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Evaluating the utility of common-pool resource theory for understanding forest governance and outcomes in Indonesia between 1965 and 2012

Forrest D. Fleischman
Department of Ecosystem Science & Management, Texas A&M University & Texas Agrilife Research, USA
forrestf@tamu.edu

Brent Loken
School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia, Canada
brentloken@gmail.com

Gustavo A. Garcia-Lopez
European Network of Political Ecology (ENTITLE), Institute of Environmental Sciences and Technology (ICTA), Autonomous University of Barcelona (UAB), Spain
garcial.gustavo@gmail.com

Sergio Villamayor-Tomas
Division of Resource Economics, Department of Agricultural Economics, Humboldt University, Germany
villamayortomas@gmail.com

Abstract: While Common Pool Resource (CPR) theory has been widely applied to forestry, there are few examples of using the theory to study large-scale governance. In this paper we test the applicability of CPR theory to understanding forest governance and outcomes in Indonesia between 1965 and 2012. Indonesia contains one of the world's largest tropical forests, and experienced rapid deforestation during this time frame, with forest cover dropping from close to 85% to less than 50%. Using a mixture of within case comparison and process tracing methods, we identify key variables that influenced the levels of deforestation during two time periods: before 1998, when governance was dominated by the dictatorship of President Suharto,

and after 1998, when democratic governance and political decentralization were initiated, and deforestation rates fell and then rose again. Our results point to the value of CPR theory in identifying important variables that influence sustainability at large scales, however they also illustrate important limitations of CPR theory for the study of forests with large spatial extent and large numbers of users. The presence and absence of key variables from CPR theory did emerge as important causes of deforestation. However, some variables, such as strong leadership and local rule-making, appeared to work in the opposite direction as predicted by CPR theory. In addition, key variables that may have influenced deforestation rates are not well captured in CPR theory. These include the intention of the governance system, the presence of clientelistic politics, the influences of international politics and markets, and the influence of top-down governance. Given that CPR theory does not fully explain the case at hand, its applicability, as is, to large-scale commons should be treated with some caution.

Keywords: Common-pool resource theory, decentralization, deforestation, democratization, forests, Indonesia, SESMAD

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1. Introduction

Human drivers of changes in forest ecosystems have been subject to intensive study for several decades, however none of the major traditions examining human-forest interactions have focused on understanding the influence of governance on forests at the level of the nation-state, where many decisions about forest management are made. Common-Pool Resource (CPR) theory, as applied to forestry, largely focuses on the prospect for collective action to solve commons dilemmas at the local or village level (Tucker 2010; Araral 2014). While Land Use and Cover Change (LUCC) scholarship focuses on large-scale drivers of forest cover change, it is largely silent on the role of policy and governance (Rudel 2008). Finally, political ecology, while frequently engaging with national-level policies, tends to focus on the impact of national governance at the local level, rather than at the

national level (Robbins 2002). Similar problems plague studies of other types of commons, with knowledge about governance of environmental commons with large spatial extent and involving large numbers of actors particularly limited (Berkes 2006).

One proposed solution to this problem is to apply common-pool resource theory derived from village and community-level studies to study systems in which the number of potential actors is large and the spatial extent of the commons and governance system is much greater than in community-level studies (Keohane and Ostrom 1995; Berkes 2006). Although CPR theory is one of the most prominent contemporary theories of environmental governance, there have not been systematic tests of its applicability to large-scale forest governance. As a result, it is not clear whether CPR theory is suitable to be applied to the study of forests with large spatial extents and large numbers of users, whether the theory requires modification to be applicable to these systems, or whether the theory is not useful for the study of these forests. Specifically, it is unclear which variables and design principles from CPR theory can be applied at these larger scales, or whether the logic of collective action underlying CPR theory can be used to study cases involving large numbers of actors. Previous scholarship on the matter (e.g. Keohane and Ostrom 1995; Dietz et al. 2003; Stern 2011; Araral 2014) has provided conflicting answers.

In this paper we address a critical research frontier and explore the applicability of CPR theory to the governance of large-scale forest systems with the goal of generating hypotheses that can be tested in more detail with a larger number of cases in the future. Our focus is on systems in which both the commons and the governance system have a much larger spatial scale than in community-level studies, and we chose to focus at the level of a large nation-state because nation states make important decisions about forest management. To do this we apply the lens of the Social Ecological Systems Meta-Analysis Database (SESMAD; see Cox 2014) to a case study of forest governance in Indonesia between 1965 and 2012. The primary research questions are: (1) What does this case tell us about the applicability of CPR theory to large-scale forest governance systems? and (2) how does the application of CPR theory contribute to understanding the outcomes of the last 45 years of forest management in Indonesia?

The case of Indonesian forestry management is useful for examining the applicability of CPR theory to large-scale systems for three reasons. First, with nearly 100 million hectares of forest remaining, Indonesian forests are an example of large-scale Common Pool Resource (i.e. a resource typified by rivalrous consumption and difficult exclusion) with global importance (Barr et al. 2006; Araral 2014). These forests represent the world's third largest tropical forested area, contain 23 GT of carbon stocks (Van der Werf et al. 2009), and 2 of 25 global biodiversity hotspots (Myers et al. 2000). Second, changes in governance of Indonesia's forests since 1965 provide a good opportunity to explore the utility of CPR theory for explaining the effect of large-scale governance on forest

outcomes. Existing literature on Indonesian forest governance emphasizes the role of corrupt state-sponsored resource extraction, government resettlement policies, and smallholder agriculture prior to 1998 (Sunderlin and Resosudarmo 1996), and of decentralization and democratization after 1998 (Arnold 2008). These are important processes which we will use in this paper to challenge CPR theory. Third, as noted above, others have used Indonesia as an example of CPR theory's inapplicability to large-scale cases. Beginning with an unlikely case provides a strong test of CPR theory – if we in fact found that CPR theory could be applied to understanding the case, it would provide strong evidence that CPR theory could be applied to other cases (George and Bennett 2005). This paper also goes beyond a focus on broad-level institutional changes to scrutinize how governance changes altered the incentives and behavior of different actors, and how those changed behaviors interacted with the biophysical system to produce changes in deforestation rates. That said, given the large number of causal variables involved, the analysis should be seen primarily as an exploratory case study which identifies potential relationships between variables, but cannot definitively prove causal relationships (George and Bennett 2005).

The paper is structured as follows. In the next section we explain why applying CPR theory to large-scale forest governance is likely to reveal new insights. We then present the research methods of the SESMAD project and show how they are applied to this case study. In the fourth section, we briefly review the history of forest management in Indonesia since 1965 and identify the main policies and actor configurations within it, and then analyze how key variables drawn from CPR theory are relevant to understanding the outcomes of Indonesian forest governance over the last half century.

2. Theory

CPR theory focuses on the ability of people to act collectively to overcome the management dilemmas inherent to common-pool resources. The theory developed in response to the work of Olson (1965) and Hardin (1968), both of whom argued that groups of people were not likely to work effectively together. Hardin, in particular, blamed resource degradation on the "tragedy of the commons," in which users are unable to cooperate to achieve mutually beneficial outcomes. Although Hardin used the term "commons" in a generic fashion, we now understand that Hardin's tragedy was the result of a confluence between two variables: a type of resource, which we call a common-pool resource (or commons for short), in which exclusion is difficult, but consumption rival, encouraging overuse, and an open-access property regime, in which there is no collective regulation of access and/or use (Hardin 1994; McKean 2000). Thus, CPR theory is a theory about the conditions under which open access management of common-pool resources can be avoided through collective action.

Beginning in the 1970s, a large number of scholars noted that Hardin's dour predictions were inconsistent with empirical observations. Syntheses of this

growing literature were published in a series of reports from the late 1980s through the early 2000s (National Research Council 1986; Wade 1988; Ostrom 1990; Ostrom et al. 1994; Baland and Platteau 1996; Agrawal 2001; Ostrom et al. 2002). These syntheses focused on identifying variables which contributed to collective action in the management of common-pool resources, and have received strong support in subsequent studies (see Cox et al. 2010). For the forest sector, CPR theory has been tested by the International Forestry Resources and Institutions (IFRI) research program on small-scale forest systems, with supportive results (Gibson et al. 2000; Tucker 2010). In this paper, we use the term CPR theory to refer both to this group of variables, as well as to the theories that connect these variables with collective action and successful resource governance.

A potential problem with CPR theory is that most of the cases used to develop CPR theory were small-scale – consisting, for example, of a village or a few villages interacting with a forest area, as in the IFRI program. CPR theory developed a focus on the ability of local users of the commons to sustain collective action in traditional management systems. This focus was later extended to examine the local management of forest resources that were decentralized by central governments (Andersson and Ostrom 2008).

Although a number of authors have attempted to apply the lessons of CPR theory at larger scales, these efforts have not been systematic. Some authors have largely confined themselves to speculations about the applicability of CPR theory, without attempting to seriously grapple with the theoretical complexities of such a process, nor systematically comparing their predictions to actual cases (e.g. Keohane and Ostrom 1995; Dietz et al. 2003; McGinnis and Ostrom 2007). A second related literature has focused on 'cross-scale' and 'multi-level' governance, providing useful insights on the role of governance at scales above the local, including the regional, national and international (see e.g. Armitage 2008; Brondizio et al. 2009; García López 2012; Mwangi and Wardell 2012; Gruby and Basurto 2014).

Others have delved into the specific problem of large-scale commons governance, occasionally informing their theory in a haphazard fashion through case studies, and have arrived at conflicting conclusions. Stern (2011) argues that global commons are potentially governable, although the nature of collective action problems at the global scale are different from those at the local scale. Specifically, he differentiates between local and large-scale commons in terms of scale, number of users, salience of degradation, distribution of interests and power, cultural and institutional heterogeneity, feasibility of learning, resource regeneration, and knowledge about and stability of resource dynamics. Departing from this observation, Stern argues that while most of Ostrom's (1990) design principles apply, "defining boundaries for resources and appropriators is not a meaningful exercise for global commons," presumably because the global scale includes everything. Stern also argues that an additional set of principles apply at global scale, including investments in science to understand resource dynamics, integrating science with deliberation, multi-level connections for rule-making, and

planning for institutional adaptation and change. However, he does not explain how he derived these principles, nor why he believes they are relevant at global, but not at local scales. A further weakness of Stern's work is that he focuses only on global commons problems such as global climate change, and thus it is not clear how his nascent theory would apply to regional or national level commons, which while much larger than those traditionally studied in CPR theory, are nonetheless much smaller than the entire globe. For example his critique of the relevance of boundaries seems to apply more to commons that are genuinely global in scale, as opposed to those that are regional or national.

By contrast with Stern's optimistic view that CPR theory can be used – with modification – at a global scale, Araral (2014) offers a pessimistic outlook on our ability to overcome collective action problems at large scales. He argues that although the theoretical dilemmas of the local and large commons are the same (e.g. overharvesting, free riding, monitoring and enforcement), differences in scale, transaction costs, and the nature of the actor groups (individuals vs. nation-states) create wicked problems in which Hardin's tragedy may be inescapable. Although Araral differs from Stern in that he discusses specific cases of large-scale commons failures to support his theory, including forests in Indonesia, these examples appear to be chosen haphazardly and are only discussed in a cursory fashion, so again, it is not clear if his theoretical reasons are well supported or are merely speculation.

The project reported on in this special issue aims to evaluate the questions raised by Araral and Stern in a systematic fashion. Because prior authors seem to disagree about what aspects of scale are theoretically most relevant – or even whether CPR theory is applicable beyond the local scale – we follow an inductive research strategy, aiming to identify what aspects of CPR theory may be relevant or difficult to apply to the Indonesian forest case. In this regard, our case – and the others in this special issue – suggest that the pessimism about applying CPR theory to understanding large-scale systems is not necessarily warranted. Although our reporting negative outcomes appears to support Araral's contention that large-scale commons problems may be particularly difficult to resolve, we also show that most of the causes of unsustainable forest management in Indonesia are not scale-dependent. Put in other words, the failures of forest management in Indonesia should probably be seen primarily as a symptom of the difficulties of resolving commons dilemmas at any scale, rather than a particular problem unique to large-scale commons. Moreover, because we follow this inductive strategy, we also engage with two additional frameworks that have been applied by scholars from other traditions to study large-scale forest commons: "Land Use and Cover Change" (LUCC) and political ecology.

The literature on LUCC grew alongside CPR theory in the 1980s and 1990s, driven in part by the easy availability of remotely sensed data on forest cover change. These studies used remotely sensed data and macro level demographic and economic variables such as population, economic growth, market prices, tenure security and the rule of law, and infrastructure projects such as roads to

understand patterns of change in forest cover, often at large scales (Lambin et al. 2001; Geist and Lambin 2002). CPR scholars have critiqued land use and cover change studies for abstracting away from the agency of local communities in conserving or destroying their local forests (Gibson et al. 2000). Furthermore, LUCC scholars have critiqued their own literature for inattention to the ways that policies and other forms of collective action influence forest management (Rudel 2008), an area where CPR theory may be well suited to making a contribution.

Political ecology offers an alternative conceptualization, focused on the influence of macro-level historical and political-economic factors – such as governments seeking to extract rents or votes, large corporate interests, macro-economic crises, and unequal power relations between communities and the state – on local collective action. As with CPR scholars, political ecologists drew on anthropological research showing communities' ability to organize and devise local institutions to manage resources collectively. Yet whereas CPR scholars have been more interested in the local-level dynamics and characteristics that facilitated this local collective action, political ecologists' focus has tended to be on how governments, markets, corporations, or other powerful actors, oppress communities and prevent local autonomy in resource management (e.g. Peluso 1992). An additional concern is the deleterious effect of privatization and commodification (the expansion of markets) of natural resources (Peet and Watts 2004; Peet et al. 2011). While political ecology offers insight into the influence of large-scale factors on local level changes, which we will show here may be used to complement CPR theory, it has somewhat less to say about the influence of these factors on large-scale outcomes, and thus suffers from some of the same limitations of CPR theory for exploring large-scale governance.

3. Methods

As with the other papers in this special issue, this paper follows methods that were developed collaboratively as part of the Social Ecological System Meta-Analysis Database (SESMAD) project, and are described in greater detail by Cox (2014). SESMAD collects systematic information on the social and ecological attributes of large-scale social-ecological systems, the basic unit of analysis, through content analysis of published studies. For the Indonesian forest case, information was gathered through a review of secondary sources, including peer-reviewed publications and grey literature published by reputable organizations such as the Indonesia-based Centre for International Forestry Research, the Food and Agriculture Organization (FAO). Controversial data and information gaps were filled with the aid of area experts. Co-author Brent Loken was conducting field research in Indonesia at the time of writing, and thus was able to add considerable knowledge based on his own research.

Information gathered was used as the basis for entering data into the SESMAD database, a relational database hosted at Dartmouth College (see Cox, 2014). This database contains information on approximately 200 variables of relevance to the

study of social-ecological systems (SESs), including variables important to CPR theory, as well as variables not emphasized in CPR theory, but important in other theories about the performance of social-ecological systems. These are stored in tables describing the SES itself, its components, and the interactions among these components. The structure of the database is based on Ostrom's SES framework (Ostrom 2007, 2009) as modified by Cox (2014).

The case table collects general information on the SES, which is defined as a unit containing at least one environmental commons, at least one governance system, and one or more actor groups that relate to the commons within the context of the governance system. An SES in the SESMAD framework then can have these three types of components. A governance system (referred to as GS in figures) is a set of institutional arrangements (including rules, policies, norms, and other governance activities – see Ostrom 2005) that are used by one or more actor groups to interact with and govern a commons (for a similar definition, see Lemos and Agrawal 2006). An actor group (A in figures) can be comprised of individuals, organizations, or nations that have developed a set of institutional arrangements in order to manage human interactions with a specific environmental system. An environmental commons (EC in figures) is an environmental phenomenon that can be subjected to human use and governance – in this case, forests in Indonesia. Within the relational database, interactions between these components are stored as records in the interactions table and in tables that link the interactions to individual components, and are labeled as such. Different interactions frequently represent different "snapshots" of time within the same case. When this is the case, we have labeled the interactions to reflect these different time periods.

Figures 1 and 2, described in more detail in the results section below, show how this framework was operationalized for this case for two separate time periods: the boxes in the figure refer to the actual tables in the relational database (the case table is not represented as it is general to the entire case), while the connecting arrows represent the linking tables.

Our focus in this paper is on the analysis of key variables that CPR theory has identified as making a major contribution to the potential for collective action. We focus on 17 variables emphasized in Agrawal's (2001) synthetic review, as well as on other seminal theoretical works and syntheses (Ostrom 1990, 1992; Cox et al. 2010; Poteete et al. 2010). These variables are all measured in the SESMAD database, along with a large number of other variables, including those emphasized in other theories such as political ecology and land use and cover change. Our aim in focusing on these variables is to identify, in the absence of specific and well-developed theories about the impact of scale on commons governance, whether those variables emphasized in CPR theory – or in political ecology and LUCC – can be applied to understanding forest management at the scale of the nation state, and if so, what their influence might be.

Inferences about the empirical relevance of the CPR variables were made in three steps. First, we examined whether the values of variables during the New Order Regime (1965–1998 – see next section) correlated with forest outcomes in

the ways predicted by CPR theory (e.g. did a lack of monitoring contribute to worse forest outcomes?). Second, we explored whether changes in these variables from the New Order period to the Democratic period (1998-present) were correlated with changes in deforestation rates, allowing us to make multiple observations within a controlled environment (King et al. 1994). Third, we used process tracing to assess whether there was a potentially causal relationship between the values of a variable and changes in deforestation rates (George and Bennett 2005; Collier 2011). Through this process, we were also able to observe that other variables not emphasized in CPR theory were playing an important role, and we conducted the same analysis with these variables that were identified inductively. In many cases, other authors had already conducted similar process-tracing exercises, and where there appeared to be widespread agreement about the process and the underlying causality associated with it, we have reported that result.

4. Results

4.1. Case synopsis and timeline

Table 1 provides an overview of the major events that have affected forest management in Indonesia. The first time period we examine in depth is the period from 1965 to 1998, which coincides with the dictatorship of Suharto. The second time period, beginning in 1998, and lasting up until the present, begins with the fall of Suharto and the onset of democratic elections at the national level and decentralization.

4.2. Structure of the case

Figure 1 depicts the structure of Indonesian forest governance during the "New Order" period (1965–1998).

From 1965 to 1998 the Indonesian forest governance system was dominated by a single actor, the Indonesian central government with President Suharto at its center. This was a top-down governance system which suppressed most forms of self-organization, raising doubts about whether those aspects of CPR theory which focus on self-organization will apply here. The workings of this system have been extensively documented elsewhere (Peluso 1992; Dove 1996; Poffenberger 1997; Dauvergne 1998; Brown 1999). Suharto maintained the political support of elites, particularly military officers, through dispensing patronage, often in the form of timber, mining and plantation concessions. The taxes and royalties generated by timber extraction flowed to the government in Jakarta. Thus the establishment of large-extractive industries was closely connected with the central government and, in particular, the military, which held many concessions and was frequently called upon to defend the claims of concessionaires (Peluso 1992; FWI/GFW 2002). Concessionaires in turn worked their connections to influence forest and other related policies, both in terms of the regulation of concessions and in terms of trade policies for the timber sector (Ross 2001). Groups of people ("Adat

Table 1: Major events in the history of Indonesian forests since 1965.

	Date	Event
Snapshot 1: "New Order" regime 1965–1997	1965	Sukarno sidelined by Suharto & placed under house arrest
	1967	Basic Forestry law asserts central govt. control over all forests. Logging permits granted by local govt. to small-scale enterprises.
	1970–1971	Central government revokes local logging permits. Large-scale concessions begin to be granted to political allies of regime.
	Early 1980s	• Transmigration program: Javanese moved to outlying islands. • Erosion of customary ("adat") law • Ban on log exports forces concession holders to invest in plywood and pulp processing, which are subsidized
	Late 1980s	Development of Industrial Timber Plantations
	Mid 1990s	• "forestry crisis" – high levels of deforestation, overcapacity in wood processing sector, decline in timber concessions • Rise of coal mining & palm oil industries
	1997	Asian monetary crisis hits Indonesia
	1997–1998	Massive forest fires due to El Nino droughts & extensive logging.
Snapshot 2: Early democratic era 1998-present	1998	• Fall of Suharto's government, democratic elections • Villagers demand local control over resources • Log export ban removed
	1999	Laws grant greater autonomy and revenue control to districts, districts permitted to grant small forest concessions New forestry law passes, reaffirming central government control over forests.
	2000	Constitution amended to recognize customary law
	2002	District government authority to grant concessions suspended
	2004	New laws reverse trend towards regional autonomy
	2006	National Land Reform Program begins
	2009	President commits to reducing CO_2 emissions by 26% by 2020
	2010	Norway and Indonesia sign REDD+ partnership aimed at reducing emissions from deforestation and forest degradation
	2011 and 2013	2 year ban implemented (2011) and extended (2013) on new logging & forest conversion concessions
	2013	Indonesia's Constitutional Court invalidates the Indonesian government's claim to millions of hectares of forest land

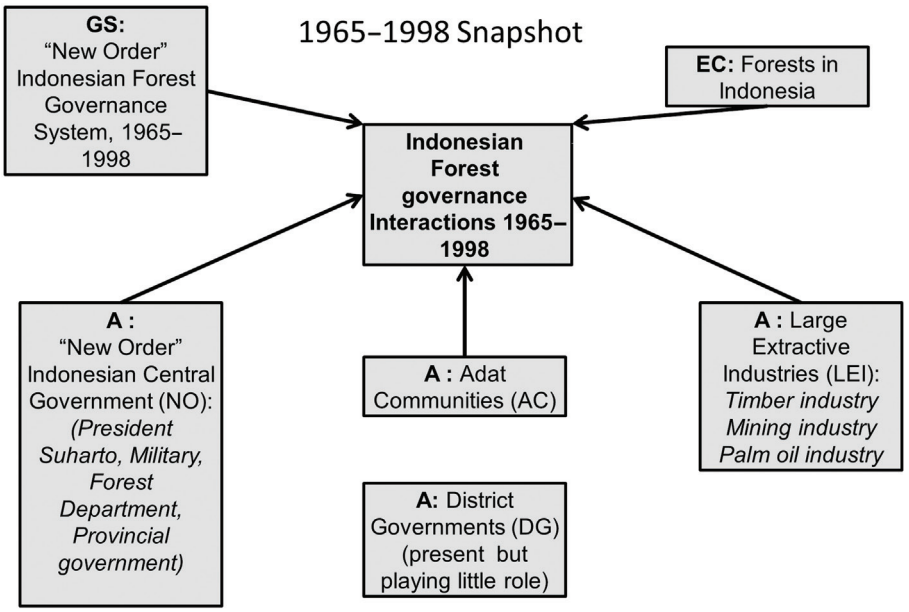

Figure 1: The structure of Indonesian forest governance during the "New Order" period, 1965–1998.

Communities") who had formerly possessed customary rights ("Adat") to use the forest continued to harvest products. The formal rights of these people to use the forests were eliminated, and people who attempted to use these rights were frequently and violently suppressed by powerful concession holders and the government. However, resistance was widespread and in some areas, particularly those that were remote or difficult for the military to access, local communities were able to enforce their own rules on community members, and even in intimidating concessionaires into following local rules (Palmer and Engel 2007).

Figure 2 displays the structure of Indonesian forest governance during the "Reformasi" period (1998-present).

Economic & political tensions within the elite, and between the elite and the rest of the population, contributed to the fall of Suharto's government in 1998 (Fukuoka 2013). A new democratic constitution dramatically altered the formal structure of the central government, decentralized substantial amounts of power to district governments, formally recognized customary rights, and opened up new spaces for local political & economic entrepreneurs, as well as media & civil society actors to play a role. The result was an entirely new governance system, with new or newly empowered actor groups. In particular, this governance system provided much greater (though still limited) opportunities for self-governance at local, regional and national scales.

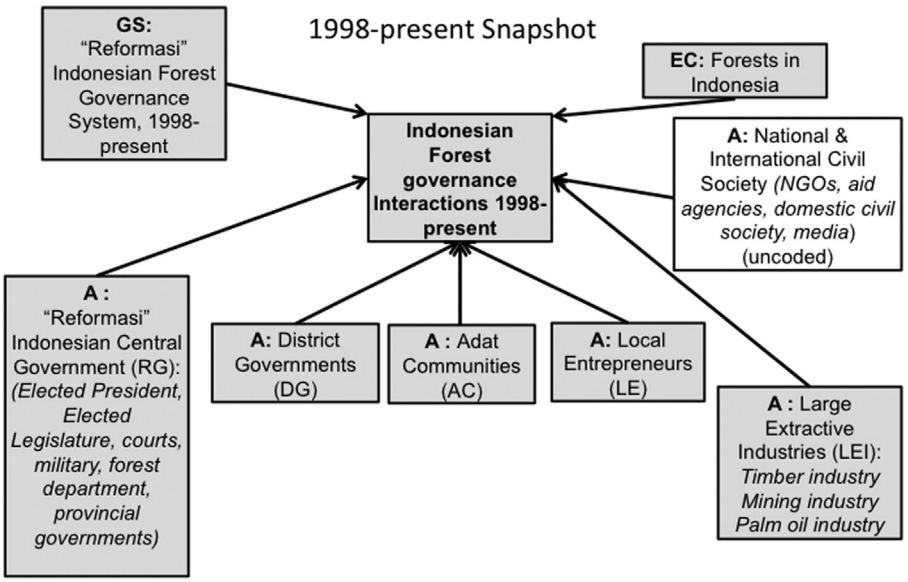

Figure 2: The structure of Indonesian forest governance during the "Reformasi" period, 1998-present.

Substantial responsibilities that formerly rested with the central government were moved to the 465 district governments (few responsibilities were given to the 34 intermediate provinces). The exact details of these arrangements varied over this time period, with districts briefly claiming the authority to grant small timber concessions from 1998 to 2002. Forest department field personnel were transferred to the district government, and district governments developed local level patronage networks between locally prominent politicians and businessmen (McCarthy 2000, 2001; Barr et al. 2006; Wollenberg et al. 2006; Arnold 2008). Decentralization provided new opportunities for local politicians and entrepreneurs to develop local patronage networks. Adat communities were formally recognized, and although their power remained weak, formal recognition and decreased suppression did provide them with greater means to build networks and increase their involvement in forest products trade.

Changes after 2005 were driven by newly emergent actors, including a growing local and national civil society and media freed from restrictions under the dictatorship, as well as international civil society groups and aid agencies. Following the 13th meeting of the Conference of Parties of the Intergovernmental Panel on Climate Change hosted in Bali in 2007, Indonesia has been involved in an increasing number of agreements to prevent or sequester carbon emissions through improved forest management. Additionally, forest certification under the Forest Stewardship Council and more recently, the United Nations REDD

(Reduced Emissions from Deforestation and Degradation) program have played significant roles in changing forest management in some areas (see Dauvergne 2005; Dauvergne and Lister 2011; Murdiyarso et al. 2011).

4.3. Social-ecological outcomes

We focus first on forest cover and deforestation rate as the primary measure of the effect of governance on resource conditions. While there are other measures of resource conditions, such as conditions of remaining forests, or presence of a diversity of species, data on these are not widely available, and forest cover is a decent proxy for the overall ability of the forest to provide ecosystem services. Forest cover data for Indonesia is difficult to obtain due to persistent cloud cover in the region, as well as low levels of investment in government monitoring, so we report the best available estimates, drawing on data from multiple sources. Forest Watch Indonesia & Global Forest Watch (2002) provide the oldest estimates of forest cover in Indonesia, basing their data on old government documents. According to these documents, forests in Indonesia covered 162.29 MHa in 1950 and 119.7 MHa in 1985, and 100 MHa in 1997, yielding an average annual rate of forest loss of 1.2 MHa between 1950 and 1985 and 1.64 Mha between 1985 and 1997. Since available sources imply that there was limited deforestation between 1950 and 1965, actual rates between 1965 and 1985 may have been higher. Other measurements place the deforestation rate for the decade of the 1990s slightly higher, consistent with the story that deforestation rates were at a peak during the final years of the Suharto regime (see Table 2).

Available data indicate a fairly dramatic drop in deforestation rates between 2000 and 2005 (see Table 2), followed by a rise from 2005 to 2012, though there is disagreement about the magnitude of the rise. FAO data indicate a modest rise to rates still substantially lower than those experienced in the 1990s, but Hansen et al.'s latest remote-sensing based estimates (2013) indicate that deforestation rates for 2011–2012 have returned to 1990 levels (see also Margono et al. 2014). This large discrepancy between published estimates introduces substantial uncertainty into our analysis: while it is clear that deforestation rates dropped in the immediate aftermath of the 1998 transition, it is not clear if that drop was sustained (supported by FAO data) or whether it was a temporary slow-down that has not been sustained (supported by Hansen et al.'s data). We believe that Hansen et al.'s estimates may be more accurate, since the FAO data is based on government self-reports, while Hansen used rigorous remote sensing methods that have been subject to peer

Table 2: Estimates of deforestation rates in Indonesia from 1990–2012.

	1990–2000 (95% CI)	**2000–2005 (95% CI)**	**2005–2012**	**Source**
Average annual forest loss	1.78 MHa (1.40–2.16)	0.71 MHa (0.54–0.88)	1.6 MHa	Hansen et al. 2013 Hansen et al. 2009
	1.914 MHa	0.310 MHa	0.685 MHa	FAO (2010, 2013)

review, however further replication of Hansen et al.'s results are needed before they can be accepted as definitive. Margono et al. (2014) report that a major source of the difference between FAO and independent remote sensing estimates by Hansen et al. (2013) and Margono et al. (2014) is an overly restrictive definition of forests adopted by government reports (and thus reflected by the FAO). On the other hand, other independent analysts claim that Hansen et al. grossly overestimate deforestation in Indonesia because they do not adequately differentiate between plantations, agriculture, and forest, and because their remotely sensed data has not been properly ground-truthed (Bellot et al. 2014).

While systematic data on forest outcomes other than forest cover are not available, anecdotal evidence allows us to make some limited claims. First there has been an increase in the rights of indigenous people to manage and benefit from their forests since 1998 (Arnold 2008), and an increased influence of local communities on the terms of logging contracts with timber companies, as well as increased benefits from logging to local people (Engel and Palmer 2006; Engel et al. 2006). Benefits to local communities still remain limited, however a landmark ruling in May 2013 by Indonesia's Constitutional Court invalidates the central government's claim to millions of hectares of land. This ruling could potentially give indigenous and local communities the right to manage their customary forests (Butler 2013a). Improving the rights and capabilities of indigenous people to manage their forests is a substantively important outcome in its own right, and it is also a factor which may have contributed to lower deforestation rates. Data are not available on the effects of access to forest products on poverty among forest dependent people. Second, while deforestation rates remain high, there are also significant levels of damage being done to forests through intensive harvesting that does not remove crown cover (i.e. degradation), but existing data do not quantify these levels of damage, so it is difficult to determine whether degradation rates are rising or falling. Finally, while illegal logging continues to be a substantial problem, increased international and domestic scrutiny of logging operations and wood-product exports have resulted in some modest improvements (Obidzinski et al. 2007).

4.4. Influence of important CPR variables

In order to assess the utility of CPR theory for explaining forest management in Indonesia, we must answer two distinct questions. First, why were deforestation rates high during Suharto's reign? Second, why did they decline after 1998 but rise to significantly higher levels after 2005? We show how causal configurations present in each period may explain the results, while recognizing how our ability to make inferences is limited both by uncertainty in outcome data, as well as by indeterminacy in the causal configurations we observe. Furthermore, while some changes in the values of variables are correlated with the effects that would be predicted by CPR theory, process tracing indicates that these variables may not be the most important causal factors. Instead, changes in other economic and political variables not normally emphasized in CPR theory may be more important. A summary of the major variables which may be important is presented in Table 3.

Table 3: Theoretically important variables used in this case.

Theoretical variable	Suharto "New Order" period 1965–1998	Democratization & "Reformasi" Period 1998–present
Social variables		
Social monitoring	Central govt. does little monitoring. Some adat communities also monitored their own behavior and that of timber concessionaires.	Govts. do some monitoring, as do local communities, civil society groups, and international agencies. Satellite technology makes monitoring cheaper.
Leadership	Dictator is strong, not accountable, and extraction oriented.	Leadership diffused between multiple levels of elected govt. & civil society.
Proportionality of costs & benefits	Timber revenue & taxes flow to central government & associated timber companies. Many costs passed on to future generations or local communities.	Benefits continue to flow to large companies & central actors. District govts. & adat communities bear costs, but tax revenue from forestry goes only to central govt.
Governance variables		
Nesting & Multilevel	Strong centralization. Little multilevel governance.	Complex multilevel relationships develop between central & district govts., adat communities, industries, civil society & international actors.
Group size	Small number of actors with power consolidated within Suharto's inner circle.	Large number of actors with power decentralized across Indonesia.
Sanctions	Govt. sanctions applied to rural poor but rarely to politically powerful. Adat communities have informal sanctioning systems.	Formal sanctioning authority shared btwn levels of govt. In last 5 years sanctions are increasingly applied to powerful interests.
Collective choice	Central government made most decisions, and some of the large extractive industries played an important role. Other collective choice venues were suppressed.	Numerous collective choice venues created at national and local level. Central politicians & industries play the largest role, but small industries, local politicians, media, & civil society have some access.
Rights to organize	Only central, politically powerful actors have rights to organize.	Formal rights to organize spread to districts, adat communities, civil society, and media.
Tenurial security	Tenurial security very weak for local communities, and somewhat weak for concessionaires.	Tenurial security improves for all actors, but remains weak.
Dependence on resource	All actors are heavily economically dependent on forest. Adat communities also have a high level of cultural dependence.	
Non-CPR variables		
Intl. markets	High prices for timber & exhaustion of other sources lead to large interest in Indonesian timber products.	While timber prices drop, prices for coal & palm oil encourage forest conversion. Indonesian recession in 1998 also suppresses all economic activity.
Intl. politics	No influence.	Forest Certification (FSC) & funding for Reduced Emission from Deforestation and Degradation (REDD) are influences on forest management.

(*Table 3: Continued*)

Theoretical variable	Suharto "New Order" period 1965–1998	Democratization & "Reformasi" Period 1998–present
Intention of governance system	The governance structure was specifically designed for large-scale and rapid extraction of timber as a strategy for economic growth and political stability.	Governance system is more balanced between path dependencies from extraction-orientation & new pressures for conservation.
Top-down state intervention	Top-down intervention is aimed at timber extraction (see Intention, above).	Since 2010, central govt. has committed to policies to conserve forests in exchange for support from developed countries wishing to offset carbon emissions.
Clientelistic relationships	Clientelistic relationships between President & military & political elites facilitated by granting of timber concessions.	Clientelism also pervades local govt, which frequently favors local industries including illegal loggers & plantations.

4.4.1. Significance of variables during the new order period, 1965–1998

Although there are a number of variables that account for high deforestation rates in the New Order Regime, we find that two connected variables appear to be the primary underlying causes of deforestation: the intentions (or goals) of the governance system (to overexploit the commons), and the presence of strong leadership. These variables interact: General Suharto, a dictatorial leader, was the person who – coalescing with political and corporate interests that supported him – designed the governance system with the intention of maximizing short-term revenues at the expense of sustainability. There is a consensus among studies conducted during this period that these two variables were essential underlying causes for Indonesia's high deforestation rates (e.g. Peluso 1992; Dove 1996; Poffenberger 1997; Barr 1998; Dauvergne 1998; Brown 1999; Dove and Kammen 2001). According to these authors, the high degree of centralization, lack of monitoring and sanctioning of forest extraction, and the undermining of local tenure, rights to organize, and collective choice processes were all results of the combination of a strong leader with an intention to overexploit the commons, and were thus secondary or proximate causes of deforestation. There is also some evidence that the most important direct driver of deforestation may have shifted in the 1980s. Prior to about 1985, state-assisted colonization by small-holders played a very important role in deforestation in Indonesia, but by the 1990s, large-scale enterprises (e.g. large plantations or logging concessions) were causing most of the deforestation in Indonesia (Rudel et al. 2009). We follow these authors in using these process-based accounts which emphasize how conditions on the ground were re-shaped by the regime in Jakarta to favor deforestation.

The role of these two variables in this case presents a strong challenge to CPR theory. The intention or goal of governance systems is not generally considered

in CPR theory, which tends to assume that sustainability is the governance goal. There is abundant evidence that the governance system was designed to enrich Suharto and his political allies while alleviating potential political tensions in Java by encouraging industrial development and out-migration to the outer (forested) islands. Forest destruction was an intentional byproduct of this system. The system worked through clientelism: concessions were granted to Suharto's allies, particularly members of the military, who aimed to extract as much money as possible from the country's vast forest estate, with little concern for longer-term sustainability (see e.g. Peluso 1992; Brown 1999; Dove and Kammen 2001; Ross 2001). The importance of intention has been emphasized to a much greater degree in political ecology, which documents how environmental degradation is often the intentional result of policies designed to benefit various powerful elites at the expense of other, typical poor and or indigenous users (Blaikie 1985; Peluso 1992; Dove 1996). Given the abundance of timber in Indonesia, Suharto and his allies did not seem particularly concerned about exhausting the commons, but they also believed that the profits from timber extraction would lead to long-term economic development, enabling them to escape from dependence on timber.

Similarly, CPR theory has largely assumed that leaders are political entrepreneurs who assist in overcoming collective action problems that hinder sustainability (Ostrom 1992; Poteete et al. 2010). In this case, strong leaders pushed the system away from sustainability. Suharto's leadership enabled elites to overcome collective action problems that might have previously prevented them from exploiting forest resources on the outer islands (McLeod 2000). In addition, Bob Hasan, a timber entrepreneur and close ally of Suharto, helped organize concession holders and reinforce their political power within the broader national governance system (Barr 1998). These leaders did help overcome collective action problems, but they did so in ways that increased the pressure for resource extraction. This finding is particularly disturbing for CPR theory which has largely equated collective action with sustainable management.

The importance of the intention of the governance system and of strong leaders in encouraging unsustainable behavior was discovered here in a large-scale case, however there is no inherent reason why similar dynamics could not take place in the sort of small-scale village level cases traditionally investigated in CPR theory. In fact, this shortcoming of CPR theory has been noted by previous authors (Agrawal 2001; Robbins 2012). However, our findings here reiterate the finding from political ecology scholarship that we need to look up from the local level to understand how power dynamics at the level of the nation state may affect the distribution of rights at the local level (see e.g. Peluso 1992; Robbins 2002).

Variables other than leadership and intent played an important role in the New Order period. These variables, which are explained below, performed largely as expected in CPR theory, but to a great extent their values were proximate causes that were themselves caused by the underlying causes of authoritarian leadership and a system designed to maximize extraction. In addition, global market forces, a variable poorly captured in CPR theory, probably also played a role in increasing

deforestation by keeping international demand and prices for Indonesian timber and agricultural products high.

According to CPR theory, users with tenurial security, rights to organize, and participate in decision-making about resource management (i.e. collective choice) are more likely to contribute to long-term sustainable management (Ostrom 1990). Tenurial security is represented in Table 2 by several other variables, including the existence of monitoring and sanctioning and collective choice mechanisms. In Indonesia under Suharto, tenurial security of all resource users was very limited, while rights to organize and participate in decision-making were confined to a narrow group of elites who, as noted above, wished to liquidate forest assets and convert them to financial assets. These variables were largely the result of the authoritarian, patronage based political system. According to Di Gregorio (2011), the heavily centralized administration system "filtered down to every village in the vast archipelago", so that the Suharto regime "effectively controlled" the forest areas. Local villagers were deprived of rights to organize formally, local leaders were coopted, and local collective choice mechanisms were destroyed, leading to increasing and uncontrolled agricultural colonization in some areas (Heydir 1999). Concessions were granted without regard to existing customary uses, and with limited monitoring or sanctioning, industrial interests often harvested timber outside of their legally granted areas, often with military support. Concessions themselves were of limited duration and could be reassigned based on political concerns.

The lack of tenurial security and rights to organize and participate contributed to deforestation in several ways. Insecurity, combined with weak monitoring and enforcement, contributed to the near open-access environment in which timber companies sought to grab as many resources as possible as quickly as possible (Ross 2001; Colfer and Resosudarmo 2002). Without rights to organize and participate in decision-making, disenfranchised users may have also contributed to uncontrolled deforestation. Furthermore, voices that may have promoted conservation were silenced or bought off by the central state, decreasing the opposition to unsustainable logging.

Perhaps the most strongly supported variables in the literature on the management of forest commons are those related to social monitoring and enforcement. Weak monitoring and sanctioning systems played a role in the high deforestation rates in Indonesia under Suharto, as CPR theory would predict. Local users were stripped of formal authority, and any attempts to enforce local customs ran the risk of state oppression. CPR theory has not clarified the relationship between central governments and local monitoring and enforcement. However, Indonesian forest department authorities in the outer islands had "little or no regulatory oversight" (Colfer and Resosudarmo 2002, 4), and rarely enforced any sanctions against timber concessionaires who violated the rules (Ross 2001) or against farmers who illegally expanded cultivation (Heydir 1999). Bureaucrats in Jakarta were in a weak position to enforce regulations on powerful actors (Ross 2001). Even if it had been willing, it is not clear how the government could have

enforced its rules in vast, remote areas where it had little authority and where local users were stripped their political power. Unsustainable rates of timber extraction led companies to increasingly remote areas, which in turn increased the difficulties of monitoring and enforcement of forest management rules (Gellert 2010).

Similarly, a lack of proportionality between benefits received from timber extraction and the costs of deforestation contributed to increased deforestation, particularly through its interaction with levels of economic dependence. Benefits from timber extraction activities flowed almost entirely to elites associated with the central state in Jakarta, yet these people bore few of the costs from deforestation and thus had few incentives to reduce their extraction, particularly given the fact that the spatial extent of the resource was sufficiently large that they could not reasonably expect to exhaust it within their lifetimes (Ross 2001). Central state actors were dependent on the forest, in the sense that forest resource extraction formed the core of their economic activities, but their activities could be moved from one patch of forest to another, or even from one industrial sector to another, and thus the loss of any particular forest patch did not hurt them, even if it did hurt local forest-dependent communities. In a sense, these actors could be compared to the "roving bandits" described by Berkes et al. (2006) – mobile resource harvesters with high discount rates who move from place to place depleting resources – however in this case, their actions were primarily contained within Indonesia. This conception of proportionality differs somewhat from conventional CPR theory which emphasizes proportionality between benefits derived from using a resource and the costs associated with contributing to public goods to make the resource available.

4.4.2. Significance of variables in the reformasi period: 1998-present

Political reforms following the fall of Suharto in 1998 transformed governance in Indonesia. These reforms correlated with a significant decline in the deforestation rate, but the deforestation rate remained high in the international context, and began to rise again after 2003 (Hansen et al. 2009, 2013; FAO 2010). Many analyses focus on the reasons for continued deforestation and the shortcomings of the decentralization and democratization processes (e.g. Colfer and Resosudarmo 2002; Arnold 2008), but there are few analyses which attempt to explain why deforestation rates first dropped, and then rose again, and the evidence we present here does not lead to definitive answers, particularly since the extent of the post 2003 rise in logging rates is contested.

Significant changes occurred in the governance of Indonesian forests after 1998 which we would predict would lead to decreased deforestation. In particular, the presence of strong leadership, one of the causes that we identified as contributing to high deforestation rates under Suharto, was removed. In addition, the governance system moved slowly but significantly towards a more inclusive and participatory political order that CPR theory predicts would lead to more sustainable resource governance. These trends, while still limited, appear to have strengthened over time, with the gradual consolidation of democratic rule, and

with the government of Indonesia making significant public commitments to forest conservation.

At the same time, although forest clearing initially declined after 1998, it has risen significantly since 2003, with some estimates placing current forest clearing rates as high as those of the 1990s. Two possible explanations for this rise are plausible: first, the governance changes described above may have been insufficient and/or have led to the development of a new order which favors deforestation (i.e. the intention of the governance system may have remained the same), and second, other non-governance factors may be driving changes in deforestation rates. Economic factors may be particularly important: governance changes in 1998 were triggered by a severe economic crisis which crippled economic activity, and in a broad sense the decline and subsequent rise of deforestation correlates with the decline and subsequent recovery of Indonesia's economy. Unfortunately, the existing literature on which this review is based is not very helpful in differentiating these causes. Most studies conducted on the post 1998 period have focused on using governance variables to explain continuing deforestation, but have not attempted to explain the drop and subsequent rise in deforestation rates, nor have they examined whether governance variables or economic variables were more important in these changes. Detailed remote sensing studies have focused on documenting changing deforestation rates, but have not been structured to understand the causes of change (Hansen et al. 2009, 2013; Broich et al. 2011; Margono et al. 2012, 2014).

Governance reforms after 1998 focused on democratizing the central government, decentralizing power to elected district governments, and opening up room for greater public engagement through a freer press & civil society. These led to changes in several of the key variables emphasized by CPR theory, in directions that CPR theory would predict would favor better resource governance. In particular a more participatory leadership, decreases in centralized power, increasing monitoring and enforcement efforts, new vertical and horizontal interplays between different stakeholders, and new political opportunities in a more open political system would all be predicted by CPR theory to contribute to lower deforestation. In addition the removal of the authoritarian leader with a strong personal and political interest in encouraging forest clearance, the most important causal factors identified above, would in and of itself be predicted to encourage lower deforestation. All of these factors could have contributed to the decline in deforestation after 1998, but it is difficult to sort out their effects from the effects of the economic downturn. Furthermore, the exhaustion of easily accessible lowland forests prior to 1998 may have made it difficult to sustain high clearance rates, regardless of governance or economic changes (Hansen et al. 2009). However, if exhaustion drove a decline in clearance rates in 1998, it is not clear why deforestation rates rose again after 2005.

At the same time, political reforms have opened up spaces for a broad variety of new actors. Some of these actors have used their newfound rights to organize and access to collective choice processes to push for decreased deforestation,

while new, democratically elected leaders are more open to listening to the demands of rural social movements and are committed to effective conflict resolution processes for land struggles (Dermawan et al. 2006; Di Gregorio 2011). The pressure of media, political parties, and local organizations for accountability – and for decreased deforestation – appears to be increasing over time as these groups gain experience and power in the new political system (e.g. see Lang 2012). Although elements of the old oligarchy retain power, our finding that new actors are having a real impact on the governance process is in contrast to literature that argues that Indonesia remains stuck in a closed, oligarchical form of democracy (Fukuoka 2013).

CPR theory would predict that these changes would consistently lead to better resource governance, but the evidence shows that even as this democratic consolidation has taken hold in Indonesia, forest clearance has increased. However, the decentralized political order has also created opportunities for many more actors at local and regional levels to pursue political and economic power through overuse of resources, and these opportunities may be driving the increase in deforestation. This could, in fact, be consistent with CPR theory: decentralization and political empowerment in Indonesia may not support improved resource governance because it has failed to empower the appropriate set of actors (Agrawal and Ribot 1999; Gruby and Basurto 2014). Decentralization has empowered district governments but not the resource users themselves, who still face serious barriers to their exercise of power (in spite of their improved position relative to the Suharto era), and it is the empowerment of resource users, not decentralization in general, which leads to improved outcomes in CPR theory (see e.g. Chhatre and Agrawal 2008; Persha et al. 2011).

In spite of reforms beginning in 1998, the reality of weak land tenure remains for many rural land holdings in the outer islands of Indonesia (Barr et al. 2006; Elson 2011). Similarly, monitoring and sanctioning of timber concessions, and of the growing number of palm oil plantations and mining operations, was largely nonexistent. This seems to have changed slightly in recent years, with a few high profile cases of sanctions. These may be the result of increased civil society pressure, or improved satellite monitoring technologies (Obidzinski et al. 2007; Lang 2012). Despite this, Indonesia remains a center for illegal logging and land conversion activities (Tacconi 2007; Dauvergne and Lister 2011). This can be understood from the perspective of political ecology, particularly the study of the politics of decentralization (e.g. Ribot et al. 2006; Potteete and Ribot 2011), which have observed a tendency to recentralize authority in powerful actors in these processes; and political ecology analyses of the politics of multi-level/cross-scale governance, which has emphasized that the definition of what decisions are taken at which scales is a power- and conflict-laden process (e.g. Gruby and Basurto 2014; Thiel and Egerton 2011).

The second interpretation of decentralization's potential negative effects on forest management is a greater challenge to conventional CPR theory. There is a large body of research demonstrating that local governments tend to be more

oriented towards economic development than larger scale entities (Peterson 1995), and at least some research demonstrating that in the US, state governments are less oriented towards protecting natural resources than the national government (Koontz 2002). This is in contrast to an assumption frequently made in CPR theory that local groups will conserve resources given the opportunity (although for a cogent critique of this assumption from within CPR theory, see Agrawal and Gibson 1999). Indonesia possesses great natural resource wealth, and there is no a priori reason for assuming that distributing power to lower levels and smaller spatial scales would not recreate the dynamic that existed in the Suharto era, in which political leaders see their fortunes tied to the development, rather than conservation, of this natural resource wealth. While it is not clear if this is occurring, there is clear evidence that forest-clearing industrial development (e.g. plantations, mining, etc.) plays a growing role in Indonesia's economy (Gellert 2010). For example, a recent study in West Kalimantan found that in 2007–2008, 27% of deforestation was ascribed to palm oil plantations, whereas over the entire period of 1994 to 2008, only 6% of deforestation was attributable to the creation of palm oil plantations (Carlson et al. 2012). This growth could create political incentives for local elites to take advantage of decentralization to promote deforesting industries. Tax policy could provide further incentives for local governments to favor deforestation, because while the central government collects all timber revenues, district governments only receive tax revenue from agriculture and mining. Therefore, local governments have strong incentives to increase the quantity of agriculture and mining in their districts, at the expense of forest.

The political pressure coming from internal groups is joined by increasing outside pressures in various forms which are not well captured in current CPR theory: global forces and top-down state intervention. There is a tendency to focus on fluctuations in global market prices as drivers of domestic policy changes, however, other international forces have promoted improvements in forest governance, such as growing forest certification initiatives (Tacconi 2007; Dennis et al. 2008; Bartley 2010; Cashore and Stone 2012) and local interventions of international NGOs (Engel et al. 2006). In May 2009, Indonesia became the first country to enact regulations for a national REDD program (Barr et al. 2009) and in 2010 the government of Norway pledged up to US$1 billion to support development of a national REDD program in Indonesia (Murdiyarso et al. 2011). The following year, the president of Indonesia announced a two-year moratorium on new logging concessions (Edwards et al. 2012; Sloan et al. 2012) and in May 2013, this moratorium was extended for two more years (Butler 2013b). The moratorium, enforced by the central government, as well as the action by international state actors (e.g. Norway) and non-state actors (e.g. International NGOs and the Forest Stewardship Council) illustrate examples of the ways that global forces and top-down state interventions could interact to reduce deforestation at large scales in ways that are poorly theorized by CPR theory. At the same time, the apparent ineffectiveness of the ban in reducing deforestation

points to the possibility that the central state either continues to lack capacity to make its intention felt in remote areas, or actually continues to see these resources as vital to future economic development, and is actively subverting its own official dictates.

5. Discussion and conclusion

Our study demonstrates that CPR theory is helpful in explaining patterns and outcomes in the governance and management of Indonesian forests over the last 45 years, however the theory may need to be revisited, and supplemented with insights from the political ecology tradition, to more fully account for the observed patterns. However, even though CPR theory did not fully explain the case at hand, we cannot dismiss its applicability to large-scale commons. For example, during the Suharto regime, a small but powerful group of actors who were economically dependent on the resource contributed to high rates of deforestation. However the absence of key variables from CPR theory, such as monitoring and sanctioning, tenurial security, participation in rule-making processes and the right to organize also emerge as important causes of deforestation, and changes in these variables may help explain some of the reduction in deforestation rates immediately following the onset of democracy in 1998. Not all variables from CPR theory, however, worked in their expected direction: strong leadership is postulated to enable overcoming collective action dilemmas, and thereby encourage conservation, however we found that Suharto's strong leadership contributed to increased deforestation, and local rule-making after 1998 has played an ambiguous role.

Other important variables from CPR theory appear to have little relevance for the case: we found that social boundaries, environmental monitoring, conflict resolution mechanisms, system productivity, and group heterogeneity did not appear to play important causal roles in driving the outcomes observable in the cases. We had difficulty locating information on levels of trust, reciprocity and communication between actors, and thus could not assess their role. There were not glaring spatial mismatches between the scale of the governance system and the scale of the resource. Group size was difficult to assess in this case, since it is not clear what group is relevant to measure, but in contrast to Araral's (2014) argument that large group size makes collective action unfeasible, we did not see clear relationships between group size and outcomes. Several sources argue that not all factors from CPR theory need be present for a case to be successful (e.g. see Ostrom 1990), so comparison with a larger number of cases will be necessary to determine whether these variables are less relevant for large-scale CPRs generally, or only for this particular case. However, this list of variables provides a preliminary list of variables from small-scale CPR theory that may be less relevant at large scales, and should be investigated in future studies.

Our analysis shows that CPR theory needs to be complemented with insights from other theoretical traditions to be useful for understanding this case. A focus solely on variables drawn from CPR theory would miss important causal factors.

CPR theory has largely ignored the impacts of these broader political and economic drivers. Without Suharto's political leadership, his intention to log forests, and the clientelistic system he developed, it is difficult to imagine deforestation on the scale it was observed between 1965 and 1998. These are variables emphasized in political ecology, including in landmark studies of forestry in Indonesia during this period (e.g. Peluso 1992; Dove 1996). Without a vibrant international market for forest products during this period, Suharto would not have had such strong motivations to encourage logging. More recently, international markets have encouraged forest conversion for oil palm plantations and coal mines, while international agreements and international NGOs have contributed to increased conservation. The negative role of leadership can also be understood through research on manipulative, corrupt and abusive or so called "dark" leaders in organizational studies, which has been applied recently to study CPR outcomes (e.g. Theesfeld 2009; García López 2012).

Again, comparisons with a larger number of cases is necessary to understand whether these variables are important in this case because this case focuses on a larger scale than CPR theory, or whether they may also be important in small-scale CPR cases, yet neglected in CPR theory. Recent studies of small-scale CPRs have emphasized the role of NGOs as interveners in local commons problems (e.g. Barsimantov 2010; Barnes and Van Laerhoven 2013), the importance of understanding local power dynamics (e.g. Pérez-Cirera and Lovett 2006; Wilshusen 2009; Clement 2010), and the role of international markets in influencing local commons management (e.g. Tucker 2008), and thus it may be that these factors are equally important, but neglected, in local scale studies of CPRs. In order to examine whether these variables are scale dependent, we will need to conduct additional studies examining the importance of these variables at both small and large spatial scales.

In the introduction to this paper we highlighted a contrast between Stern's (2011) optimistic view of the value of CPR theory at large-scales, and Araral's (2014) pessimistic view, and critiqued both authors for giving insufficient attention to empirical cases. Our findings partially support Araral's pessimism – it is in fact the case that forest clearing in Indonesia continues at a rapid pace. At the same time, supporting Stern, we did not find that there are fundamental differences between small-scale and large-scale systems. Since there are many cases of governance failure in small-scale CPRs, we should expect that large-scale CPRs will also not always be well governed, and the existence of an example of continuing weak governance should not be taken as a sign that CPR theory is not applicable to large-scale forest governance.

Araral argued that the failure to halt deforestation in Indonesia was typical of the challenge of governing systems involving large numbers of actors, however we were unable to draw conclusions about the relevance of group size for the governance of Indonesia's forests. While decentralization certainly increased the number of actors engaged in governing Indonesia's forests, our analysis points to other factors – notably a continuation of a clientelistic system dependent on

resource extraction to support elites and denial of rights to local people – as central to continued deforestation. This is consistent with broader arguments that democratization has not fundamentally changed the exploitative character of Indonesia's democracy (cf Arnold 2008; Fukuoka 2013). It also may imply that the failings of CPR governance in Indonesia are not the result of its large-scale (as argued by Araral), but instead the result of other factors which could potentially be present in small as well as large-scale cases.

Findings from this study have to be taken with caution for several reasons. First, while CPR theory emphasizes collective action, the linkage between collective action and environmental sustainability is unclear. Establishing a causal connection between cooperation and sustainability may be relatively straight forward in local contexts but it is much less so in large scale-contexts. Second, the political environment in Indonesia has changed rapidly in the last three decades which further complicates analysis. Third, inferences in this case are drawn with a limited focus on forest policy from 1965 to present. We have not focused on other potentially connected policies like trade or agriculture, nor assessed the variation within or between districts. Finally, our analysis here is based on published literature which leaves great uncertainty on several points, including the extent of recent deforestation, as well as the identity of the main drivers of change in deforestation rates in the post-Suharto era. More in-depth, field-based research needs to be done to understand the nature of these changes, particularly as the international community is investing large amounts of money in policies (such as the ban on new logging concessions) that may not be effective.

Our results point to the value of CPR theory in identifying important variables that influence sustainability at large scales, however they also illustrate important limitations of CPR theory for the study of forests with large spatial extent and large numbers of users, including the study of forests at the level of the nation state. CPR theory tends to assume that actors aim for sustainability, but under Suharto, actors specifically extracted forest resources unsustainably. While these variables are likely to be important in both large and small-scale systems, greater spatial extent may enable predatory and destructive actors to persist in single locations for longer periods of time – a predatory actor or group of actors owning a small forest is likely to degrade it quickly and be forced to move on, leaving little evidence of their actions for scholarly study. By contrast, Indonesia has witnessed decades of overexploitation, yet still has some of the world's largest forest resources.

The finding that CPR theory's most important shortcomings with regards to understanding the Indonesian case are probably not scale dependent supports the use of CPR theory to understand forest management at the level of the nation state or even larger. At the same time, it points to areas where the traditional focus of CPR theory should be complemented with other theoretical frameworks such as land use and cover change and political ecology, which offer deeper insight into some of the drivers of forest change. Assessing whether these theories offer conflicting explanations, or whether they can

be usefully combined to generate a more integrative theory of forest cover change, will require investigation of a larger number of cases, as well as more carefully examination of cross-scale linkages that connect patterns observed at the local level to policy-making at the national level. Based on this study, we argue that these studies will need to pay particular attention to the role of power dynamics, governance intention, market forces, and NGO and international interventions to better conceptualize the roles of these variables, while continuing to examine variables drawn from the core of CPR theory. Such studies will also require more consistent and higher quality measures of changes in forest level outcomes across scales.

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