The SESMAD project

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Abstract: This article introduces the Social-ecological systems meta-analysis database (SESMAD) project, which is the project behind the case studies and synthetic articles contained in this special issue of the International Journal of the Commons. SESMAD is an internationally collaborative meta-analysis project that builds on previous seminally synthetic work on small-scale common-pool resource systems conducted at the Workshop in Political Theory and Policy Analysis at Indiana University. This project is guided by the following research question: can the variables found to be important in explaining outcomes on small-scale systems be scaled up to explain outcomes in large-scale environmental governance? In this special issue we report on our findings thus far through a set of case studies of large-scale environmental governance, a paper that describes our conceptual advances, and a paper that compares these five case studies to further examine our central research question.

Keywords: Common-pool resources; environmental governance; social-ecological systems

1. Introduction:

Large-scale environmental problems are arguably the most difficult to address due to the number of actors and the complexity of social-ecological interactions involved. By their nature they also impact the welfare of large numbers of people. Examples of large-scale environmental issues include degradation of the ozone layer, deterioration of migratory fish stocks, and pollution of international watersheds. While some large-scale environmental problems have been successfully addressed, extensive governance and analytical challenges must still be met in order to systematically understand and confront these types of problems.

This article introduces a special issue in the International Journal of the Commons that is designed to accomplish two goals. Firstly, it presents a set of case studies of large-scale environmental management that employ the same methodology in arriving at their findings. Secondly, it moves forward with a larger research project known as the Social-ecological system meta-analysis database (SESMAD) Project, of which these cases are a part. Details on this project can be found at the following web address: http://www.dartmouth.edu/~sesmad/. Each of the papers in this special issue contributes to addressing the following research question that guides the larger project: what variables and theories developed in the analysis of small to medium-scale common-pool resources (CPRs) are also important in explaining success or failure in the long-term governance of large-scale environmental systems?

Quite a bit of work has been done studying small-scale CPRs such as forests and fisheries (Gibson et al. 2000). Despite this, one of the challenges that CPR research still faces is producing synthetic findings that span many types of CPR settings (Poteete et al. 2010). One of the primary ways in which this challenge has been met is through the methodology of meta-analysis (Ostrom 1990, Poteete et al. 2010). A meta-analysis in this context is a synthetic analysis of a set of case studies of particular systems. While meta-analyses have successfully contributed to the study of small-scale CPRs, similarly synthetic analyses of larger systems have mostly been lacking, with the notable exception of the international environmental regimes project (Breitmeier et al. 2006). SESMAD is a new meta-analysis research project oriented towards large-scale systems, and the case studies presented in this special issue will eventually become part of a database containing many consistently coded cases of large-scale environmental governance spanning a range of regions and resource systems.

This SESMAD project is unique in several respects. First and foremost, it is a collaboration among fourteen young scientists from diverse backgrounds, each trained to consistently code data into a common database. The SESMAD project began during a conference held by the Resilience Alliance in the spring of 2011. During this conference, a group known as the Resilience Alliance Young Scholars (RAYS) met and formed teams oriented around particular projects. SESMAD was one of those projects. The team has met several times since this and will continue to meet throughout the duration of the project. Project members became part of the project either through their affiliation with RAYS or with the Workshop in Political Theory and Policy Analysis at Indiana University, a well-recognized leading center in the synthetic study of small-scale CPRs.

An additionally unique aspect of SESMAD is that it entails the development of tools and an approach as much as it involves the production of scientific results. In this issue we will describe this approach as well as the preliminary results that we have found to this point in the project. Finally the collection of case studies in this special issue represents the first such set that consistently operationalizes the same set of variables. While other sets have employed a common framework, they have not consistently operationalized the variables within such a framework, leaving that up to the authors of the individual studies. This severely limits the comparability of such studies, in the sense that conceptual validity is too low to enable inter-case comparison and produce a better understanding of the importance of particular variables across cases.

2. Relevant past work

2.1. Common-pool resources

The methodological foundations of SESMAD come from previous synthetic work on small-scale CPR systems pioneered at the Workshop in Political Theory and Policy Analysis at Indiana University. Previous projects from this research program include the Common-Pool Resource Research Project (Ostrom 1990; Schlager and Ostrom 1992; Tang 1992; Ostrom et al. 1994), the Nepal Irrigation Institutions Systems (NIIS) Project (Lam 1998; Shivakoti and Ostrom 2002), and the International Forestry Resources and Institutions (IFRI) Project (Gibson et al. 2000; Poteete and Ostrom 2004; Wollenberg et al. 2007). The most famous output of the work is Ostrom's design principles for successful community-based CPR management (see Ostrom 1990 and Cox et al. 2010).

These projects have established protocols for building databases that code information about the characteristics of governance and resource systems, social-economic attributes of the individuals involved, and the outcomes achieved. These projects have also shown the power of the synthetic methodologies, producing findings that have challenged the persistent belief that external authority must impose government or private ownership on user communities that share the use of a CPR such as a forest or irrigation system (Hardin, 1968; Terborgh, 1999). Theoretical and empirical studies from this research program have likewise challenged earlier theories of helpless resource users trapped in complex environments and shown that, under certain conditions, communities can avoid the tragedy of the commons (Ostrom, 1990; Ostrom and Nagendra 2007).

The starting point for much of this research is in fact the paradigmatic tragedy of the commons highlighted by Hardin (1968). The primary research question that has been addressed in studies of small-scale CPRs is: how do resource users cooperate to overcome collective-action problems, or divergences between group and individual-level interest, to avoid the deterioration of a shared resource? Thus, collective-action (or the lack of it) is seen as the ultimate cause of environmental outcomes, and research focuses on the proximate factors that affect the likelihood of human cooperation in SESs.

Our research tests both the importance of this ultimate cause (and the collective-action orientation of traditional CPR work) as well as the importance of specific proximate factors that affect the likelihood of successful collective action. Among these proximate causes, institutions play a primary role in affecting collective-action outcomes. Institutions are the rules and patterns of behavior used by individuals to order their relationships (Ostrom 2005). Several key institutional arrangements include monitoring and sanctioning and conflict resolution mechanisms. Other explanatory variables in this literature include group size, leadership, trust, social capital, autonomy, and social heterogeneity, each of which can help or hinder participants' efforts to maintain the cooperation needed to sustain a natural resource (Agrawal 2001).

While the findings from CPR work have been important, there are several reasons to question their applicability to large-scale systems. First, smaller systems are less complex and are frequently isolated from larger-scale dynamics. This allows researchers to relax concerns about interaction effects and spurious relationships. Second, larger-scale systems, with their large number of disparate actor groups, provide reason to doubt whether the basic logic of associating collective-action with positive environmental outcomes can be scaled up (Stern 2011).

2.2. International environmental regimes

One research project that has focused on large-scale SESs is the international environmental regime program. Parallel to the challenges facing researchers of small-scale systems, international regime scholars have confronted the inherent limitations of case-based research by conducting synthetic meta-analyses (Keohane and Ostrom 1995; Young 2010; Breitmeier et al. 2011). Mitchell (2003), for example, created a database to statistically analyze the formation and institutional structure of over 1,700 international environmental agreements. Miles et al. (2002) combined 15 in-depth case studies to begin to scale up the analysis of the effectiveness of environmental regimes. Breitmeier et al. (2006) took this one step further and built a database of 172 "regime elements" or historical snapshots of regimes, to also look at regime effectiveness.

Similar to the SESMAD project, this research has focused on outcomes of the governance of natural resources and pollution. In particular, they all examine regime effectiveness as the key dependent variable, subdividing this into the output (the creation of rules), outcomes (the compliance with rules), and impacts (whether natural conditions change as a result of human action). In addition, these projects analyze a broad range of independent variables, similar to many of the variables in the SESMAD database, including monitoring and enforcement of rules, criteria for membership in actor groups, regime boundaries, watershed events, heterogeneity of actor groups, and number of actor groups. However, all of these approaches focused solely on the governance aspects of the regimes, leaving out biophysical characteristics from their list of independent variables, as well as social-ecological feedbacks within the systems of interest.

3. Cased-based meta-analysis

3.1. The approach

Most studies conducted on the dynamics of SESs focus on a single spatially bound system – such as a country, a watershed, a protected area, or on a single governance arrangement such as an international treaty or important national environmental law. Two widely applied techniques that do attempt to aggregate across systems are statistical meta-analyses, which pool data on the same phenomenon gathered in multiple studies in order to test effect sizes, and informal literature reviews which summarize and compare the findings of multiple studies. Statistical meta-analysis is a powerful technique, yet it can only be used when data gathered in multiple studies address the same questions using the same or similar techniques. However, studies of SESs rarely have these needed characteristics. Informal literature reviews, meanwhile, can provide for meaningful comparison, but are inherently non-systematic.

In contrast to these other synthetic methods, the methodology we use is a meta-analysis of case studies (Geist and Lambin 2002; Young et al. 2006; Rudel 2008). Meta-analyses of case studies combine the rigor of formal statistical meta-analysis with some of the flexibility of a literature review. They do not require that the case studies by conducted in an identical fashion in order to produce comparable data, but instead rely on standard coding protocols utilizing nominal, ordinal, interval and qualitative variable definitions to create a database which uses existing information to compare across cases.

This methodology distinguishes between "cases" and "studies." A study, for our purposes, is a published piece or work (e.g. book, book chapter, journal article) that describes one or more cases in depth. A study is our unit of observation, or the unit on which we collect our data. A case, meanwhile, is closer to our unit of analysis. It is a particular SES where a governance regime and set of actors are affecting, and are affected by, a particular resource. The data collection phase of a meta-analysis involves conducting content analyses of studies in order to produce data for a set of cases. This coding process is guided by a coding manual that describes the relevant theoretical background for the project and each variable in the database.

The relevant population of cases for this project are those systems that: (1) have at least one governance system, actor group, and resource interacting with each other, and (2) are of a sufficient geographic and organizational scale (geographic extent exceeding 10,000km^2 and/or including more than 100,000 individuals). We will describe how we define these constituent components below. Geographic extent is largely determined by the extent of the main resource in a SES. In the case of mobile resources (e.g. fish or pollutants) this is defined as the range of the resource. Building on these criteria, we further define our sampling frame to include four different broad types of SESs: forest regimes, fisheries, protected areas, and transboundary pollution cases.

3.2. Primary challenges: maintaining reliability and addressing heterogeneity

The most challenging part of both this special issue and of the larger project is maintaining inter-coder reliability, or the extent to which each team member as a coder interprets the variables consistently enough to warrant analytical comparison across cases. This is a standard issue in the practice of content analysis (Neuendorf 2002). While having a large team provides a valuable range of expertise and knowledge of particular systems, the project faces a trade-off between this advantage and the additional costs imposed by the possibility of divergence in understanding between team members.

Establishing a common understanding of the some 200 variables that the database contains has been one of the primary goals of the first phase of the project. Indeed, conducting the case studies was initially suggested as a way of solidifying this understanding. Each case study was conducted by at least three team members, with a fair amount of membership overlap across the cases to ensure that the understanding reached by each group was consistent with that reached by the other groups.

An additional challenge that this project has faced comes from the high levels of complexity and heterogeneity inherent in large-scale SESs. By complexity I mean the number of distinct components within an SES and the interactions among these components. By heterogeneity I mean the variation in the values a variable takes on either (1) across multiple instances of a component (e.g. across multiple actor groups), (2) within sub-sections of a particular instance (e.g. within a particular forest), or (3) over time. At least some portion of the complexity and heterogeneity with a case must be captured in order to explain the outcomes achieved, but trying to capture too much leads to onerous (or unending) coding of that case, and data that is not comparable to other cases. The trade-off between the two extremes of non-generalizable specificity and non-meaningful generality has been well established (see Cox 2008 and Levin 1999 for examples from CPR theory and ecology, respectively).

The current structure of the SESMAD database is the result of several iterations that have attempted to achieve a balance between these extremes. In addition to the structure of the database itself which I will describe below, two specific protocols have arisen from these iterations, the first to deal with heterogeneity at a given point in time, and the second to deal with heterogeneity over time. The first protocol requires that the default interpretation of a SES and any of its components be at the largest scale or highest level of aggregation possible. As needed, more disaggregated versions may be introduced to a case, but we do not as a rule proceed all the way to individual members of component instances (e.g. individual fish or fishermen). There is no meaningful way to add a record in the SES database for such individuals: only groups or types of groups may be added.

This approach is fairly consistent with the emphasis on collective-action mentioned earlier. We are interested in collective outcomes, not individually-measured variables and outcomes. At the same time, we believe that many of the important outcomes in SESs are produced by the psychological states and motivations of actors, which is a view sometimes associated with "methodological individualism." What we do not believe is that such a stance limits us to only the individual level of analysis (see Brennan and Tolluck 1982). Rather, evolutionary work on human evolution has shown that, because humans have faced both individual and group-level selective pressures during their evolutionary history (Wilson and Wilson 2007), they are capable of acting as coherent and rational social units at both the individual and group level, and can be analyzed as such. We follow the argument made by Hodgson (2007), that the best approach is not to consider individuals alone, but individuals (and their psychological motivations and incentives) plus the institutional context in which they operate.

The second protocol relies on the concept of a snapshot, or a period of time in which the values of a set of variables in a SES remain fairly constant over a long enough period of time such that meaningful inferences regarding their values and influences on outcomes can be made. This snapshot concept is an adaptation of the concept of a "threshold" from the work on international environmental regime elements discussed earlier. The snapshot as it is implemented in the relational SESMAD database is slightly more complicated, and this will be discussed in the following sections.

4. The social-ecological framework and database

Our conceptualization of SESs has been inspired by a framework proposed by Ostrom (2007, 2009). We have adapted this framework to the requirements of analyzing large-scale SESs, resulting in our own SES framework and database structure. Figure 1 shows a modified version of the original SES framework as developed by Ostrom (2009), and layers on it the tables of our relational database that correspond to components of the SES framework.

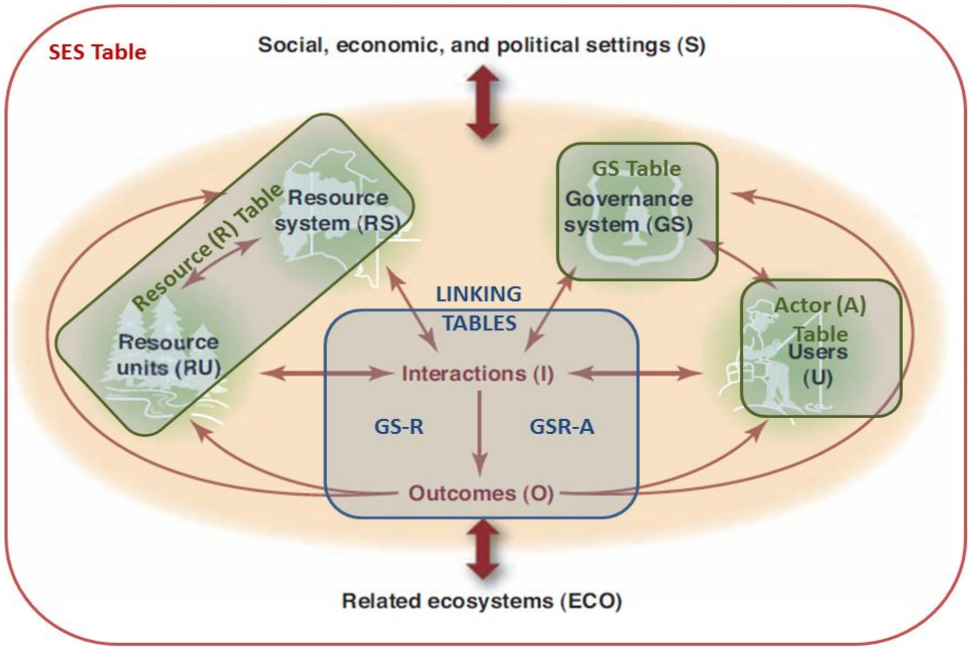

Figure 1: Implementation of the SES framework as a Relational Database

Figure 1 shows a SES as consisting of four main components: governance systems, actor groups, resource units, and resource systems. Ostrom did not define the components in her introduction of the framework. As a result, we adopted the following definitions at an early point in the project, using the term “actor groups” in place of “users, which is mostly consistent with more recent applications of the framework:

Governance system: A set of institutional arrangements (such as rules, policies, and governance activities) that are used by one or more actor groups to interact with and govern a resource system and/or resource unit. Examples include the Montreal Protocol regime, the Great Barrier Reef Marine Park Act, and the International Convention for the Conservation of Atlantic Tunas.

Actor group: A group of actors, i.e. of individuals, organizations or nations, that have developed a set of institutional arrangements in order to interact with a resource system or unit. In our analysis we include groups whose members that actually interact with each other (e.g. a particular management agency) as well as groups whose members may not interact very often if at all (e.g. fishermen who appropriate Bluefin tuna in the Atlantic Ocean).

Resource system: a geographic area within which the interactions among biophysical units are comparatively stronger than they are with other units outside of the system. Within resource systems, actors can impose spatial externalities on each other via their actions towards the resource system and/or resource units it contains. These externalities create collective-action problems.

Resource unit: Resource units in this project include both natural resources and pollutants. "Unit" does not refer to an individual, but to a type. A unit is anything that can be isolated within a resource system and subjected to consumption, management or governance. Units can be conceptualized at several levels of aggregation (for example, a resource unit could be "bluefin tuna" or it could be "fish").

In translating this framework into a relational database, we have made several changes, which are reflected in figure 2. To begin, while we initially created a table for each of the four main SES components, we eventually combined the resource unit and resource system components into one table in the database. We did this for several reasons. First, beyond the paradigmatic and often-used irrigation example that has water as a resource unit and the infrastructure as the resource system, it proves very difficult to clearly delineate the two types of resources consistently across multiple types of systems. For example, it is not at all clear in a forest whether we should focus on a particular species of tree to as a resource unit, or on the larger forest to as a resource system. Or in a pasture-based system, it isn't clear whether the grass on the pasture, the cows, or say the milk produced from the cows are the most relevant resources, and which of these is a unit or a system.

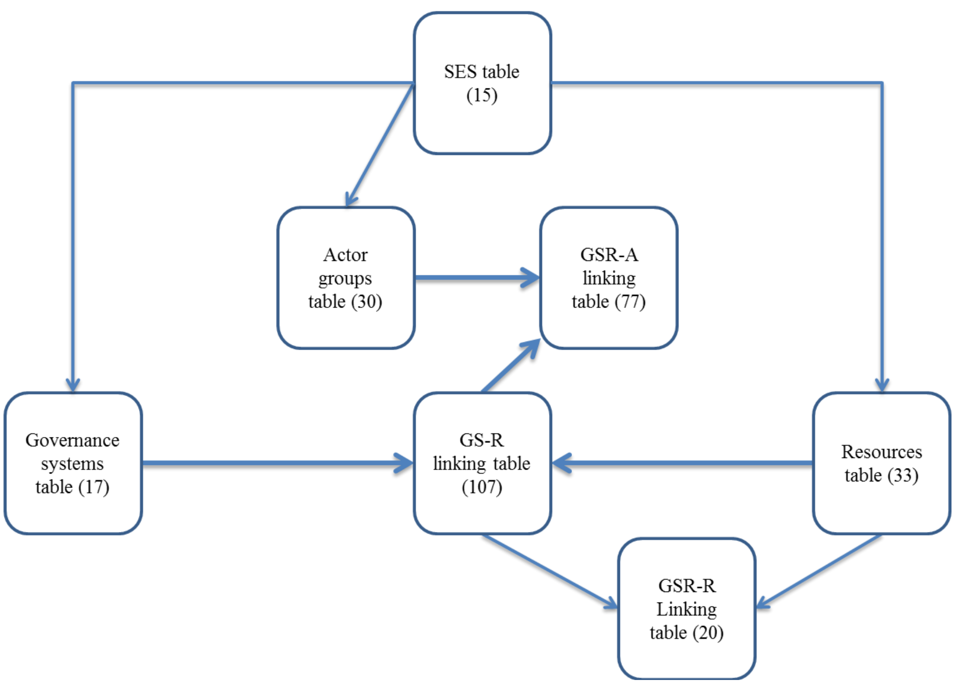

Figure 2: Database Structure

Moreover, we found that the relevant variables for resource units and systems overlap to a significant extent, belying the fuzzy nature of the distinction between them. This contradicts the SES framework as Ostrom (2007) described it, as she assigned distinct objects to each component. In any case, one variable in the combined Resources table is used to indicate whether each record it contains is a resource unit or a resource system, enabling the team members to record units or systems and the relevant variables for each. However, recording both a resource unit and a resource system for a SES is not required by the database. Coding both a resource system and a distinct resource unit in one SES is possible, but not required.

Additionally, we have expanded upon the general notion of interactions and outcomes from the original framework to specifically look at three broad sets of interactions: one between governance systems and resources (table GS-R), another set of interactions that capture how specific actor groups participate in the broader governance process of a resource (table GSR-A). These two tables effectively create two main levels of analysis: one at the level of the GS-R table, which captures broad governance patterns and effects and aggregates over the activities of potentially many actor groups, and the second at the GSR-A level, which captures the actions and effects of a particular actor group within the context of a broader set of governance arrangements.

Finally, we introduced a third set of interactions, this one between the governance of a primary resource and a secondary resource (captured in table GSR-R). A primary resource is one subject to direct institutional management, such as CFCs by the Montreal Protocol regime or bluefin tuna by ICCAT. A secondary resource is a resource whose conditions are affected by the governance of a primary resource, such as the atmospheric ozone layer as it is indirectly affected by the regulation of CFCs.

Figure 2 shows the relational database structure that results from these changes. Each box signifies a table, and each arrow points in the direction of a one-to-many relationship between two tables. These relationships are created in the standard way, using primary keys and foreign keys in the appropriate tables. The numbers in parentheses within each box indicate the number of variable that table contains. These numbers illustrate that the largest tables in the database are the linking tables GS-R and GSR-A.

Our model of a SES then consists of at least one governance system, at least one resource, and one or more actor groups that relate to the resource within the context of the governance system. These three components represent the purely social and biophysical aspects of the SES, respectively. Each is modeled as a table in the relational database, and each table records values of important social or biophysical variables. The interactions between these components are captured in the two linking tables, labeled GS-R and GSR-A. Each row in the GS-R table records a relationship between a governance system and a resource. It is here where the interactions between the two are recorded. Similarly, each row in the GSR-A table records the relationship between an actor group and the broader governance of a particular resource. Finally, the GSR-R table records the relationships between the governance of one (primary) resource and another (secondary) resource.

With this understanding of the database in mind, we can turn to the concept of a snapshot as it is implemented in the SESMAD database. Unlike previous work on international regimes, where a particular snapshot was defined in one particular table, in the SESMAD database each table defines its own snapshot. This is done by the presence of two variables in each table that capture the dates that mark the beginning and end of record in that table. As such, in a way each table has its own "snapshot" or period of time that each record covers. Because of the one-to-many relationship between the SES components and the linking tables, one snapshot for the instance of a SES component can be related to more than one snapshot in a linking table. The most important and dynamic snapshots in the database are captured in the GS-R and GSR-A linking tables.

5. Using the database to code cases

The structure of the database lends itself to a stepwise approach to analyzing and coding a particular case. This process is guided by the two protocols mentioned earlier, which are to (1) begin the coding of a SES based on the most aggregated components involved, and (2) code each component and their interactions based on a well-defined snapshot for each record entered. The steps are the following:

1) Code a record in the SES table for the case.
2) Code a record in the GS table for the case.
3) Code a record in the Resource table for each primary resource that is managed by this GS.
4) Code a record in the GS-R table for the governance of each primary resource by the GS.
5) For each GS-R record:
    a. Code records in the GSR-R and R tables for any important secondary resources.
    b. Code a record in the Actor table for a relevant Actor group, and a record in the GSR-A table for its relationship to the larger system (to the GS-R record). Repeat for each actor group.
6) Repeat steps 2-5 as necessary for the SES.

6. Conclusion: introducing the articles in this special issue

This special issue of the International Journal of the Commons is composed of this introductory article, five case studies, one comparative paper, and one synthesis paper. The case studies examine the following SESs:

1. Governance of Atlantic Bluefin Tuna by the International Commission for the Conservation of Atlantic Tuna (Epstein et al. this issue)

2. Governance of Indonesian forests through the Suharto and decentralized post-Suharto regimes (Fleischman et al. this issue)

3. Governance of ozone-depleting substances by the Montreal Protocol (Epstein et al. this issue)

4. Governance of pollution problems within the Rhine river in Europe (Villamayor-Tomas et al. this issue)

5. Governance of the Great Barrier Reef via the Great Barrier Reef Marine Park (Evans et al. this issue)

Each case explores a core set of variables from CPR theory, testing their applicability to the governance of a large-scale environmental problem and/or system. Each also discusses whether additional variables must be added to explain outcomes, as well as the challenges involved in coding a case using the approach that I have described in this article. Following these five case studies, there is a paper comparing each of the studies, leveraging this comparison to further explore the applicability of CPR theory to large-scale systems (Fleischman et al. this issue). Finally, Schoon et al. (this issue) explore the conceptual issues that have arisen to this point in the SESMAD project.

Following this special issue, the SESMAD team is moving forward with the project in several ways. Most basically, we will continue to enter cases into the database. With additional data we will conduct further comparative and eventually statistical analyses of the data. It is our goal to produce synthetic findings across a wide range of cases of large-scale environmental governance. Equally importantly, however, we aim to move the practice of social-ecological analysis towards a more broadly collaborative paradigm. Such collaboration is needed to understand complex social-ecological systems with dynamics that are beyond the understanding of any single scholar. As a part of this collaborative vision, the website mentioned at the beginning of this article that houses the SESMAD project (http://www.dartmouth.edu/~sesmad/) is planned to serve as an important hub for integrative social-ecological analysis. Through this site, cases that are coded into the database will eventually be viewable in a wiki-like fashion, enabling casual users to efficiently browse the data and delve into the specifics of particular cases. In addition to this website, several project members will use the SESMAD project as a key part of a set of methods courses in social-ecological analysis. Finally, researchers interested in the project are encouraged to contact the author to see how they might become involved.

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