis of associations did not yield as many significant relationships as the researcher had expected. For example, the "higher suppression" variable divided the data set into relatively equal portions but did not generate associations with the condition variables, and the structural and institutional condition variables yielded only limited results. However, there were some revealing patterns that were significant in the bivariate analysis and some surprising findings as well.

Despite these limitations, the approach provides a model for moving beyond the case study and for addressing some of the challenges of formal comparative analysis as described above. The study also shows how the processual analysis of sequences can be a valuable complement to the limitations of comparative analysis of small-N data sets. It provides a model of how to study sensitive topics where interviewing and detailed case studies create high barriers due to the resources needed and the potential risks for both interviewees (those who have faced suppression) and researchers.

4 | RESULTS

4.1 | Associations with conditions

The study analyzed independent variables or conditions for four institutional positions of the scientist and five structural conditions. (See Table 1 to review the lists.). Before analyzing the relationship with outcome or dependent variables, it is important to discuss relationships among the condition variables. For the institutional positions, it was not surprising that government employees and tenured university employees were negatively correlated (phi = −0.70). Scientists tended to work either in government or in universities, and most of the university employees were tenured. Position in the chemical research field and the post-2000 period were also negatively correlated (phi = –0.60). In other words, the chemical cases tended to be more before the year 2000 in comparison with the climate science cases. Possible reasons include the reduction after the 1980s of the corruption for government chemical test procedures, the more effective influence of industry on government regulatory agencies that limited opportunities for independent scientific expertise, and the growing political controversy over climate mitigation policy after 2000.

Table 3 shows relationships between the condition variables and the outcome variables. It shows variables with significant relationships using Fisher's exact tests for the column variable (e.g., chemical research or not) and the row variable (e.g., whistleblower triggering event or not). Associations can range from –1 to 1. Both government and tenured university scientist variables are shown because they had different relationships with the dependent variables.

For the first research question (the institutional position of the scientist), chemical field position and government employment position were not highly associated with each other (phi = 0.09), but both were significantly related to whistleblowing. (See Table 3). These cases often were officials in federal regulatory agencies who protested corrupt or weak regulation of chemicals and risk, and they were also more likely to be involved in episodes with risk or threat to employment. Government employees tended to be more involved in defensive investigations that they or their supporters initiated, usually under the U.S. Department of Labor, an inspector general, or a supportive member of Congress. Government scientists were less likely to receive support from other scientists compared with scientists in other employment positions (universities and nonprofit organizations). An example is the case of a government administrator and public health scientist who became a whistleblower when a federal agency failed to disclose the exposure of government workers to a toxic chemical that the workers were

TABLE 3 Significant associations for five contextual conditions.

	N	Institutional position of the scientist			Structural condition	
Independent variables:		Chemical research	Government	Tenured university	Republican president	2001–2016
Comparison:		(Climate research)	(Other employment)	(Other employment)	(Democrat president)	(1981–2000)
Dependent variables						
Triggering event						
Whistleblower	8	0.35*	0.35*	–0.37**	0.14	–0.30
Suppressive action						
Employment	18	0.46**	0.55***	–0.47**	0.22	–0.30
Negative press	18	–0.09	–0.28	0.38*	0.04	–0.02
Records	12	–0.41*	–0.20	0.46**	–0.18	0.43**
Response to suppression						
Defensive investigation	13	0.25	0.45**	–0.41**	–0.28	–0.24
Methods defense	12	0	–0.31	0.35*	0.13	0.22
Other scientists support	16	0	–0.38*	0.27	–0.06	–0.10
N (44 possible episodes)		22	22	17	21	25

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ (Fisher's Exact Test; phi scores range from –1 to 1).

investigating in the field. From his position of supervising 150 employees, he was reassigned to a small office without such duties. His subsequent litigation led to a settlement, and he left the government (Schrader-Frechette, 2007).

With respect to the second research question (on structural conditions), the first analysis was of the political party of the president. (See Table 3). This variable was not significantly associated with any of the three groups of dependent variables (triggering circumstance, type of suppression, or type of response). To examine this puzzle, a more detailed analysis was conducted of suppression patterns during the Obama administration, which were expected to have lower government suppression than under the previous Bush administration. From a review of the cases, there was low executive branch suppression during this Democratic Party administration; however, there were other episodes of suppression by state government actors, conservative members of Congress, or nongovernmental conservative actors. Here, shifting levels to the cases helps to explain the surprising result.

With respect to the time period, there was no significant association with the "higher suppression" variable. However, after 2000, records demands or electronic hacking became more prominent (phi = 0.43, $p < 0.01$). (See Table 3). These records attacks tended to be directed at university scientists in tenured positions who worked on climate change. Additional analysis indicated that nongovernmental actors were more likely to be suppressing actors after 2000 (phi = 0.37, $p < 0.05$). An example of this type of case is a prominent climate scientist at a public university who was interviewed in a national media outlet, and an NGO used the open records law to gain access to his emails. Although he had to comply with this request, this episode and others have led climate scientists in public universities to be careful about what is stated and retained in electronic records (Ogburn, 2014).

In summary, the results provide support for the expectation that there are systematic relationships between the condition variables and the outcomes of the types of triggering events, suppressive actions, and responses. With respect to the institutional position of the scientist, those in the chemical research field tended to become whistleblowers and experience employment threats, in comparison with those in the climate science field. Scientists in tenured university positions did not tend to become whistleblowers, and they faced lower threats to employment than those in other positions. However, episodes involving tenured scientists had a higher level of records attacks and negative press. These episodes tended to be high-profile cases in the media, and they involved both the chemical and climate research fields. Tenured university professors were also less likely to launch defensive counter-investigations, partly because they were not whistleblowers or government employees suffering from suppression from their workplace organization. Instead, they engaged in strong methods defenses, often in the media, to defend their claims from criticisms from industry and conservative government officials.

The analysis for the first two research questions also points to the importance of the institutional position of the scientist in comparison with structural conditions (party of the president, time period). As discussed above, this is not to say that there have been no changes in suppression after 2000 or that the party of the president has no effect on suppression. The growth of records attacks is one example of how suppression tactics underwent innovation.

4.2 | Sequential processes

The second analysis classifies episodes into three composite sequences using the three types of suppression identified in the first analysis (employment loss, records attacks, and negative press). The three composite sequences, which cover 36 unique episodes out of the 44 total, are the following: government employees with employment threats, scientists in all employment positions with records demands or hacking, and university scientists who faced methods attacks or negative press but no records attacks. Episodes with censorship as a triggering circumstance are not included because of the overlap with the other groups, but most of the residual episodes involved censorship.

The first group (14 episodes) was all government scientists and mostly in the chemical field. (See Table 4, which should be read vertically or down the column for the sequence.). The suppressing actor was the government agency where the scientist worked, sometimes with influence from industrial actors. The triggering event was a breach of agency direction or rules, including the following variables: blowing the whistle on bias or corruption in the agency; media coverage of research that was at odds with the political orientation of the government administration or an influential industrial interest; or violation of a policy or rule change in the agency, usually involving restrictions on public communication. In response to the triggering event, the scientist faced demotion, dismissal, or a hostile workplace environment, and the majority of cases had an accompanying misconduct investigation. The scientist and/or allies responded with a whistleblower complaint, a formal grievance with a government inspector, and/or litigation. They often had support from NGOs and positive press coverage, and in three of the cases, members of Congress launched inquiries to support the scientist. For outcomes, most episodes resulted in reinstatement with return to the status quo in the organization or in some kind of settlement (payment without reinstatement of position). However, in four of the cases, the scientist lost the grievance process and/or litigation.

The second group (12 episodes) included demands for records that generally used government-based subpoenas or Freedom of Information Act litigation that were part of campaigns to discredit the research (that is, not part of internal misconduct investigations that could occur in the first group). Two episodes were records theft (hacking of emails). The 12 episodes in this group were mostly in the climate science field, after 2000, and with university scientists. The most frequent suppressing actors were conservative NGOs, climate science contrarians, and/or a member of Congress or a state legislature, and some episodes included multiple actor types. The triggering event was a research publication and/or media coverage of the research. As noted in the example above, scientists in public universities or government agencies were often required to turn over records as part of open-records laws. They sometimes responded by providing redacted records or by noting that data sets were already in the public domain (e.g., Wing, 2002). In three cases, there were extensive court battles over what had to be turned over,

TABLE 4 Composite sequential processes.

Sequence unit	Process 1: Employment threats for government scientists	Process 2: Records attacks or theft	Process 3: Public reputation attacks of university scientists
N	14	12	10
Position of scientist(s)	Government employee (14), mostly chemical field (11)	Mostly after 2000 (11), climate scientists (10) and university scientists (9)	University scientists in either chemical (3) or climate (7) fields
Position of suppressing actor(s)	Government employer (14), also industry (3)	Conservative NGO (7), government actor (5)	Industry (6), climate science contrarians (3)
Triggering circumstance or events	Whistleblowing (7) public position at odds with government (9), or violation of rule change (3)	Research publication and/or media coverage of research (11)	Research that conflicts with industry interest in safety (7) or with climate science contrarians (3)
Suppression type	Employment threat (14) often with misconduct investigation (8)	Records demands or electronic hacking (12)	Negative press (9), methods attacks (8), sometimes with investigations (5)
Primary response	Defensive investigation or litigation (13), NGO support (6), positive press (7)	Turn over records where required by law, sometimes with redaction and after litigation	Public defense of methods (7) and positive press coverage (6)
Outcome	Usually reinstatement or financial settlement (10), but some failure to gain remediation (4)	No loss of employment but high personal toll	No loss of employment but high personal toll

and in two cases, the courts protected the scientists' records from disclosure. In this group of sequences, scientists did not lose their jobs; however, the experiences were stressful and time-consuming.

The third group (10 episodes) was of university scientists (both fields) who experienced reputation attacks but without demands for records. Suppressing actors were diverse and included industry actors or industry-aligned scientists and politicians. The triggering event was research or testimony that undermined an industry interest in an established public perception of safety (chemical episodes) or that went against the views of climate science contrarians (climate episodes). These attacks were generally focused on methods and reputation, and five of the episodes also had investigations by a university or a government actor. The scientists defended their methods and reputations, and some received positive press coverage and support from other scientists. They all continued their research, but again they experienced considerable disruption and stress.

In summary, the analysis of sequential processes shows how the bivariate analysis can serve as a first step to alert the researcher to potentially significant relationships and clusters of variables. These insights then enable the researcher to construct composite sequences of conditions, actions, responses, and outcomes. In this study, there were three main types of composite sequences: employment risk for government scientists, records demands or hacking for both government and university scientists, and reputation attacks on university scientists. By identifying compositive sequences, researchers can provide a complementary view of causality to associational analysis, and they also generate maps of the field of action that are potentially valuable to scientists who face suppression.

5 | DISCUSSION

This study shows the value of developing a sociology of suppression, censorship, or dissent that examines the relationship between institutional and structural conditions and strategic action analysis (triggering events, types of suppressive actions, and responses). It finds that the analysis of suppression can benefit from comparisons across research fields and across the different occupational positions of scientists, such as in the government or the universities. Furthermore, the forms of suppression (the different types of tactics) remain relatively stable during this time period, but there is also some evidence for innovation, such as the increased use of records attacks.

The study also shows how comparative or quantitative approaches to suppression (that is, the study of associations between variables) can be made more insightful with the analysis of composite processual sequences that takes advantage of the case study level of detail. This approach identifies common pathways or processual sequences, and it can be practically useful because it helps scientists and their supporters to know what kind of scenario that they are in and to understand the strategic action associated with that scenario.

There are several ways that a next step of research could build on the combined comparative-processual approach developed here: include a more diverse range of research fields with suppression (such as the health field and radiation research, both of which also have multiple suppression cases), expand the geographical scope to include other countries, expand the temporal scope to include the Trump (2017 to 2020) and subsequent presidential administrations, and expand the method to include interviews or surveys that could capture cases that did not meet the inclusion criteria. If other researchers were to expand the analysis to other countries, institutional differences could result in substantially different patterns (Moore & Strasser, 2022). There is also some evidence that suppression is changing over time (such as the change in records attacks), and there is a need for better understanding of historical change (Oreskes & Conway, 2011). In short, there are numerous opportunities for a combined comparative-processual approach that would advance the sociological study of the suppression of science across countries, time periods, and research fields or industries. Furthermore, the combined comparative-processual method can potentially be of value to a wider range of case study collections in sociology and the social sciences.

6 | CONCLUSION

The project advances the broader literature in the political sociology of science and research on suppression and dissent by making theoretical, empirical, and methodological contributions. From a theoretical perspective, it brings together two main approaches in the literature (termed here structural-institutional and strategic) into a single framework, and it develops evidence to test prior expectations about relationships derived from the framework. From an empirical perspective, the findings include the following: demands for records increased after 2000, government scientists and scientists in the chemical field are more likely to have episodes that begin with whistleblowing and to face employment threats, and tenured positions in universities provide some protection but also tend to have higher levels of negative press and public defense of methods. The analysis of composite processual sequences also suggests that the outcome of an episode is often in the scientist's favor even though there may be considerable stress and reputation damage.

From a methodological perspective, the study advances the literature on the suppression of science, which to date tends to be based on the analysis of one or a small handful of cases. The study also shows how to use a combination of bivariate analysis with the construction of composite processual sequences. The method provides an efficient way to identify groups of cases for processual sequences, and it provides hypotheses that could be tested at the case level through detailed process tracing methods.

In addition to the theoretical, empirical, and methodological contributions, the approach can also contribute to providing improved guidance for scientists and their partners in government, communities, and civil society who are working to address the challenges of suppression and scientific dissent. For example, regarding Martin's well-founded caution that internal investigations do not generally work to the scientist's favor, this study suggests that investigations by an independent government agency or sympathetic legislator can be effective (Martin et al., 1986). The study also shows that although hostile public records requests can be time-consuming for scientists and their partners (such as university legal offices and legal defense organizations), compliance with the law can include successful redaction of some material to protect participant and community confidentiality, and proactive steps can also reduce the burden of such demands. In summary, research on the conditions that drive suppression, the forms of suppression and types of response, and the links between responses and outcomes can be of ongoing value to scientists who want their research to be of value to advocates and policymakers who are concerned with environmental and climate policies that serve a broad public interest.

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CONFLICT OF INTEREST STATEMENT

The author has no conflicts of interest with the persons, organizations, case content, or analysis in this study.

DATA AVAILABILITY STATEMENT

The sample coded data set is available on the author's web site at www.davidjhess.net. Because of the confidentiality and reputations involved, the sharing of additional details on the episodes is not publicly available, but serious objective researchers may contact the author.

ETHICS STATEMENT

I approve of the ethics statement and guidelines, and I have followed all ethical procedures. The study does not involve human subjects research.

ORCID

David J. Hess https://orcid.org/0000-0001-8117-0260

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AUTHOR BIOGRAPHY

David J. Hess is Professor of Sociology and the James Thornton Fant Chair in Sustainability Studies at Vanderbilt University, where he is the Director of Climate and Sustainability Studies. His research and teaching are on the sociology, anthropology, and policy studies of science, technology, health, energy, and the environment.

He is the recipient of the Robert K. Merton Prize, the Diana Forsythe Prize, the Star-Nelkin Prize (shared with coauthors), and the William H. Wiley Distinguished Faculty Award. He has been a Fulbright scholar and the PI and Co-PI on grants from the National Science Foundation and other organizations. His web site is at www.davidjhess.net.

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