

Learning on Governance in Forest Ecosystems: Lessons from Recent Research

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Abstract: Research on forest governance has intensified in recent decades with evidence that efforts to mitigate deforestation and encourage sustainable management have had mixed results. This article considers the progress that has been made in understanding the range of variation in forest governance and management experiences. It synthesizes findings of recent interdisciplinary research efforts, which indicate that sustainable management of forest resources is associated with secure rights, institutions that fit the local context, and monitoring and enforcement. At the same time, the variability in local contexts and interactions of social, political, economic and ecological processes across levels and scales of analysis create uncertainties for the design and maintenance of sustainable forest governance. By identifying areas of progress, lessons learned, and gaps in knowledge, the discussion suggests priorities for further research.

Keywords: Complexity, context, forest governance, institutions, sustainable management

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I. Introduction

How can forests be governed productively and sustainably? In an age of environmental degradation, deforestation, and global climate change, forest governance has become a pressing research topic. Despite several decades of intensive efforts by governments, non-governmental organizations, and environmental activists to improve forest conservation and foster sustainable management, results have been mixed. At the same time, research in forest communities around the world has found a range of variation. While some governments and communities have governed forests sustainably over long time periods, others struggle to mitigate degradation or lack commitment to manage forests sustainably. Research has made progress in understanding the conditions associated with well-managed forests, but we still have much to learn about why some forests endure and others suffer degradation and deforestation. Studies relevant to forest governance represent many disciplines and approaches, which complicates efforts to synthesize the information. Identifying common findings and well-supported evidence is made more difficult because most of the information comes from case studies. Comparative studies remain the exception, but in conjunction with case studies, have shown that certain conditions are consistently associated with sustainable forest governance across different social and ecological settings. This article aims to synthesize what is currently understood, the lessons learned, and the persistent challenges and puzzles of governing forests. Given that forests are complex social-ecological systems (Agrawal et al. 2008), the discussion considers the problems posed by context and complexity, and suggests priorities for further research.

A large body of research on forest change and management has focused on the causes and consequences of deforestation. If we understand the causes of deforestation – the reasoning goes – then we should be able to mitigate them, and design better forest governance. We now know that the proximate causes of deforestation vary across locales and regions, from agricultural expansion and exploitation of timber or other natural resources, to infrastructure development (such as road-building) and urbanization. Few of these causes prove easy to mitigate, because they typically are associated with underlying causes, including policies, economic factors, demographic processes, perverse institutional arrangements, and cultural attitudes that interact to drive forest exploitation

(Geist and Lambin 2002). Instead of direct, simple causes, there are diverse chains of causality in which multiple factors interact for variable forest outcomes. Studies of causes of forest destruction have increased our knowledge of the complexity of the problem, but have helped little to create more effective forms of forest governance. An alternative approach toward improving forest governance involves studying locales where forests have been governed sustainably, with the rationale that we may learn how to govern effectively by studying successful cases. A third approach involves comparative studies of forest outcomes and governance approaches across the range of biophysical, ecological, sociocultural, and political-economic contexts in order to identify patterns. All of these approaches make contributions, but fieldwork indicates that most cases of forest governance entail a combination of shortcomings and successes; they present reasons for hope as well as concern. Theories of forest transition and political ecology suggest that historical processes of settlement, clearing and regrowth, as well as relations of power in a society influence forest transformations in ways that may resist political or institutional remedies (Haenn 2005; Rudel 2005). Even outstanding examples of forest governance can come to teeter on the edge of catastrophe due to internal strife, external interventions, natural or human-made disasters (e.g. hurricanes, wars), or rapid transformational processes. Thus, one of the main lessons is that there are no guaranteed, calamity-proof means of governing forests well.

The discussion opens by presenting central questions that have driven research and the basic definitions and concepts of forest governance. It considers the interdisciplinary methodological approaches that have advanced data collection and analysis on forest governance. Then it moves on to look at insights and lessons that have emerged in recent years. The information draws particularly on the collaborative and comparative work done through the Center for the Study of Institutions, Population, and Environmental Change (CIPEC) (www.cipec.org) and the International Forestry Resources and Institutions (IFRI) Research Program (www.sitemaker.umich.edu/ifri/home). It broadly addresses principles that relate to successful forest governance across diverse forms of ownership and management. Subsequently, the discussion turns to lessons learned as researchers have encountered complexity, contingency, and a range of contextual factors that impinge on governance and forest outcomes. The issues of context and complexity receive additional consideration with respect to gaps in existing knowledge and priorities for further research. The article closes by considering enduring challenges of forest governance, and the potential for advances through rigorous, coordinated and comparative study.

2. Theoretical questions and key definitions

Research on forest governance covers a broad range of questions. Here, I address two central questions. First, “How do different forms of governance influence forest outcomes?” This question aims to discover whether certain forms of governance work better than others. It includes the kinds of tenure and institutional

arrangements associated with sustainable forest management. Second, “What conditions or principles are conducive to effective governance?” This question intends to discover how broader contexts – ecological, social, institutional, political economic, and other aspects – influence governance and its outcomes. Exploring forest governance requires definitions of key concepts, especially “governance”, its allied term “institutions”, and “sustainable forest management” as I use them here.

“Governance” is the exercise of authority, including the processes, acts, and decisions of a group or entity within a given context, in this case a forest. Forest owners, whether communal, private (individual or corporate), or public, generally have the proximate authority to govern. However, many of the world’s forests fall under multiple levels of governance, which may include local, regional, national or international governmental and non-governmental entities. At each level, recognized entities can have authority to make certain decisions and shape the processes and activities affecting a given forest. Governance encompasses the design, implementation, and enforcement of institutions, which may take place at any level.

“Institutions” are rules in use. They establish what people may do, must do, or must not do in a specific situation (Ostrom et al. 2002). Institutions may be formal (written) or informal. What matters is that most people recognize institutions as legitimate and use them as guides for behaviour. If rules are set in writing but not recognized or enforced, they are not institutions; they are abstractions. This discussion focuses on the types of institutions associated with conserving forest resources, but many institutions and governance choices do not prioritize sustainable forest management; demand for fuel, timber, and land often take precedence (Agrawal et al. 2008).

“Sustainable forest management”, in ideal terms, refers to the maintenance of a forest, including ecosystem functions and its native biotic and abiotic components. Sustainable management exists as long as perturbations of natural or human origin permit recuperation. Harvesting and other uses may be permitted as long as they do not cause permanent degradation or destruction of the ecosystem, its functions, and its components. Despite this idealized definition, sustainable forest management is a highly contested concept. Uncertainties exist in our knowledge of forest ecology and our understanding of how social and climate change processes affect forests. This definition of sustainable management assumes that forests are relatively undisturbed, but most forests have experienced profound transformations due to human activity (Williams 2003). Many modern forests present human-maintained compositions. Where forests are transformed or degraded, the question arises: What does sustainable management entail? It may include (a) maintaining human-created conditions, (b) mitigating degradation, (c) pursuing restoration, or (d) finding a nuanced approach to fit local contexts. As a result, sustainable management has normative dimensions because it is shaped by human values and preferences. For the purposes of this discussion, sustainable management exists insofar as degradation and decline do not occur over an

extended time period, and conditions appear to be stable or improving given the management approach.

Governance, institutions, and sustainable forest management interrelate closely. They are jointly necessary to the concept of successful forest governance. Herein, “successful forest governance” involves exercising authority and developing institutions to maintain forests in good condition with respect to the given biome, ecosystem functions, species composition and human needs. In these terms, successful forest governance contributes to the sustainability of a social-ecological system. Through effective institutions, it mitigates interventions or transformations that could lead to permanent degradation of the ecosystem or loss of constituent flora and fauna, while accommodating the human beings who depend upon forest products or environmental services for their sustenance and well-being.

Because forest governance requires attention to social as well as ecological dimensions, it can be wrought with tensions and conflict. Many forested areas have been subject to confrontations between groups with different values and priorities for forest management. A continuum of management approaches has evolved out of struggles to manage forests sustainably, ranging from strict protection that excludes humans, to limited use, to multiple use forests. Even when substantial accord is reached on institutions to manage forests, people may disagree on the details (e.g. should infested or damaged trees be extracted or not?). In some cases, forest protection and biodiversity conservation have been emphasized above all other considerations, to the detriment of people who rely on access to forests or on forest clearing for economic activities, cultural survival, or bare subsistence (Schwartzman et al. 2000). Conservationists and activists for indigenous rights have repeatedly clashed over the role of native populations as protectors or destroyers of the Amazon rainforest (e.g. Alcorn 1993; Terborgh 1999; Redford and Sanderson 2000). Thus, another general lesson is that successful forest governance has a better chance of emerging where appropriators and other stakeholders generally agree on the goals and approaches to forest management and conservation. For many forested areas, consensus among stakeholders does not exist. Often significant discrepancies in power, access to resources, and other dimensions of social inequality underlie or exacerbate conflicts over the use and management of forest resources, as occurs in the Amazon. If successful forest governance is to be achieved in contexts of competing or oppositional stakeholder groups, it implies finding ways to build effective institutional arrangements through negotiation and compromise, or despite continuing discord. Research has barely begun to examine the conditions that enable competing groups to negotiate mutually acceptable compromises, and overcome social inequities associated with unsustainable use of forests.

3. Methods

Research on forest governance has advanced by integrating methods from the social and natural sciences. Collaborations among natural and social scientists

and the use of multiple data collection methods in CIPEC and IFRI research have proven to be especially productive for analyzing relationships among forest transformations, institutional arrangements, and patterns of human activity. An integrated methodology for research can include social data, forest measurements, satellite images, geographic information systems (GIS) data, and modeling (Green et al. 2005). Fieldwork on the ground reveals the biophysical, social, economic, political, and institutional factors that are critical for analyzing why forests change and how local contexts shape outcomes (Tucker and Southworth 2005). Analyses of satellite images over time serve as a powerful tool to track changes in forest cover, which short-term fieldwork cannot observe (National Research Council 1998). Modeling of land-use and land-cover changes offers a productive approach to test and discover possible relationships among contingent variables, and can pull together data from remote sensing, forest mensuration, and social fieldwork (Evans et al. 2005). Modeling also can be useful to test what kinds of social and biophysical dynamics may have driven historical changes and continue to shape forest-cover transformations (Evans and Kelley 2008). Each data collection method complements the others by compensating for each others' weaknesses and together permitting a more holistic analysis. In conjunction with multiple data collection methods, a comparative approach proves more robust than separate case studies to test hypotheses regarding forest governance. In order to achieve comparability across research sites, CIPEC and IFRI employ a common set of protocols for collecting and analyzing social, institutional, biophysical, and remotely sensed data (Poteete and Ostrom 2004). Detailed information on the methods used by CIPEC and IFRI can be found in Moran and Ostrom (2005), Gibson et al. (2000), and the CIPEC and IFRI websites.

4. Lessons learned regarding forest governance

What have we learned to answer the questions "How do different forms of governance influence forest outcomes?" and "What conditions or principles are conducive to effective governance?" Each question will be examined in turn, with a focus on major lessons as well as some of the contexts that shape outcomes.

4.1. How do different forms of governance influence forest outcomes?

A key finding is that no form of governance nor property regime is necessarily more successful than any other. Property regimes have received considerable attention in the discussion of sustainable forest governance. Does governance based on private, public, communal ownership or some combination work better than other options for managing forests sustainably? The short answer is that any property regime can result in well-managed or poorly managed forests (Moran and Ostrom 2005). The outcomes depend on the contexts of the property regime and the forest in relationship to historical and legal precedents, political-economic processes, social relationships, biophysical characteristics,

forest conditions, and people's experiences in managing natural resources (Dietz et al. 2003a). Given that few governance arrangements are isolated from other levels or entities, the hierarchical relationships and interactive dynamics of governing entities within and across levels must also be considered. For example, common property is unlikely to be successful if people have little or no experience with collective action or joint forest management, or if higher-level governing entities oppose communal arrangements. In these circumstances, private, public or co-management arrangements have greater chances to achieve successful governance (Tucker et al. 2007). Yet forest governance arrangements based on private or public property regimes can result in serious shortcomings. Privatization typically involves dividing a forest into parcels for individual ownership, which results in diverse, uncoordinated activities. Private owners may convert forest cover to agricultural fields, pastures, or other uses. From an ecological standpoint, subdivision of forests can undermine ecosystem functions and lead to deterioration (Mwangi 2007). Public governance of forests has also experienced failures. National governments can lack the resources or political will to invest in protecting forests, or make poorly informed management choices. Alternatively, governments may intentionally use forests to generate income through concessions, timber sales, or economic development initiatives, which often entail forest conversion, resource degradation and undervaluing of forest resources. Deforestation in a number of nations, including Indonesia, Malaysia, the Philippines, Ghana, Liberia, and the Ivory Coast, among others, has been driven at certain historical intervals by national policies and programs that sought to reap benefits by exploiting public forests (Repetto and Gillis 1988). In other cases, as in Brazil and Nicaragua, governments opened public forests for colonization and resettlement programs to ease population pressures or diffuse social tensions (Browder 1988; Utting 1993).

4.2. What conditions or principles are conducive to effective governance?

Conditions or principles that do need to be present for most forest governance regimes to work are secure rights, institutions that fit the local context, and monitoring and rule enforcement. These are a subset of design principles identified by Ostrom (1990, 2005) as key elements in long-enduring common-property regimes, but they have been recognized as important for forest governance across a wide range of property arrangements. These principles should not be seen as sufficient. Research on common-property regimes has found over 30 variables that influence governance and its outcomes (see Agrawal 2002). Other key principles, such as a certain level of local autonomy, high-levels of trust, low-cost mechanisms for conflict resolution, and accountability of managers to users appear critical for common-property regimes (Dietz et al. 2003a). Successful forest governance under private and public regimes may involve additional or contrasting factors. For any given forest biome or property rights regime, differences exist in which variables matter, and to what extent (Ostrom 2007).

The principles detailed below are noteworthy because they have been found to be associated with sustainable forest governance in public, private and common-property regimes, as well as across diverse forest types, cultural groups, national contexts, and political economic situations.

4.2.1. Rights must be secure:

A key aspect of governance success is security of forest rights, which is generally understood as secure property rights or secure tenure. This principle has long been recognized as a necessary component of good governance. In some cases, rights may be specific-use rights, as when people have legally recognized rights to specific activities or products. Whatever the context, rights become secure insofar as they are recognized as legitimate and enduring by formal government entities and the general population. Only where forests are inaccessible, distant from roads or markets, or exposed to minimal human presence does secure tenure fade in importance (Nagendra et al. 2004; Moran and Ostrom 2005). Security typically must include legal recognition (land title or something comparable) for specified owners or appropriators, clearly defined boundaries, and a set of rights to make decisions and to use resources (Banana and Gombya-Ssembajjwe 2000). Land-titling programs have attempted to provide secure tenure under private ownership, and governments have nationalized forests in order to provide secure tenure under public ownership. Imposing private or public regimes can be an effective means of achieving secure rights where none existed before. But where common property regimes exist, the top-down imposition of public or private ownership terminates rights previously believed to be secure by local groups, and abolishes arrangements and institutions that often had governed forests relatively well (Ascher 1999). People usually feel angry and want restitution when their rights are abrogated. Few governments are prepared to dedicate adequate resources to protect newly nationalized or privatized forests, or to confront the conflicts with local populations that may ensue. Without protection, and in the context of an angry and disenfranchised local population, forests can become open-access zones subject to uncontrolled exploitation and degradation (Ostrom 2005). For example, the creation of the Monarch Butterfly Reserve in Mexico sought to protect the endangered forests that shelter monarch butterflies during their winter hibernation. The reserve's creation stripped local communities of their rights to use those forests, even though they held legal land titles (Tucker 2004b). The government lacked the resources to monitor activities and enforce the rules it had established, and communities that lost rights turned against the reserve. Processes of deforestation in the reserve continued unabated or accelerated (Brower et al. 2002).

Many researchers and policy-makers have thought that common-property forests inevitably suffer from poor governance. But a growing body of literature shows that with secure property rights and other favorable conditions, groups can govern common-property forests well (e.g. Netting 1976; McKean and Ostrom 1995; Gibson 2001; Ghatge 2004; Tucker 2004a). When groups have experience in cooperating, share common understandings, trust each other, and invest time and

labor to joint governance, common-property arrangements can be as effective, or more so, than private or public tenure (Ostrom 1990). Moreover, common-property regimes can offer benefits in terms of equity and reduced bureaucracy (Runge 1986). But like other forms of governance, common-property regimes can fail if they lack key components and if larger-level institutions undermine them. Under any property regime, some owners and appropriators simply lack the knowledge, skills, commitment, or resources to govern forests sustainably. In short, secure rights represent a crucial dimension for governance, but they alone will not protect forests; appropriate institutions that convince rights-holders to use forest resources wisely must also exist.

4.2.2. Institutions need to fit the local context:

Extensive research of governance arrangements around the world has found a wide variety of institutions that meet local needs and protect natural resources successfully (Ostrom 2005). Institutions are context-dependent. The same rule can have different effects on resource governance due to variations in biophysical conditions, characteristics of the managers/appropriators, and the surrounding socioeconomic, political and institutional environments (Agrawal 2002). Institutional fit is most likely to emerge where the people who understand local contexts and use the forest participate in designing and modifying rules. This is true regardless of the tenure regime. A comparative analysis of 163 forests, including public parks and private and common property, found that where appropriators had rights to design rules to manage a forest, vegetation density was greater. Forests were sparser where appropriators were not involved in rule making (Hayes 2006). Rules designed locally carry advantages in that they can (1) accommodate local appropriators' needs, (2) respect local technical and cultural preferences, and (3) incorporate appropriators' intimate knowledge of local forest ecology, flora, and fauna. When people participate in making rules, they are more likely to see the rules as legitimate, and obey them. If the process is open to all, including the least advantaged, the resulting institutions have greater chances of operating equitably. Rules that incorporate knowledge of the resource base are also more likely to support sustainable management than rules designed by politicians and scientists who do not know the forest. It is possible for top-down governance decisions to accommodate local participation and contexts. Uganda's gazetted forest reserves have survived for decades in contexts of population growth and high demand for forest products because local people maintain traditional but limited rights to certain products, boundaries are monitored and clearly marked with flowering trees, and local guards enforce the rules (Vogt et al. 2006). In other cases, top-down institutions that intended to improve governance have promoted deforestation. In 1974, the Honduran government ruled that it owned all trees and forest management rights, even where land titles belonged to private or communal owners. The nation suffered high losses of forest cover to fires as angry landholders laid claim to their land by eliminating trees (Ascher 1999; Tucker 2008). As this example illustrates, well-intentioned institutions can backfire when

imposed on locales and people with different perspectives from those who created the institutions (Ostrom and Nagendra 2006).

4.2.3. Monitoring and enforcement are key elements for sustainable forest management:

One of the most significant findings for forest governance is that monitoring and enforcement are strongly associated with maintenance of good forest conditions. These results have emerged with case studies and time-series analyses of satellite images, which confirm stable forest boundaries under monitoring and enforcement (Schweik 2000; Dietz et al. 2003a). These results have proven to be statistically significant through large-N comparative studies of forest governance based on data collected by IFRI researchers. In a comparative study of 178 user groups in 220 forests, statistical analysis showed that forests with regular monitoring were more likely to be in good condition than forests with sporadic monitoring. This was true regardless of whether the group was formally organized, its level of dependence on the resource base, or the degree of social capital (Gibson et al. 2005). In a related study, local enforcement was significantly associated with the likelihood of forest regeneration (Chhatre and Agrawal 2008).

5. Lessons learned from complexity, context, and contingency

These principles – secure tenure, locally appropriate institutions that protect forests, and monitoring and enforcement – interact with a series of contingent variables. The effect of one variable can change the state or impact of other variables (Chhatre and Agrawal 2008), thus context matters (Dietz and Henry 2008). Many contingent variables, a number of which have been mentioned, interact to constitute the relevant context for the emergence and outcomes of forest governance. As contingent variables change, so do their relationships and implications. Therefore, researchers must deal with complexity. I will discuss several outstanding lessons that have come from recognizing the contingent, complex, and sometimes unpredictable interplay among variables that influence forests and prospects for governance.

5.1. Governance must be able to manage dynamic processes and adapt to change

To speak the obvious, forests are not static. They go through natural succession, and may experience damage from severe weather events, fire, and invasive species, as well as human interventions. Forest-cover change related to social contexts and natural successional processes can be far more dynamic than generally supposed (Southworth et al. 2002). In Guatemala and Honduras, studies of landscapes under agroforestry systems suggest that complex interactions of individual decisions, traditional practices, and institutional arrangements can maintain overall forest cover as a dynamic mosaic of successional forests, fields,

and fallows (Tucker and Southworth 2005). Traditional peoples have been known to design institutions that conserve resources by respecting natural cycles and processes; for example, prohibiting hunting or gathering at certain times in an animal or plant's reproductive cycle (Berkes and Folke 1998).

By contrast, certain top-down or newly implemented governance arrangements fall short in addressing natural cycles or social change processes. Institutions may be designed for a specific kind of forest or species composition, or rest on assumptions about what the forest should be, rather than principles to manage natural succession, useful species, or variability in human needs. As circumstances change, conflicts can erupt. An example comes from Yellowwood State Forest in Indiana. Neighboring residents, environmentalists, and government authorities have faced new tensions as natural succession has changed forest composition from sun-tolerant to shade-tolerant species. Certain commercially valuable trees and food sources for wildlife have been declining. The state and hunting groups want to increase logging to regenerate sun-tolerant species. Many residents and environmentalists argue that expanded logging will degrade the ecosystem, cause erosion, and pollute a lake known for exceptionally clean water and a rare, native jellyfish (Arnold et al. 2008). The issue has gained media attention because the forest has become an increasingly popular site for camping, hiking and fishing, thus the decision also concerns the general public. In such cases, decision makers must find a path for governance among conflicting convictions about how to manage natural succession, and possible ramifications for the forest ecosystem and its stakeholders.

5.2. Partnerships and deliberative processes can support successful governance

In a complex world undergoing constant change, individuals, communities, and higher-level entities often come into conflict over how to govern forests. Given contrasting goals and differences in perceived knowledge, there are multiple perspectives and objectives. Deliberations and negotiations among opposing groups may find points of compromise or bridges to build agreements. Recent studies of successful governance point to the importance of linkages among groups and entities operating at different levels, or in parallel, with local forest appropriators and owners (Berkes 2007). Creating partnerships offers another way to overcome gaps in understanding and construct mutually beneficial relationships. Through partnerships, local groups can access resources, information, technology, and training that support their governance efforts. In some cases, financial and technical support from external sources may be critical, although questions arise as to what will happen when the support ends (Nagendra et al. 2004). When dealing across levels of governance, where local-, regional-, and national-level entities may compete for influence and contrast in their goals or understanding, deliberative processes can increase the possibility of balanced and nuanced decision making (Berkes 2007). At the same time, genuine partnerships can be difficult to achieve. When one partner has considerably more political power and

economic resources, less advantaged partners may be denied a voice. Differences in education, experience, and values also may confound cooperation. The further risk exists that uninvited or domineering partners could disrupt local governance systems (Nagendra 2007). Partnerships appear more likely to succeed when all partners have an equal voice in decision-making.

Despite the potential for inequitable partnerships and related risks, cross-level linkages and partnering have the potential to support commitments to sustainable management. Successful partnerships typically include multiple partners for redundancy and access to diverse knowledge and resources (Seixas and Berkes 2010). As a corollary, the absence of partnerships to reinforce commitments to conservation can mean that forest owners and appropriators may change their minds easily. For example, private owners may decide to opt out of conservation programs to harvest timber if prices rise or if they need cash. New market opportunities may convince owners to transform forests to other land uses. When increasing demand for ethanol, a biofuel, drove up prices and demand for corn in the USA, farmers responded by clearing forested areas to plant more corn (Searchinger et al. 2008). Facing similar incentives, farmers in Southeast Asia and Brazil have shown interest in planting more soybeans, sugar cane and palm oil trees for biofuels (Fargione et al. 2008). Indigenous communities with communal forests have been known to accept timber contracts in order to finance public works, such as roads or schools (Tucker 2008). Neither are national governments immune to market incentives. The discovery of petroleum in the Maya Biosphere Reserve in Guatemala led to its opening to oil drilling and concomitant environmental degradation (Dietz et al. 2003a). Thus, commitment to sustainable management in any governance regime can be undermined by evolving personal, community, or market pressures. The opposite is also true; problems with deforestation or perceived risks to valued resources can motivate appropriators to support sustainable management (Tucker 2008). Because forest appropriators at any level can face changed incentives, the chances of successful governance increase when individual owners or groups are linked into networks or nested within multiple layers that support sustainable management. Moreover, partnerships may be able to restrain a powerful actor, such as the state, when it threatens to abrogate local governance rights. In 1989, for example, Brazil's Kayapó people stopped the national government from building a dam on their territory with support from international environmental organizations and media events. More recently, the Kayapó have sought to rebuild alliances to fight the nation's renewed dam-building plans (Warren and Jackson 2003; Clendenning 2008).

5.3. There are no panaceas

The lessons discussed herein highlight that despite a few general principles, no formula exists for successful forest governance. Blueprint thinking, where a single model or set of institutions is imposed unilaterally, has failed consistently to result

in reliable outcomes for forest governance (Ostrom and Nagendra 2006; Ostrom 2007; Ostrom et al. 2007). Forests survive or decline in relationship with diverse conditions and pressures that interact with human and ecological variability, and divergent historical experiences. In short, the range of conditions and degree of uncertainty in evolving social-ecological systems means that policies, programs, and institutional arrangements affecting forest governance need to be flexible, adaptive, and responsive to unpredictable contingencies (Unruh et al. 2005).

6. Challenges for research

6.1. Addressing context and complexity

We only beginning to understand how variables interact to influence outcomes in complex social-ecological systems (Anderies et al. 2007). Although certain principles associated with sustainable forest governance have been identified, questions remain as to which conjunctions of circumstances contribute to their presence or absence. We know that context matters, but given the numerous variables that may impinge upon outcomes, it is difficult to tease out the relevant variables and interactions. Ostrom (2007) has developed a multi-tier framework of key variables believed to be important for studying complex social-ecological systems; the framework includes six top tier variables and 51 second tier variables. With this number of potentially relevant variables that interact among each other and across scales and levels, the task appears daunting. Systematic research, however, requires examining only a few key variables at a time, while controlling for other variables. It is neither possible nor necessary to examine all possible variables at once, nor will all the variables apply in a given situation (Agrawal 2002; Ostrom 2007).

Through systematic research, gains are being made in understanding the ways that context can influence the effects of a variable on governance and forest outcomes. As an example, the effects of group size have puzzled researchers for years. Experimental studies have shown that small groups achieve higher levels of cooperation than large ones (Ostrom 2005) but findings in studies of resource management have been inconsistent. Examination of specific contexts has helped to explain the discrepant findings (Ostrom et al. 2002). It appears that the effects of group size varies with its proportionality to forest size, the resources available to the group, and pressures on the forest. A small group may govern a small forest well, but lacks the resources of larger groups to monitor large forests when pressures exist (Agrawal 2000). Moreover, very small and very large groups often fail to manage resources well, but for different reasons. Small groups lack resources, but as groups become larger, more variables affect the outcomes. Therefore, size appears to have a curvilinear relationship with resource management outcomes (Agrawal 2002; Ostrom 2005).

As the issue of group size suggests, understanding how contexts affect outcomes has the potential to reveal how and why forest governance is successful in some places, and may fail utterly in other places. Much work has yet to be

done to understand how the large number and different states of variables impact sustainability and governance outcomes. The challenge is complicated because complex social-ecological systems are non-linear, multi-scale and evolutionary in ways that elude prediction (Holling et al. 1998; Ostrom 2007). To make progress in understanding this complexity, there is a need for coordinated, multidisciplinary research and comparative analyses to address knowledge gaps and uncertainties. I briefly discuss two priorities for research: cross-scale and cross-level linkages, and systematic study of power relations and social inequity in social-ecological systems.

6.2. Cross-scale and cross-level linkages

While researchers widely recognize that cross-scale and cross-level linkages impact outcomes in forest governance, few studies have explored them systematically and comparatively across different settings. The kinds of cross-scale and cross-level linkages that communicate or mitigate systemic change processes appear particularly critical for study. Rapid change processes and external shocks have been implicated in the dissolution and decline of successful resource governance. Therefore, it is urgent to learn whether linkages exist that can mitigate the impacts of rapid change and severe shocks (such as a global economic downturn), and the contexts in which governance arrangements may be able to adapt more readily to change. Agrawal (2002) proposes the development of hypothesized causal linkages across scales, which can then be tested systematically. If we can identify interactions and probable outcomes among sets of causal linkages, we have greater chances of encouraging sustainable outcomes.

6.3. Power relations and social inequity

Many studies have implicated power imbalances and social inequities as underlying factors in resource degradation and failed governance (Mannix 1993; Utting 1993; Scott 1998; Ascher 1999; Kopelman et al. 2002). Conversely, sustainable resource management has been linked to participatory governance in which all stakeholders have a voice in decision-making and rights to resources (World Bank 2002; Ostrom 2005). Forest governance may have greater chances for success in contexts that include relative social equity, power sharing within and across groups, and empowering the disenfranchised. Nevertheless, social inequity and power imbalances – including poverty, gender-based discrimination, and social class or caste – have rarely been the focus of systematic research by scientists concerned with sustainable management and governance of natural resources. Therefore, knowledge gaps persist surrounding the contexts that foster equity (or inequity) and balanced (or skewed) power relationships, and how these play out in relationship with other variables to shape the prospects for successful forest governance. Although path dependency helps to explain the persistence of certain power relationships and inequity in societies, further research is needed to explore how these paths or patterns undergo transformation. Eventually, such research

may help policy-makers and practitioners to mitigate the pernicious consequences of social inequality, and find ways to build equity and sustainability for forest governance and society in general.

7. Concluding thoughts

Where do we go from here? Some progress has been made in identifying patterns and principles associated with successful forest governance even as we recognize the complex, contingent, and variable contexts that shape the specific outcomes for each forest. However, even if all forests were governed by the principles identified here – secure tenure, institutions that protect forests and fit local contexts, effective monitoring and enforcement, avoidance of blueprint thinking, flexible adaptation to social, economic, political, and forest-change processes, and partnerships within and across levels – governance would still fail in some instances. We do not know and cannot predict how current and future events will impact forests and their governance. From the outset, we must accept the possibility of failure, and see such cases as an opportunity to learn. Yet the process of learning will not be able to solve all the problems of uncertainty experienced by complex systems. Many contingencies and events that impact forests lie beyond the influence of forest users and governance, including climate change and international markets. Our risks of failure at a global level will be diminished if the world's forests are governed by a multiplicity of approaches. While recognizing general principles for successful governance, each forest should be governed with respect to its specific contexts. The best defense and preparation for the unexpected is for governance systems at all levels to encompass diverse forms of knowledge and perspectives, and aim to develop appropriate institutions, recognizing that some will not work well and many will need to evolve. Governance is an adaptive process that requires ongoing work with many different elements (Ostrom 2005). Diversity gives systems more options for adapting to unpredictable or extreme events. More forests are likely to survive, and humanity will be more likely to thrive, if policies and programs embrace the richness of options available for context-specific governance arrangements and locally appropriate institutions. This implies that a flexible balance must be attained among different powers and stakeholders in social and political processes that shape governance on the ground.

The way forward is to continue to investigate the complex processes and interrelationships found in human-forest systems. As we gain knowledge of the relationships among contingent, evolving variables, we can continue to learn lessons, and develop diagnostic approaches that identify which variables and issues are most important within given contexts (Nagendra 2007). More large-N studies are needed to find common patterns, but these can integrate coordinated, in-depth case studies. Participatory research and applied projects have the potential to test relationships in the field, and these may grow out of findings from experimental studies and computer modeling of complex systems. Uncertainties about ongoing dynamism in human-forest systems will continue to challenge us,

but rigorous research has the potential to inform policy and identify approaches likely to support successful governance within given contexts.

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