Journal of Environmental Management 284 (2021) 112069

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

The structure of environmental governance: How public policies connect and partition California's oil and gas policy landscape

Tanya Heikkila [a,*], Christopher M. Weible [a], Kristin L. Olofsson [b], Jennifer A. Kagan [c], Jongeun You [a], Jill Yordy [a]

[a] University of Colorado Denver, 1380 Lawrence St, Ste. 500, Denver, CO, 80204, USA
[b] Oklahoma State University, 201 Murray Hall, Stillwater, OK, 74078, USA
[c] University of Hawaii Mānoa, 2424 Maile Way, Saunders Hall 631, Honolulu, HI, 96822, USA

ARTICLE INFO

Keywords:
Oil and gas development
Fracking
Hybrid governance
Institutional grammar
Energy policy

ABSTRACT

In this paper, we ask how the written composition of public policies structure an environmental governance system. We answer this question using semi-automated text analyses of 22 state-level policies governing oil and gas development in California between 2007 and 2017. The findings portray an environmental governance system that is both partitioned and connected into different focal areas (called "targeted action situations") through certain actors, issues, and rules. We conclude with substantive insights about California's oil and gas governance system, as well as theoretical and methodological contributions for analyzing the composition of public policy to advance knowledge about hybrid governance.

1. Introduction

Addressing and mitigating environmental problems necessitates a governance system that relies on networks of public, private, and non-governmental actors to devise and implement policy approaches. Such approaches can be described as hybrid governance, rather than governing by government alone. Many environmental governance arrangements are established through public policies created in government venues (e.g., legislatures or regulatory agencies). These policies target the specific actors who are authorized or mandated to participate in governance decision-making or implementation around various issues, and under particular sets of rules. Thus, analyzing public policies can help diagnose the structure and function of environmental governance systems. Such diagnoses provide a critical portrayal of the nature of authority and allow us to compare and contrast differences in the functional capacity and scope of governing systems.

The structure and function of environmental governance systems can be diagnosed in a variety of ways. For instance, some scholars look at how decision-making venues overlap and interrelate through the networks of actors involved (Lubell, 2013). Others have studied how networks of actors form coalitions in trying to influence decision-making venues and the policy choices therein (Jenkins-Smith et al., 2017). However, such approaches often ignore how public policies establish venues and structure interactions among actors engaged in these systems. We contribute to the environmental governance literature by asking: How do public policies structure an environmental governance system, by both connecting and partitioning different types of actors, issues, and rules?

We pursue this question in the policy landscape of oil and gas development in the state of California. State-level policies play a particularly important role in structuring oil and gas governance. States have been the primary locus of authority, for instance, in regulating many of the externalities associated with oil and gas development, such as noise, dust, air pollution, risks to groundwater, risks from spills, and risks to public health. Although state-level policy approaches may use coercive designs that regulate industry behavior, substantial variation exists in the range of actors who implement, engage in, and interact within this policy landscape (Heikkila and Weible, 2018). Additionally, a wide range of rules and policy approaches – beyond traditional command-and-control regulations (e.g., information disclosure, voluntary mechanisms, and collaboration) – may be used in oil and gas governance. Such a governance system, although primarily regulatory or coercive, can involve diverse actors from multiple sectors and a variety of policy approaches.

California offers a valuable setting to examine the characteristics of oil and gas governance. California is often depicted as a highly

* Corresponding author.
E-mail address: tanya.heikkila@ucdenver.edu (T. Heikkila).

https://doi.org/10.1016/j.jenvman.2021.112069
Received 28 February 2020; Received in revised form 19 October 2020; Accepted 26 January 2021
Available online 10 February 2021

polycentric state in its governance of environmental issues, such as water and land use (Blomquist et al., 2001; Henry et al., 2011). Yet, the extent to which its oil and gas governance system includes diverse and overlapping centers of authority has not been explored. We use data from 11 years of state-level policies in California, passed between 2007 and 2017, in four different policy venues with authority over oil and gas governance. This time period covers the boom in shale gas development and hydraulic fracturing, which has led to increased attention in many states toward the challenges and externalities of governing oil and gas. In studying this context in California, we build on methodological insights that have examined how public policies can influence the degree of polycentricity, or overlap, among various actors involved in oil and gas governance in Colorado (Heikkila and Weible, 2018).

Heikkila and Weible (2018) analyzed the structure of an oil and gas governance system by measuring the interconnections of actors and rules assigned to them using semi-automated text analyses of regulations. In addition to applying the textual analysis methods in a new setting, here we take the approach a step further. Specifically, we draw more attention to the issues that cut across policies, as well as how policies intersect around action situations targeted by multiple policies across multiple venues. This study therefore offers new methodological insights for analyzing how public policies structure environmental governance, while also providing new empirical evidence of how oil and gas governance in the United States is designed.

2. The structure of environmental governance and action situations

For decades, scholars have recognized that complex environmental governance usually involves multiple venues and actors with overlapping authority that address different parts of the system (Lubell, 2013; Ostrom and Ostrom, 1971; Tiebout, 1956). Extensive interconnectedness is a hallmark of many of these governance systems, which are often described as polycentric (Stephan and Blomquist, 2019). Even in systems that are highly regulatory, evidence of different levels of and degrees of overlap among actors and venues can emerge within different components of a governance system (Heikkila and Weible, 2018). In this paper, we explore the levels and degrees of overlap in the California context through the lens of action situations, or the contexts where actors, who are governed by configurations of rules, interact and engage (McGinnis, 2011; Ostrom, 2005).

2.1. Governance systems as interconnected action situations

The concept of action situations is a useful heuristic for examining the structure of governance systems (Ostrom, 2005). An action situation may include a policymaking venue where decision makers formulate and adopt public policy as the output. Alternatively, one may depict an action situation as a configuration of actors and associated rules focused on implementation of those public policies, as might be found in delivering goods and services or regulating behavior in that policy landscape. Action situations individually and collectively produce various forms of governance outputs, such as new policies, implementation of policies, operational activities governed by policies, or monitoring and enforcement of policies (Ostrom, 2005).

Action situations exist with their own discretionary arrangement of rules and obligations but are also interdependent in their structure, function, and effects on the broader policy landscape (McGinnis, 2011). The means of interdependence among action situations are numerous. This is because highly focused action situations are often nested within broader action situations, for example, the vertical structure of a government. In this vertical scenario, the means of connectedness might be public policy outputs from one action situation structuring another. Likewise, outputs might affect other action situations horizontally in governing a similar policy issue.

Action situations might also interrelate via actors who participate in more than one policy issue. The result is a governance landscape that is difficult to represent, as it potentially involves many action situations with distinct foci that are interconnected in many ways. Furthermore, such governance arrangements can allow for diversity in the tools and institutional forms that structure different action situations. For instance, some may have narrow scopes or targeted authorities, while others may be more extensive. Theoretically, environmental governance systems characterized by diverse institutional forms that arise through linked action situations are likely more capable of aligning governance arrangements with the scale of environmental problems, and creating opportunities for information sharing, learning and adaptation among governance actors (e.g., see Dietz et al., 2003; Lemos and Agrawal, 2006). Yet, before we can effectively test such expectations, we need to be able to measure and analyze governance systems using tools that are comparable across contexts. Studying action situations via related public policies is one way to build such analytic capacity.

Theoretically and methodologically, we need to be aware of the diverse ways in which governing systems are structured via partitions between action situations and the connections between them. As we discuss further below, we focus on three features of action situations that help uncover how a governance system is connected and partitioned.

2.2. Actors as a means of connecting and partitioning

The ways that governance actors participate simultaneously in different action situations is a key to identifying the nature of interrelationships within complex governance systems (Berardo and Lubell, 2019). Recent work has recognized that actor interactions in polycentric governance systems can be characterized as forms of competition, cooperation, and coercion (Thiel et al., 2019). In competitive interactions, actors compete for limited resources to provide for the same target population, similar to private markets. Under the cooperative form, decision centers are relatively equal in status and strive to make decisions in a participatory manner. Cooperation as a form of polycentricity is closely aligned with a large body of work on collaboration and participatory approaches to environmental governance (Berardo and Lubell, 2019; Davies and White, 2012; Schulz et al., 2008; Wyborn and Bixler, 2013). Coercion, as a form of interaction, is driven by more centralized decision-making and the use of regulations. A government agency or group of agencies with formal authority often play dominant roles in governance systems that are more coercive, driving coordination among actors. Traditional command-and-control regimes are an example of coercive polycentricity. All power, however, is not necessarily concentrated at one level; there is often layered devolution and spreading of some power to multiple decision centers. However, the coercive decision-making that takes place is still characterized by a power imbalance (Williamson, 1975). Such forms of interaction are common, for example, in governing natural resource extraction issues, such as oil and gas development.

Coercion, cooperation, and competition may occur simultaneously in a governance system, even when dominated by one form (Koontz et al., 2019). Rarely does a governance system adhere exclusively to one institutional form. There are elements of each form that can work well with others. For instance, stakeholder consultation in rulemaking by a regulatory agency, which incorporates a cooperative element into a coercive action, is a regular feature of natural resource governance. This combination of coercion and cooperation is common in the goverance of oil and gas. More coercive forms of command-and-control may be used for particular issues, such as requiring oil and gas producers to reduce greenhouse gas emissions from drilling operations, while cooperative approaches among diverse stakeholders may be used to develop and inform decision-makers about policy priorities of local communities (Heikkila, 2019). Thus, multiple institutional forms are often in use across the policy landscape of the various issues targeted by a governance system.

2.3. Issues as a means of Connecting and partitioning

Broadly speaking, "issues" relate to the characteristics of the problems (e.g., externalities), public goods, or resources that are the focus of a given action arena in environmental governance. Even within the same overarching policy domain – e.g., oil and gas governance – multiple sub-issues can arise, such as protection of groundwater, protection of air quality, and operational safety in the industry. Issues often drive politics and thus policymakers' attention and interests in addressing particular issues (Baumgartner and Jones, 2005). For instance, distributional issues with sharing natural resources lead to different forms of problem-solving, and thus action situations, than issues related to the provision of public goods, or how resources are appropriated (Heikkila and Schlager, 2012). Although issues can partition action situations within an overarching governance system, they also create mechanisms through which action situations are connected. Financing the provision of public goods, for example, may require particular types of property rights for environmental governance. Thus, an action situation involved with protecting and establishing rights may be linked to an action situation that involves taxing activities, such as resource extraction on the property.

When exploring issues through public policies, there may be multiple governance issues addressed in a given policy, and these issues may each target distinct action situations. In other words, there is not necessarily a one-to-one constant relationship between policies and action situations. One of the contributions of this paper is expanding on how common issues, across policies, can help identify the functional areas of action situations when exploring how issues within policies differ or interconnect.

2.4. Rules as a means of connecting and partitioning

The bundles of diverse rules targeting action situations will also play an important role in structuring a governance system. The Institutional Analysis and Development Framework (IAD) recognizes that different types of rules can structure what actors are permitted or required to do in a given action situation and that each action situation may be organized with a particular combination of different rules, which help differentiate or partition one action situation from another (Ostrom, 2010). The types of rules that typically govern an action situation include authority, choice, aggregation, information, payoff, and scope rules. Different institutional statements that create these rules may be structured to have more or less emphasis on what is required (e.g., through "must" statements), versus what is permitted (e.g., through "may" statements), or recommended (e.g., through "should" statements) of specific actors, and under what conditions. Within regulatory policies, institutions often set forth the mechanisms for enforcing rules.

While particular patterns of rules may partition action situations, rules can also connect action situations within a governance system (Heikkila et al., 2011; McGinnis, 2011). For instance, information rules may establish how actors in an operational action situation connect to actors in another action situation that uses such information to inform decisions. Operational activities of oil and gas drilling, for instance, may be structured by rules that require gathering information on methane leakage. Such information may then be required as part of another action situation around recordkeeping of greenhouse gas emissions for oil and gas and other industries. In this way, patterns of rules can build upon each other across multiple action situations.

2.5. Using actors, issues, and rules to assess oil and gas governance systems

Recent work has begun to examine, within a regulatory system of oil and gas governance, how public policies structure connections in a governance system (Heikkila and Weible, 2018). In particular, this work has shown that within a set of policies, it is possible to measure how diverse types of actors – including public, private, and nonprofit – overlap or interrelate. The degree to which actors interrelate can vary within policies. Yet, how actors interrelate may also be reflected in the ways in which they connect across the issues that are governed by multiple policies. That is, some actors interact around mitigating negative externalities or around how to manage the supply of a resource. Others, however, may be connected by their functional relationships driven by shared policies. Determining which actors engage in which issues is one way to assess how a governance system can be structured to achieve different types of policy goals.

Within any governance system, we may find variation in how engaged particular actors are within the system, which matters for understanding governance authority. Moreover, there is likely to be variation within different action situations in terms of how interconnected actors are, based on the common issues and rules that they share. In the case of California's oil and gas system, we expect to see such variation as well as notable differences in how this system compares to other cases that have been studied through an institutional lens.

3. Oil and gas governance in California

California is one of the leading states involved in oil and gas development (seventh in crude oil production, according to the U.S. EIA, 2019). Broadly speaking, authority for creating policies that govern oil and gas in California can occur through legislative action, executive decision-making (e.g., the governor and administrative agencies), and through citizen ballot initiatives. The governor's formal authority is generally limited to executive orders, while administrative agencies have legislatively mandated authority for rulemaking. The two agencies with primary rulemaking authority over oil and gas issues in California are the California Air Resources Board (CARB) and the California Geologic Energy Management Division (formerly the Division of Oil, Gas, and Geothermal Resources, or DOGGR). Many other actors, however, play a role in how state level policies are implemented, monitored, and enforced. For instance, numerous state agencies in California have MOUs with the DOGGR (Dorr, 2017) related to oil and gas governance issues. Some federal agencies play limited roles in oil and gas governance in California. Additionally, local governments have authority over certain issues, such as zoning, that can shape oil and gas development. Finally, non-governmental actors, including industry and researchers, often aid policy implementation and design. For instance, they may do so through monitoring oil and gas activities or co-production of particular policies, such as disclosure requirements for the chemicals involved in hydraulic fracturing. Thus, each action situation involves the accumulation of actors, issues, and rules that preceded or coincided with it across various decision centers.

The discussion that follows derives from the 22 policies in our study that were adopted between 2007 and 2017 in California. Oil extraction in California was active throughout our study period, as shown in Fig. 1, although California lagged behind other states in enacting fracking-specific policy. Interest in and concerns about fracking grew in 2011 when the US EIA estimated that the Monterey Shale Formation might hold up to 23.9 billion barrels of oil, which would make it the largest oil formation in the country. Up to this point, fracking was largely unregulated in California, and while the EIA later reduced its estimates, the need to regulate became clear.

In 2013, coincident with discussions at the DOGGR, the legislature considered multiple fracking-related bills, including three calling for some sort of moratorium (AB 669, AB 1323, and AB 288). Ultimately, only SB 4 passed. This comprehensive bill established a permitting system for hydraulic fracturing, required producers to notify people living near wells, mandated groundwater monitoring, and required chemical disclosures. Many were upset by the passage of SB 4, framing the law as a decision by the state to allow hydraulic fracturing, and as in other states, some cities banned fracking or placed moratoria on the practice (Jaquith, 2017).

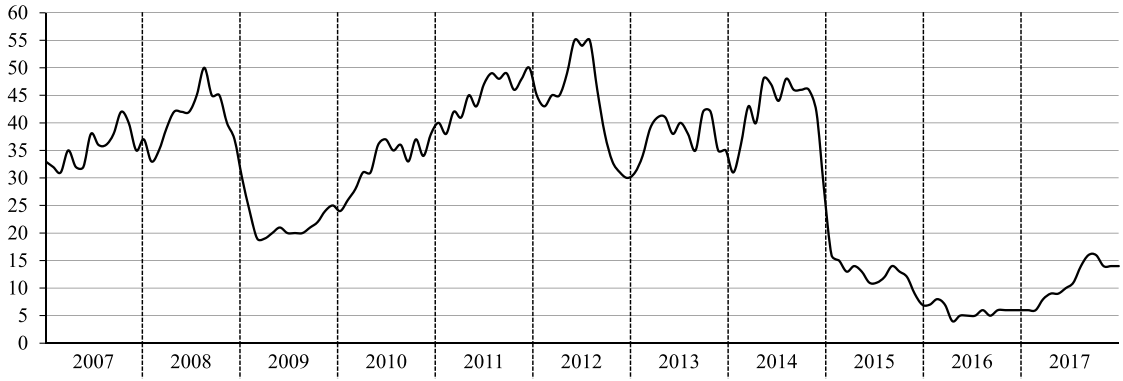

Fig. 1. California active weekly crude oil rig count 2007–2017. Source: Baker Hughes (2020).

Around the same time as SB 4, the legislature also passed measures requiring crude oil rail carriers to disclose more information (SB 861), increasing disclosures about water use in oil and gas operations (SB 1281), and strengthening bond requirements for oil and gas operations (SB 665). Other policies in our sample also relate to one another and to major focusing events. For example, following a methane leak at the Aliso Canyon Natural Gas Storage Facility in 2015, which resulted in the displacement of 8000 families, the legislature enacted bills increasing monitoring, mapping, and testing of gas pipelines. Following the Deepwater Horizon disaster in 2010, the governor called for additional oversight of offshore drilling, which coincided with failed legislation (SB 188) to prevent drilling in federal waters and California's decision to join a federal lawsuit against the US Department of the Interior to prevent drilling off the coast. More information about additional policies is provided in the results section below.

4. Methods

We extracted data from 22 public policies adopted between 2007 and 2017 in California's oil and gas governing system. Some of these policies are described in the previous section and include 12 bills, 9 regulations, and 1 executive order. The procedures for data extraction from text were developed based on the original institutional grammar (Crawford and Ostrom, 1995), utilizing its more recent adaptation in the Institutional Grammar Tool (Siddiki et al., 2019) as well as semi-automated text extraction methods employed by Heikkila and Weible (2018).[1] Institutional grammar has been used as a way to operationalize and measure key components of "institutions", such as the rules or strategies written into public policies, and how those components structure the design of institutions. We also used a semi-automated method in Automap (Carley and Diesner, 2005) to extract the components within the public policies. The 22 public policies were identified from four key decision-making venues: rules passed by the DOGGR and the CARB, state legislation, and governors' executive orders.[2] We started with 2007 because that year marked the beginning of a growth period in the use of hydraulic fracturing for oil and gas development across the U.S.

Conceptually, we drew upon the three syntactic concepts identified by Crawford and Ostrom's (1995) institutional grammar in their "attribute", "aim", and "deontic." We also drew upon the syntactic concept of the "object" from Siddiki et al. (2011). In developing the institutional grammar, the "institutional statement" has typically served as the unit of observation and been interpreted as the sentence in a public policy. The grammar components essentially then correspond to the grammatical parts of a sentence. Over the past decade, the institutional grammar has been revised and updated to improve its reliability in data extraction, typically by hand coding but also through automated procedures (see Siddiki et al., 2019).

Among the questions not studied in institutional grammar scholarship is that regarding the validity of upscaling syntactic concepts (as corresponding to parts of a sentence) to large numbers of statements across multiple public policies. For example, when analyzing a small number of institutional statements, it is possible to interpret the role of an actor who is the subject of a statement (e.g., the attribute). When analyzing a large number of institutional statements together, however, it becomes more difficult to determine how the subject of any one statement relates to the syntactic components of multiple sentences. In other words, the Institutional Grammar Tool succeeds in zooming in to analyze the micro properties of the textual trees but falters in zooming out to analyze the macro properties of the textual forest. To facilitate this upscaling, we treat the public policy as the unit of observation rather than the institutional statement.

Table 1 summarizes our approach. We adapted the institutional grammar definitions to apply to public policies in the first column. For example, Crawford and Ostrom (1995) define the "attribute" as to whom the institutional statement applies. We convert this as to whom the public policy applies, which basically refers to any actor written into the public policy. We took similar approaches in redefining the object, aim, and deontic concepts in the institutional grammar.

Through both manual review and auto-generated lists of actor names, we identified 232 distinct categories of attributes in the 22 public policies. However, these 232 distinct categories of attributes overlap in meaning. For example, the 232 attributes include 40 representing local governments (e.g., the words "town", "municipality", "local jurisdiction", "county", numerous named local governments, etc.). Therefore, rather than analyzing all of the individual terms or names for local

Table 1
Coded concepts for 22 public policies in California oil and gas governance.

Institutional grammar's concept definitions[a]	Number of text-level concepts in the thesaurus	Number of high-level concepts in the thesaurus	Frequency of extracted word (s)
Attribute: The "who" targeted by the public policies	232 attributes	44 actors	2736 actors
Object: The "what" targeted by the public policies	510 objects	8 issues	6199 issues
Aim: The "actions" stipulated by the public policies	294 aims	7 rules	8873 rules
Deontics: The "imperatives" specified by the public policies.	16 deontics	3 deontics	2647 deontics
Totals	**1052 text-level classifications**	**62 high-level classifications**	**20,455 extractions of words**

[a] The "Attribute", "Aim", and "Deontics" concepts are adapted from Crawford and Ostrom's (1995); the "Objects" concept is adapted from Siddiki et al. (2011).

governments, we produced a high-level list of generalized concepts in the thesaurus under the label "local governments" to categorize the 40 terms representing local government. This process was repeated for other attribute words, which then created 44 high level concepts for types of "actors" as found in the third column in Table 1. We repeated this for the institutional grammar's other concepts. See Appendix 1 for the list of high-level concepts in the Automap thesaurus.

Once all the text-level and high-level concepts were created, we used Automap to extract from the text the frequency of words that fit into each of the text-level and higher-level conceptual categories. In Automap, these text-level and higher-level categories become the "thesaurus" that guides the automated text extraction. We adapted the text-level and high-level concepts used by Heikkila and Weible (2018) for analyzing oil and gas regulations in Colorado as the baseline for the thesaurus[3], by manually reviewing the California policies for additional text-level concepts and high-level concepts. The thesaurus expansion process involved an iterative approach of refining text-level and high-level concept categories and establishing inter-coder agreement on words within each category.[4]

The total frequencies of extracted text are listed in the fourth column in Table 1. The total number of all words falling under the attribute or actor categories totals 2736. In total, the dictionary extracted 20,455 words across the four concepts or sub-concepts.

Before analyzing the data, we also created a variable for the venue where the policy was produced and a variable for the word count of the policy. The word counts allow for standardizing the counts of the variables for each category of the actors, rules, and issues in the dataset. We divided the number of observations of these variables in a policy by the number of words in each policy to create a standardized score. The dataset was analyzed using descriptive statistics, Multi-Dimensional Scaling, and Tabu Cluster Analysis in UCINet 6 (Borgatti et al., 2002).

5. Findings

In California, four policymaking venues have produced policies that directly or indirectly address oil and gas production between 2007 and 2017. These include the Governor's Office, the state legislature, and two regulatory agencies – the DOGGR and the CARB. As shown in Fig. 2, these policymaking venues adopted 22 policies over this period: the state legislature enacted 12 bills, CARB promulgated six regulations, DOGGR promulgated three regulations, and the governor signed one executive order.

The 22 policies over this 11-year period contain 95,386 words related to oil and gas development in California. The smallest policy by word count was the 2015 DOGGR rule relating to the protection of California aquifers, with 625 words. The largest policy by word count was the 2014 DOGGR policy on greenhouse gas (GHG), with 9165 words. By word count and number of adoptions across these four venues, Fig. 2 portrays a steady pattern of policymaking over time on California's oil and gas issues, with noticeable variance in the length of legislation from year to year. Certainly, adoptions varied by year, with some years producing no new policies (2009 and 2016) and one year producing four new policies (2014).

To portray the targeted action situations that emerge from these policies, we portray the diverse types of actors, issues, and rules embedded within them in Fig. 3, which uses three visualization techniques. First, Fig. 3 displays the 22 public policies in its center area with the coordinates of their location calculated by the Multidimensional Scale (MDS). Based on the frequency by which each of the 22 public policies includes each of the 44 actor categories written in their text, MDS simplifies this space into horizontal and vertical dimensions. Our 44 actor categories include 24 state government or agency affiliates, one local government category, six federal agency and government affiliates, six expert categories, four oil and gas industry affiliates, two new entities associated with implementing GHG policies, and one general public category. For each public policy, this produces horizontal and vertical

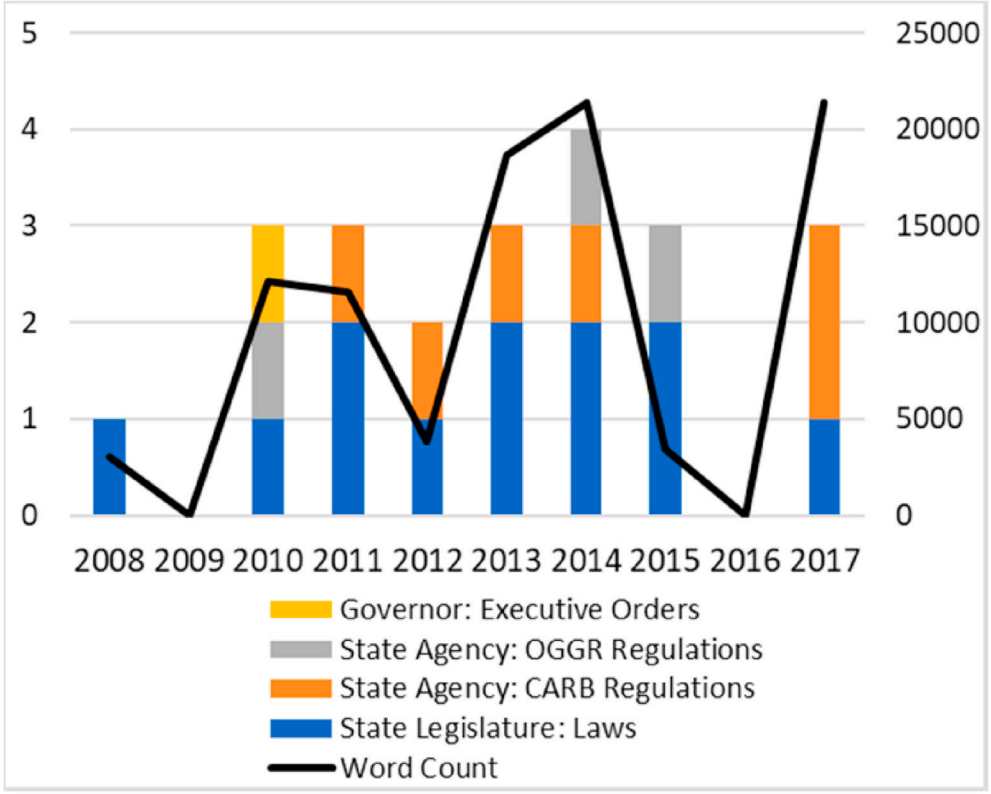

Fig. 2. California oil & gas policy adoption over time.

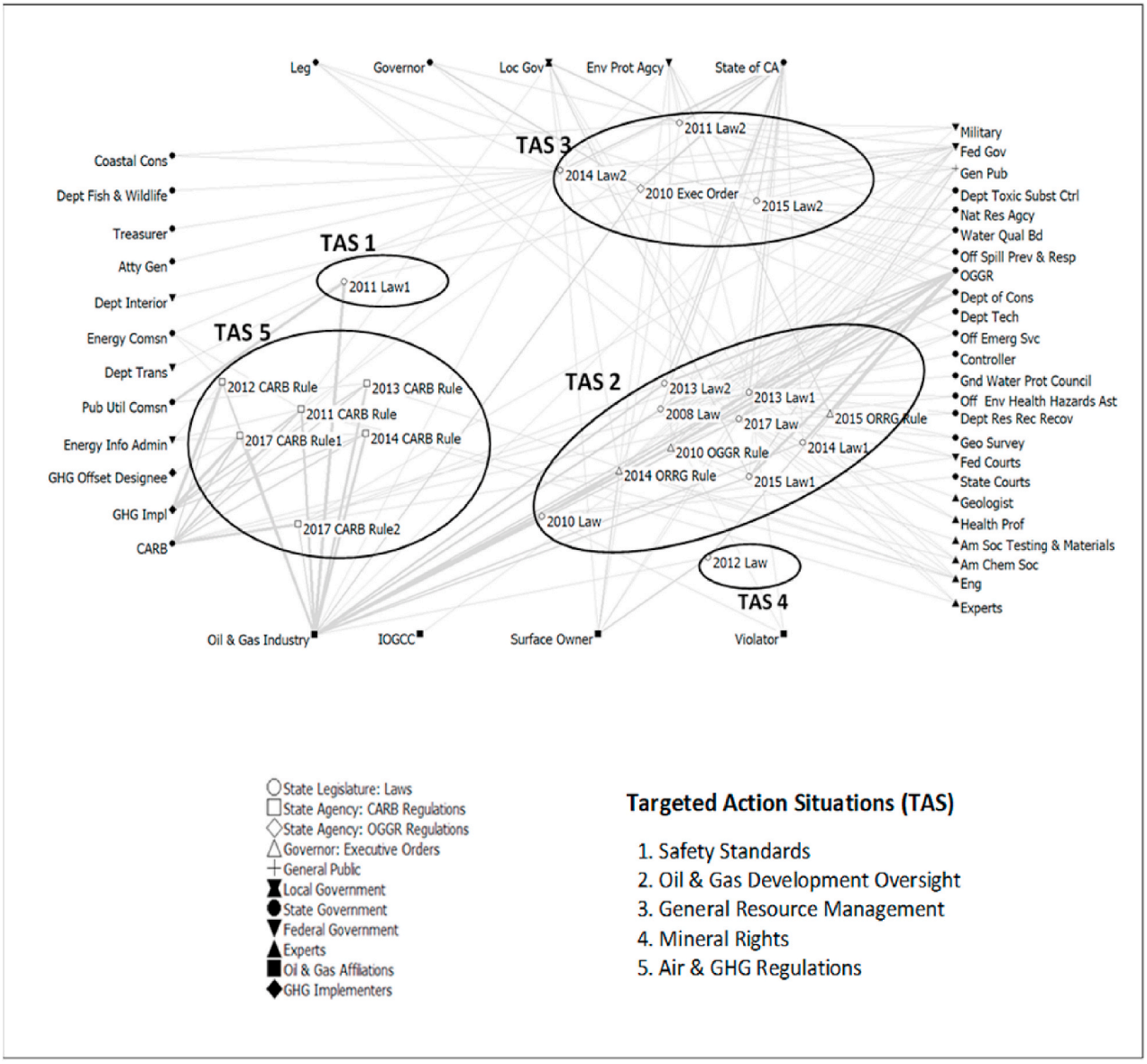

Fig. 3. Targeted action situations of California oil and gas policies with shared actors.

coordinates that allow them to be mapped in two dimensions. The stress level is 0.16, which suggests an acceptable fit for the MDS (Dugard et al., 2010). From the MDS, those public policies in close proximity share similar sets of actor types in their text. From the placement of these public policies, we begin to build a visual representation of the targeted action situations written in their texts.

Second, we clustered the public policies using a Tabu Search Cluster Analysis. The Tabu Search Cluster Analysis re-arranges the 22 public policies to optimize correlations within a cluster of policies. After running iterations of different cluster numbers, the optimal number was five ($R^2 = 0.72$). These five clusters are shown by the circles around the public policies that comprise them. These five clusters represent the targeted action situations (TAS) within and across the 22 public policies in California dealing with oil and gas development.

Third, to visualize which actors associate with each TAS and public policy, we present the ties between each of the 22 public policies and the 44 actor categories. We display the 44 actor categories on the edges of the MDS map. Their placement was based primarily on our judgment of their proximity to different clusters and for visual clarity. The weight of the tie, represented by the density of the line, between a public policy or policies and the actor is based on the strength of the connection, calculated by the number of times any particular actor appears written in the public policy. The shape of the nodes in Fig. 3 indicates the type of public policy or actor category.[5]

From Fig. 3, patterns emerge in the topics and actors associated with each TAS. TAS 1 includes just one bill passed in response to a 2010 gas explosion that killed eight people. The bill focuses on safety standards around gas pipelines and, thus, targets primarily the Public Utility Commission and the oil and gas industry. TAS 2 (at the lower right) contains policies that most directly regulate oil and gas operations, including hydraulic fracturing. In addition to SB 4 and its associated regulations finalized in 2014, TAS 2 includes legislation and regulations related to oil spill prevention and penalties (AB 1960, 2008; SB 861, 2014), bond requirements for oil and gas operations (SB 665, 2013), and DOGGR procedural rules (AB 2453, 2010), among other measures. These policies especially involve DOGGR, but they also involve an extensive number of agencies and non-governmental actors beyond the oil and gas industry, such as health professionals, experts, and the Groundwater Protection Council.

TAS 3 deals with policies related to natural resource management.

For example, SB 1281 (2014) increased disclosure requirements about water use in oil and gas operations, and Executive Order S-16- 10 strengthened oversight of offshore drilling following the 2010 Deepwater Horizon disaster. Actors associated with natural resource management include various state agencies, along with the governor, local governments, and the U.S. Environmental Protection Agency (EPA). TAS 4 contains just one law focused on mineral rights, which deals primarily with surface owners, the oil and gas industry, and DOGGR.

Finally, TAS 5 involves CARB regulations focused on GHG emissions reporting. Although these regulations include the oil and gas industry, their application is also much broader. Not surprisingly, these regulations target CARB, along with many actors involved in implementing the reporting mechanisms. Thus, as this discussion suggests, we begin to see patterns of targeted action situations that are interdependent through the actors that are linked to the different clusters. The actors that are connected to the policies show notable patterns in terms of how particular actors are associated with particular policies, but also how many actors are implicated across multiple action situations.

We can also infer from Fig. 3 how the structure of the policies established linkages among existing governance actors that are part of the broader federal system of governance. For example, all 24 state government and agency affiliates had been established and operated in California irrespective of the adoption of these public policies. At the same time, the policymaking venues and the issue of oil and gas development in California simultaneously shape the governance structure within which it is embedded. The policies adopted in California by the policymaking venues influence the authority and behavior of the actors therein. For example, the governor's executive order and the laws enacted by the legislature shape various aspects of the policies adopted by the two government agencies. All of these policies affect the various actor categories in this system. While Fig. 3 is static in its presentation, we can imagine through Fig. 2 the nodes and ties in the network as dynamic interactions that can evolve over time as policies within the governing system change.

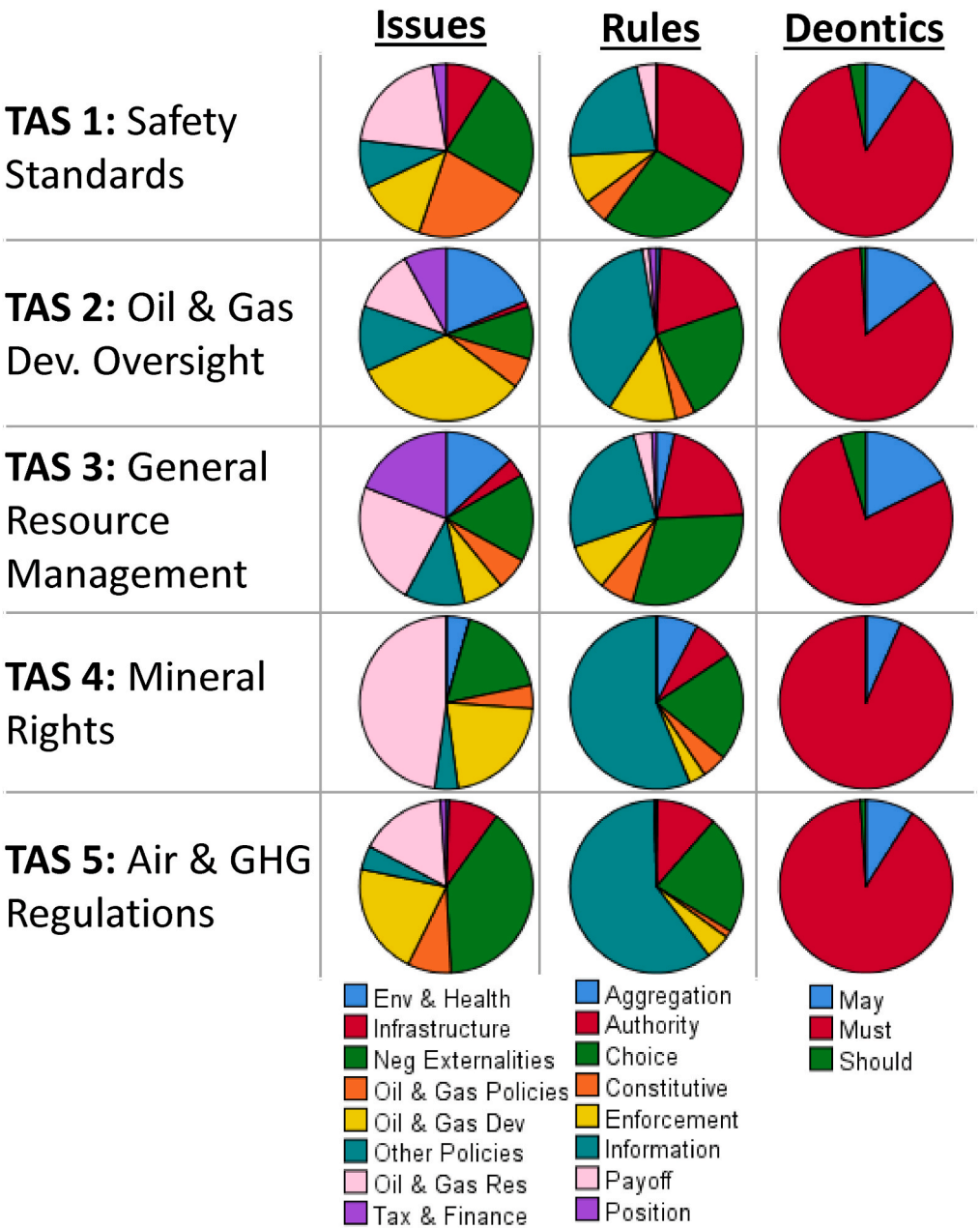

Fig. 4. Patterns of issues, rules, and deontics in targeted action situations.

How these policies structure the targeted action situations, and their interrelationships, depends not just on the types of actors, but also on the governance issues that are bundled within the policies and the nature of the rules that actors must follow. Therefore, as shown in Fig. 4 below, we identify how the targeted action situations (based on shared actors) overlap with particular policy issues, as measured by the issues, rules, and deontics in our dataset.

Fig. 4 illustrates visually how the eight categories of coded issues and eight categories of rules relate to the five targeted action situations in Fig. 3. We can, thus, imagine the public policies targeting actor categories that can be clustered in targeted action situations that, in turn, affect similar issues in the governing system. Furthermore, these targeted action situations are associated with bundles of rule types and deontics that vary in their overall composition.

These relations are represented in Fig. 4 through a combination of pie charts. Each pie chart tallies the total number of coded entries for a given targeted action situation. For example, the Safety Standards targeted action situation ("TAS 1") in the upper left corner of Fig. 3 partitions the proportion of all issues mentioned in that cluster. The coded issues from the policies follow distinct patterns across the targeted action situations. In TAS 1, there are many issues that the policy targets, with negative externalities, oil and gas resources, and other policies as the more common issue themes. TAS 2, for oil and gas development regulation, is frequented by text linked with oil and gas development, followed by environment and health and several other issues. For general resource management, TAS 3 involves many issues, with tax and finance and oil and gas resources playing a relatively strong role. In the mineral rights focused TAS 4, oil and gas resources are frequently mentioned, while for air and GHG regulations (TAS 5), there is a heavy proportion of negative externality issues.

A few differences and similarities arise when looking at the patterns of rules and deontics across the targeted action situations. In TAS 1, rules are balanced between authority, choice, and information rules, with fewer enforcement, constitutive and payoff rules. In TAS 2, information rules are most prominent, but there are also many authority and choice rules, and more relative enforcement than the other clusters. Rule composition is fairly balanced in TAS 3, looking very similar to TAS 1, with the addition of some aggregation rules. TAS 4 and TAS 5 have more information rules relative to the other targeted action situations. All of the targeted action situations have a significant proportion of "must" deontics. However, we see more "may" and "should" deontics in TAS 3 relative to the others. This may reflect the diversity of actors and rules in TAS 3, and the broader scope of issues being addressed relative to those that are more specific. At the same time, the preponderance of "must" deontics across all action situations likely reflects the more coercive or regulatory nature of this governance system, as well as the relative intensity of the diversity of rule types in the targeted action situations.

Thus far, we have visualized and described how the different actors, issues, rules, and deontics interconnect in oil and gas development in California. Yet another lens by which we can describe how the actors, issues, and deontics serve both to partition and connect this system of governance is by measuring their associations with the horizontal and vertical dimensions of the MDS in Fig. 3. The MDS in Fig. 3 places the public policies based on horizontal and vertical coordinates. We can take these coordinates and calculate the Pearson correlations and their significance for our actor categories, issues, rules, and deontics. Through these calculations, we can provide one quantitative indicator of the strength of these entities' associations with the horizontal and vertical dimensions of the MDS. Doing so provides another means of showing how the public policies interrelate and the role that particular aspects of the system play in partitioning or connecting the governing system.

Table 1 lists the significant Pearson correlation coefficients for the entities of actors, issues, rules, and deontics in weighted frequency as they appear in the public policies with the horizontal and vertical coordinates for the public policies from the MDS calculations for Fig. 3 (see appendix for the full list of correlations). A significant value in the first column of Table 1 suggests that a particular entity is strongly associated with either being on the left side of Fig. 3's horizontal dimension (negative coefficient) or right side of the horizontal dimension (positive coefficient). A significant value in the second column of Table 1 shows a strong association with the bottom of the vertical dimension (negative coefficient) or top of the vertical dimension (positive coefficient) in Fig. 3. As seen in Table 1, DOGGR and the EPA are positively associated with the horizontal dimension. In contrast, the Energy Commission, the EIA, GHG implementers, the oil and gas industry, and CARB are negatively associated with the horizontal dimension. Actors that are significantly associated with the vertical dimension include the State of California (generally), the federal government, California's Coastal Conservation Commission, the military, and the governor. Such actors tend to be more involved in the issues of spills or emergencies, which are addressed for instance in some of the policies under TAS 3. Must deontics are negatively associated with the horizontal dimension and, thus, align with the left side.

What pulls one entity in Table 2 into the realm of significance is its strong association with one or more of the public policies – and hence the targeted action situation – compared to others. This could be related to tie strength (the amount of times an actor is listed), but it is more related to the single association of that actor with one of the four portions (left or right, bottom or top) of the MDS. Several actors without significant correlations are not listed in Table 1. A lack of significant correlation indicates that either an actor spans across the full spectrum or is only loosely tied to any one dimension. In other words, these actors without significant correlations may either be spread thin with their associations across targeted action situations or be weakly associated with any of them. In contrast, Table 1 lists those actors that show a strong association with the ends of eitherdimension and, thus, represent aspects of the partitioning of the governing system into targeted action situations.

6. Conclusion

We know that environmental governance involves diverse actors and organizations and complicated institutional arrangements, which interrelate in dynamic ways to address interdependent aspects of the natural, physical, and built environment. Scholars have used various terms to capture these attributes and dynamisms, such as polycentricity,

Table 2
Actors, issues, and deontics correlated with MDS dimensions.

	Horizontal Dimension	Vertical Dimension
Actors		
DOGGR	.638**	
EPA	.450*	
State of California		.800**
Federal Government		.751**
Coastal Conservation Commission		.591**
Military		.534*
Governor		.507*
Energy Commission	-.461*	
EIA	-.503*	
GHG Implementers	-.716**	
Oil & Gas Industry	-.720**	
CARB	-.800**	
Issues		
Environment & Health	.683**	
Tax & Finance		.515*
Negative Externalities	-.766**	
Infrastructure	-.818**	
Rules		
Choice	-.527*	
Information	-.695**	-.478*
Deontics		
Must	-.652**	

Note: Only significant relationships are shown (*significant at 0.05 level, ** significant at 0.01 level).

hybrid governance, multilevel governance, and collaborative governance, across a range of environmental governance areas including water, fisheries, land, transportation, and agriculture (Bodin et al., 2016; Carslile and Gruby, 2017; Morrison, 2017; Thiel et al., 2019). Despite decades of research, we continue to struggle in portraying the many complex features of environmental governance that are embedded in public policies, particularly with approaches where both theory and methods operate side-by-side to inform each other. Ongoing attention to the co-development of theoretical and empirical approaches is, therefore, critical for advancing knowledge about these systems.

In this study, we used the theoretical lens of action situations and methodological lessons from Crawford and Ostrom's (1995) institutional grammar to analyze a governance system. Through semi-automated text analysis, we extracted the actors, issues, and rules that constitute the public policies governing oil and gas development in California, produced by four venues of authority. We found that these policies can be clustered around targeted action situations by the types of actors they share.

Overall, these targeted action situations illustrate the expected theoretical variation in terms of how actors interrelate within the governance system. Within the targeted action situations, we further find notable differences in the patterns of the types of actors, issues, and rules that emerge. This offers several theoretical and methodological insights:

I. A coercive or regulatory form of governing system can appear responsive to signals in its environment. The case of California provides an example of a largely coercive regulatory system. Some may argue that such systems are less responsive or adaptable than competitive or cooperative systems given their rigid institutional structures and limitations on flows of information into decision-making. In this paper, we find a coercive regulatory system that appears fairly responsive to at least some signals in its environment (Jones and Baumgartner, 2005). Of course, understanding each policy decision and associated mechanisms lies outside of the scope of this paper. We also lack insights about what signals were dampened or ignored and the extent that the observed policy changes were proportional to the signals received. Putting these unknowns aside, we can still claim that this governing system is responding to at least some of its signals. This also supports recent findings of the adaptation of regulatory policies in Colorado related to oil and gas development over the same time period (Heikkila and Weible, 2018; Heikkila, 2019).

II. Policy-making venues produce policies that connect actors in the broader governance system via targeted action situations. Formal governance venues adopt policies that create a complex network of interrelationships within a governance system in which policies interrelate through targeted action situations. These action situations pull actors from the broader governing or political system. Some of these actors fulfill a certain niche. Some regulate air, and some regulate a natural resource; others are affected or have something at stake. In the case of oil and gas governance in California, nearly all of the actors identified, except the GHG entities, existed before the policies were created. The policies link these governance actors to the issues in a particular targeted action situation.

III. Interdependent action situations are connected in multiple ways. Hybrid governance systems are often assumed to be interdependent through the actors involved. What we find in our analysis is that the actors can be policymaking venues (governors, agencies, legislatures) and through their public policies, other actors are targeted with governance authority, some of whom are other policy-making venues, while others may be private and non-governmental actors. Interconnectedness also can be depicted through the issues we observe in the policies and the rules that structure action. Depending on the theoretical lens we use, and the methods employed to create our image of a governance system, we will observe different forms of connectivity. There is no singular way to portray methodologically how governance systems are structured. Given that all systems change, our portrayal might not generalize over time but does provide some articulation of what is more or less contextual and what may generalize to other governing systems.

IV. The actors, issues, and rules in a governance system tend to partition or connect the system. We identified a complicated mix of actors and policies that tie together the public policies and, hence, our targeted action situations. Yet, as evidenced in the correlations, we find partitioned patterns are driven primarily by a smaller set of actors. These dimensions also correlate with a few types of rules and a few types of issues. As we zoom out over a decade in environmental governance, a few signature features emerge that structure the main contours of environmental governance and other features (or entities) tend to blur these features. In other words, if we found no significant correlations in Table 1, then we would have a single targeted action situation in Fig. 2 and high interdependence of all measured entities. Instead, what we are observing in California is a governing system partitioned into five target action situations.

V. The institutional grammar can be adapted to study public policies. The methodological approach for extracting the textual data was based on the original institutional grammar (Crawford and Ostrom, 1995) and part of its later adaptation in Siddiki et al. (2011; 2019). Our approach returns to the original conceptual definitions in Crawford and Ostrom (their attributes, aims, and deontics) and adapts them for studying public policies instead of institutional statements (typically sentences). Similarly, we adapted the "object" from Siddiki et al. (2011) for the study of public policies as well. These conceptual refinements sidestep any threats to validity of drawing meaning from syntactic categories as now found in Siddiki et al. (2019) meant for institutional statements at the scale of public policies. Additionally, we apply a semi-automated approach, which avoids the time intensity of hand coding hundreds or thousands of statements. Thus, one of the contributions of this paper is its methodological approach, which conceptually adapts institutional grammar to analyze entire public policies and uses a semi-automated approach for organizing the corpus of text to reveal aspects of a governance system. In doing so, we also extended the coding approach of a governance system in Colorado (Heikkila and Weible, 2018), by analyzing not just the actors and rules but also the issues of policies. Although this methodological approach is not blind to context and requires knowledge of the governing system under study, it provides a method for comparisons, insights, and theoretical development.

In addition to theoretical and methodological insights, this analysis offers substantive insights into oil and gas governance in California. First, although California has lagged other states in developing regulations that target hydraulic fracturing, the issue of hydraulic fracturing early in the shale boom was not as salient in California as in other states. By looking at the design of the policies produced, however, we see that the policymaking actors might be paying close attention to negative externalities associated with oil and gas, as well as linking oil and gas governance with broader energy governance issues, such as GHG reporting, which targets sectors beyond oil and gas. We also see that, not surprisingly, in a state known for polycentric governance, there are many diverse actors – including those from all levels of government, private actors, experts, and non-governmental actors – who are incorporated into the system. These actors play multiple roles as well, interacting through different action situations.

The lessons from California are similar in many ways to insights gleaned from similar approaches used in the study of Colorado's oil and gas governance system. For example, as in the Colorado governance system, we see that even in systems designed to be primarily "regulatory" or coercive, diverse types of actors – not just government actors who regulate the industry – interact to shape and produce policy outcomes. These actors are also governed under various combinations of rules. However, unlike our analysis in Colorado, our approach in California is able to portray even more nuance in actors' overlapping authority across the governance system by identifying targeted action situations and the diverse sets of issues that actors address in these action situations. The next step is to compare the topic of oil and gas

development across a number of states to see if similar states have similar structures and dynamics on this topic. We expect, for instance, that states with more home-rule traditions, such as California and Colorado, would look more similar to each other than a state that is more centralized, such as Oklahoma. We also need to compare and use this same method on different topics in the same state to explore the generalizability of these findings across governance issues.

We further acknowledge that the theoretical framework and methods we use to portray interrelationships in a governance system, and the sub-set of action situations within them, can result in different characterizations of the system. Viewing the complexity of a system through for instance the ecology of games (EG) framework tends to pay less attention to the role of rules that structure actor participation in different policy venues (or action situations) than the lens we use. The methods of analyzing the structure of a governance system also matter. Analyzing the content of thousands of words within formal policies to elicit the structure of a system will likely portray the system differently than a survey of actors involved. We do not claim that one lens or approach is more valid than another. Rather, we emphasize the need to be explicit about the advantages and limitations of each lens. Although both approaches offer valid ways of measuring the polycentric nature of governance systems, it would be valuable to directly compare both approaches to see if we have similar or different conclusions on the specific ways that actors engage in action situations or policy venues, and how their interactions are structured. Both approaches could also inform one another and potentially improve the validity of our understanding of the characteristics of governance systems.

Other limitations arise in the methods, such as using the public policy as the unit of observation. In doing so, we are attempting to overcome challenges of aggregating institutional analysis that can arise when measuring individual institutional statements as the unit of analysis, which can be onerous (Siddiki et al., 2019). By using the entire public policy as the unit of analysis we lose precision in understanding how specific actors, issues, and rules connect to each other. However, we gain the ability to measure and compare across a larger number of policies and enhance our understanding of how the policies interrelate in a broader governance system. The result is a representation of a governing system that captures characteristics of its polycentric structure and dynamism.

Credit author statement

Tanya Heikkila and Christopher Weible co-led the writing and data analysis for this paper. Kristin Olofsson was central in the initial drafting of the paper concept and early iterations of data collection. Jennifer Kagan, Jongeun You, and Jill Yordy equally participated in supporting data collection, editing, and writing of the paper.

Declaration of competing interest

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

Acknowledgements

Funding: This work was supported by the National Science Foundation [award IDs 1734310, 1917908].

Appendix 1

List of high-level issue categories in reference to Table 1.

1. *Infrastructure* words are associated with facility that is separated from the oil and gas development (e.g., educational facility, hospital, highway).
2. *Oil and Gas Policies or Strategies* include words related to policies or formal strategies (e.g., approaches following industry standards, certification guidelines, plans for implementing policy requirements, etc.) during the oil and gas development process (e.g., spill contingency plan, leak investigation, underground injection).
3. *Other Policies* reference named policies that are not restricted to oil and gas development (e.g., the Federal Water Pollution Control Act, cap-and-trade program, eminent domain).
4. *Tax/Finance* words are indicative of public finance activities (e.g., the Oil, Gas, and Geothermal Administrative Fund, severance tax, cleanup fund).
5. *Oil and Gas Resources* include words associated with the physical properties of extractable natural resources (e.g., reservoir, hydrocarbon, the Kern River Formation).
6. *Environment or Health* words are related to environment, wildlife, or human health (e.g., watershed, elk, air quality).
7. *Negative Externalities* reference words that indicate a negative impact from oil and gas development (e.g., contamination, pollutant, earthquake).

List of all high-level rule categories in reference to Table 1.

1. *Aggregation rules* indicate collective decision-making. This includes words such as “settle,” “consult,” and “negotiate.”
2. *Authority rules* grant authority to an actor and are indicated by words such as “regulate,” “allow,” “approve,” and “mandate.”
3. *Constitutive rules* define phenomena. Words in this category include, among others, “declare,” “define,” “comprise,” and “deem.”
4. *Choice rules* involve actions and decisions about procedures. In the context of oil and gas, we include words such as “build,” “install,” “load,” “drill,” and “operate.” Additional, general choice terms such as “employ,” “maintain,” and “serve” are included.
5. *Enforcement rules* capture words that refer to enforcing or potentially enforcing violations and failing to meet regulatory expectations (e.g., “enforce,” “compliance,” “fines,” “penalty,” “prohibit”).
6. *Information rules* involve requirements for collecting, giving, disclosing, documenting, or receiving information (e.g., “document” or “receive”). We also include words about monitoring, inspecting, and reporting (e.g., “monitor” or “report”).
7. *Payoff rules* involve requirements for actors to compensate for other actors and include words such as “pay,” “distribute,” “compensate,” and “deposit.”

List of all high-level deontic categories in reference to Table 1.

The three high-level concepts include “must” (including “shall and “will”), “may”, and should”.

Appendix

Table 1
Correlations of Weighted Frequencies of Actors, Issues, Rules, and Deontics per Public Policy to the Horizontal and Vertical Dimensional Coordinates of the Public Policies from MDS Calculations in Fig. 3.

	Horizontal Dimension	Vertical Dimension
Horizontal Dimension	1	0.039
Vertical Dimension	0.039	1
Am Chem Soc	0.272	−0.075
Am Soc Testing & Materials	0.113	−0.113
Eng	−0.026	−0.089
Experts	0.217	−0.050
Fed Gov	0.119	.751**
Fed Courts	0.020	−0.242
Dept Interior	0.072	0.368
Energy Info Admin	-.503*	−0.070
Env Prot Agcy	.450*	0.199
Military	0.106	.534*
Geologist	0.181	−0.057
GHG Impl	-.716**	−0.071
Health Prof	0.265	−0.052
IOGCC	0.193	−0.006
Loc Gov	0.244	0.182
Oil & Gas Industry	-.720**	−0.259
GHG Offset Designee	−0.362	−0.053
Gen Pub	0.289	0.046
Atty Gen	−0.012	0.397
State of CA	0.311	.800**
Dept Res Rec Recov	0.265	−0.052
Dept Trans	−0.248	0.194
CARB	-.800**	−0.244
Dept Fish & Wildlife	−0.012	0.397
Dept Tech	0.193	−0.006
Energy Comsn	-.461*	0.120
Geo Survey	0.265	−0.052
Coastal Cons	0.108	.591**
Controller	0.096	−0.039
State Courts	−0.034	−0.237
Dept of Cons	−0.015	−0.196
Dept Toxic Subst Ctrl	0.297	0.131
Governor	0.086	.507*
Ground Water Prot Council	0.193	−0.006
Leg	0.342	0.219
Nat Res Agcy	0.277	0.314
Off Env Health Hazards Ast	0.265	−0.052
Off Emerg Svc	0.087	0.245
OGGR	.638**	−0.415
Off of Spill Prev & Resp	0.091	0.356
Pub Util Comsn	−0.250	0.194
Water Qual Bd	0.343	0.195
Treasurer	−0.012	0.397
Surface Owner	0.261	−0.292
Violator	0.116	−0.109

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

[1] The methods in this article mirror the methods used in a study of oil and gas governance in Colorado (Weible et al. under review), which also extends semi-automated methods employed by Heikkila and Weible (2018).

[2] We also searched for relevant ballot initiatives and policies from other possible regulatory agencies. We did not find pertinent policies that met our search criteria (inclusive of the terms 'oil and gas' or 'fracking' or hydraulic fracturing'). We recognize we may have missed potential policies that affect oil and gas development in California, however. Also, we did not include legislation and regulations passed before 2007 that pertain to oil and gas that were not changed during this time period.

[3] The original thesaurus was subjected to an inter-coder reliability test to ascertain the correct assignment of words from the regulations to word categories. Two coders, who were not the authors, assessed a random sample of 42% of the words and their categorization in the dictionary and found 86% were correctly allocated.

[4] Some words were removed in the inter-coder agreement process for inconsistent or ambiguous usage (e.g., words like "permit").

[5] Node size is the same across actors and policies, not related to power or centrality as it is common in many network studies.

References

Baker Hughes, 2020. North America Rig Count. https://bakerhughesrigcount.gcs-web.com/na-rig-count. (Accessed 21 February 2020).

Berardo, R., Lubell, M., 2019. The ecology of games as a theory of polycentricity: recent advances and future challenges. Pol. Stud. J. 47 (1), 6–26.

Blomquist, W., Heikkila, T., Schlager, E., 2001. Institutions and conjunctive water management among three western states. Nat. Resour. J. 41 (3), 653–683.

Bodin, Ö., Robins, G., McAllister, R.R.J., Guerrero, A.M., Crona, B., Tengö, M., Lubell, M., 2016. Theorizing benefits and constraints in collaborative environmental governance: a transdisciplinary social-ecological network approach for empirical investigations. Ecol. Soc. 21 (1), 40.

Borgatti, S.P., Everett, M.G., Freeman, L.C., 2002. Ucinet for Windows: Software for Social Network Analysis. Analytic Technologies, Harvard.

Carley, K.M., Diesner, J., 2005. AutoMap: Software for Network Text Analysis. Center for Computational Analysis of Social and Organizational Systems.

Carlisle, K., Gruby, R.L., 2017. Polycentric systems of governance: a theoretical model for the commons. Pol. Stud. J. 47 (4), 927–952.

Crawford, S.E., Ostrom, E., 1995. A grammar of institutions. Am. Polit. Sci. Rev. 89 (3), 582–600.

Davies, A.L., White, R.M., 2012. Collaboration in natural resource governance: reconciling stakeholder expectations in deer management in Scotland. J. Environ. Manag. 112, 160–169.

Dietz, T., Ostrom, E., Stern, P.C., 2003. The struggle to govern the commons. Science 302 (5652), 1907–1912.

Dorr, A.J., 2017. Fractured Politics: the Evolution of Oil and Gas Well Stimulation Regulation in California. Doctoral dissertation, University of California, Los Angeles, US). https://escholarship.org/uc/item/9jz0q3zj.

Dugard, P., Todman, J., Staines, H., 2010. Approaching Multivariate Analysis: A Practical Introduction. Routledge, Abingdon.

Heikkila, T., 2019. Conflict and conflict resolution in polycentric governance systems. In: Thiel, A., Blomquist, W.A., Garrick, D.E. (Eds.), Governing Complexity: Analyzing and Applying Polycentricity. Cambridge University Press, Cambridge, pp. 133–152.

Heikkila, T., Schlager, E.C., 2012. Addressing the issues: the choice of environmental conflict-resolution venues in the United States. Am. J. Polit. Sci. 56 (4), 774–786.

Heikkila, T., Weible, C.M., 2018. A semiautomated approach to analyzing polycentricity. Environ. Pol. Gov. 28 (4), 308–318.

Heikkila, T., Schlager, E., Davis, M.W., 2011. The role of cross-scale institutional linkages in common pool resource management: assessing interstate river compacts. Pol. Stud. J. 39 (1), 121–145.

Henry, A.D., Lubell, M., McCoy, M., 2011. Belief systems and social capital as drivers of policy network structure: the case of California regional planning. J. Publ. Adm. Res. Theor. 21 (3), 419–444.

Jaquith, K., 2017. The tension between state interests and municipal zoning rights in the realm of fracking regulations. Environ. Claims J. 29 (1), 49–65.

Jenkins-Smith, H., Nohrstedt, D., Weible, C.M., Ingold, K., 2017. The advocacy coalition framework: an overview of the research program. In: Weible, C.M., Sabatier, P.A. (Eds.), Theories of the Policy Process. Westview Press, Boulder, pp. 135–171.

Jones, B.D., Baumgartner, F.R., 2005. The Politics of Attention: How Government Prioritizes Problems. University of Chicago Press, Chicago.

Koontz, T., Heikkila, T., Garrick, D., Villamayor-Tomas, S., 2019. Assessing performance of polycentric governance systems interactions. In: Theil, A., Blomquist, W.A., Garrick, D.E. (Eds.), Governing Complexity: Analyzing and Applying Polycentricity. Cambridge University Press, Cambridge, pp. 173–194.

Lemos, M.C., Agrawal, A., 2006. Environmental governance. Annu. Rev. Environ. Resour. 31, 297–325.

Lubell, M., 2013. Governing institutional complexity: the ecology of games framework. Pol. Stud. J. 41 (3), 537–559.

McGinnis, M.D., 2011. Networks of adjacent action situations in polycentric governance. Pol. Stud. J. 39 (1), 51–78.

Morrison, T.H., 2017. Evolving polycentric governance of the great barrier reef. Proc. Natl. Acad. Sci. Unit. States Am. 114 (15), E3013–E3021.

Ostrom, E., 2005. Understanding Institutional Diversity. Princeton University Press, Princeton.

Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. Am. Econ. Rev. 100 (3), 641–672.

Ostrom, V., Ostrom, E., 1971. Public choice: a different approach to the study of public administration. Publ. Adm. Rev. 31 (2), 203–216.

Schulz, T.F., Kypreos, S., Barreto, L., Wokaun, A., 2008. Intermediate steps towards the 2000 W society in Switzerland: an energy-economic scenario analysis. Energy Pol. 36 (4), 1303–1317.

Siddiki, S., Weible, C.M., Basurto, X., Calanni, J., 2011. Dissecting policy designs: an application of the institutional grammar tool. Pol. Stud. J. 39 (1), 79–103.

Siddiki, S., Heikkila, T., Weible, C.M., Pacheco-Vega, R., Carter, D., Curley, C., Deslatte, A., Bennett, A., 2019. Institutional analysis with the institutional grammar. Pol. Stud. J. https://doi.org/10.1111/psj.12361.

Stephan, M., Blomquist, W.A., 2019. Part I: foundations for understanding and researching polycentric governance. In: Theil, A., Blomquist, W.A., Garrick, D.E. (Eds.), Governing Complexity: Analyzing and Applying Polycentricity. Cambridge University Press, Cambridge, pp. 19–110.

Thiel, A., Garrick, D.E., Blomquist, W.A. (Eds.), 2019. Governing Complexity: Analyzing and Applying Polycentricity. Cambridge University Press, Cambridge.

Tiebout, C.M., 1956. A pure theory of local expenditures. J. Polit. Econ. 64 (5), 416–424.

U.S. Energy Information Administration, 2020. California Profile: State Profile and Energy Estimates. https://www.eia.gov/state/?sid=CA. (Accessed 15 December 2020).

Williamson, O.E., 1975. Markets and Hierarchies: Analysis and Antitrust Implications. Free Press, New York.

Wyborn, C., Bixler, R.P., 2013. Collaboration and nested environmental governance: scale dependency, scale framing, and cross-scale interactions in collaborative conservation. J. Environ. Manag. 123, 58–67.