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Polycentric governance of multifunctional forested landscapes

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Abstract

Human-induced causes of forest change occur at multiple scales. Yet, most governance mechanisms are designed at a single level – whether international, national, regional or local – and do not provide effective solutions for the overarching challenge of forest governance. Efforts to “decentralize” governmental arrangements frequently do not recognize the importance of complex, polycentric arrangements and are based on a presumption of a single government at one level taking charge of a policy arena, often ignoring the existence of many vibrant self-governed institutions. Polycentric institutions provide a useful framework for governance, enabling aspects of preferred solutions to be used together in efforts to protect the long-term sustainability of diverse forested social-ecological systems. By considering the interaction between actors at different levels of governance, polycentricity contributes to a more nuanced understanding of the variation in diverse governance outcomes in the management of common-pool resources based on the needs and interests of citizens and the complexity of resources and governance systems at local, regional, national, and global levels. In this paper, we discuss challenges to polycentricity such as the matching of the boundaries of those who benefit, those who contribute with the boundary of the resource. We describe some approaches that have been effectively utilized to address these challenges in forests in various parts of the world. We also provide a brief overview of how the concept of polycentricity helps in the analysis of climate change and the closely related international effort to reduce greenhouse gas emissions through degradation and deforestation (REDD).

Keywords

Common pool resources; forest governance; forested landscapes; polycentric governance; REDD

1. The problem

Native forests are shrinking in area and degrading in quality, while the human footprint on all parts of the world continues to extend and intensify. While deforestation is particularly alarming in the tropics, a small number of tropical countries (along with several temperate countries) have recently experienced an overall “forest transition”, with a net increase in tree cover ([Lambin and Meyfroidt 2011](#)). The ecological consequences of forest clearing and recovery are varied across locations, depending on a number of factors that include the type of change in forest cover (such as secondary forest regrowth, forest plantation or agroforestry), the nature of local human pressure (such as fire, grazing, or clear-felling), and the larger socioeconomic and policy factors that shape trends in forest change (ranging from market dynamics to international climate treaties) ([Meyfroidt and Lambin 2011](#); [Southworth and Nagendra 2010](#)).

Human-induced causes of both deforestation and afforestation occur at multiple levels. Population can increase in one particular community while declining across a larger region. The impact of population growth can differ depending on scale as well. For instance, population growth can drive deforestation at a regional scale, especially in densely forested frontier regions ([Bray 2010](#)). At the local scale, however, increased population density concomitant with wood scarcity can lead to an increase in tree density through the promotion of agroforestry programs ([Meyfroidt and Lambin 2010](#)). Property rights may be well defined at the national level but deficient at the community level or vice versa. International trade affects the market price of many commodities, but the particular price received by farmers may also depend on government taxes and subsidies or the infrastructure provided in a specific community. Thus, as the theme of this special issue stresses, it is essential to adopt a multilevel approach to the analysis of human action that impacts over time the quality and extent of forests in diverse parts of the world.

More research has been devoted to the study of diverse macro processes leading to deforestation than to the study of the dynamics of reforestation, especially in tropical forested landscapes. Instead of designing careful studies of regions where reforestation has occurred and an effort to sort out the diversity of micro-level processes that cumulate to produce different land-use changes ([Turner and Meyer 1991](#);

[Southworth and Nagendra 2010](#)), many scholars and activists have instead simply proposed major policy reforms that they presume will lead to reforestation. There are also multiple types of reforestation, ranging from forest plantations to agroforestry, private forests, regenerating secondary forests, and modified natural forests ([Meyfroidt and Lambin 2011](#)).

An important theoretical contribution of this article will be a careful study of the role of *diverse* institutions at multiple scales in encouraging reforestation across the world, thus contributing to the discourse on the drivers and factors impacting forest transitions at multiple scales ([Lambin and Meyfroidt 2011](#)). First, we will briefly review policy proposals frequently made for establishing one level or type of governance as “the” solution to the problem of massive deforestation across the world. We will then discuss the concept of “polycentricity” and why this may be a better approach to improving forest policies across the world than reliance on any single approach. We will conclude with a discussion of the challenges of forest governance at different levels, and some ideas for how these challenges can be approached.

A number of local, regional, national, and global efforts to address challenges of forest conservation and sustainable forest use are ongoing, resulting in programs as varied in scale as government-owned protected areas, REDD+, community forestry, agroforestry, and privately managed forests ([Southworth and Nagendra 2010](#)). Yet, while new laws, programs, and policies of forest governance are being developed at national and global levels, implementation takes place largely at the local level, in specific locations, by particular groups of people. Although a growing number of countries have now embraced some forms of decentralization, this has largely meant that responsibilities have devolved to lower levels of administration, while rights are predominantly retained by governments ([Agrawal and Ribot 1999](#)). In addition to requirements negotiated by international agreements such as on climate change, and national decisions about conservation and forest governance, the incentives of a complex array of local actors – including politicians, farmers, forest cooperatives, and conservation NGOs – also shape the trajectories and outcomes of forest governance in different locations ([Clark et al. 2011](#)). Thus, governance mechanisms designed at any single level – whether international, national, regional, or local – cannot provide complete solutions for the overarching challenge of forest governance.

2. Blueprint thinking and uni-level policy proposals

In the last century, most of the proposals made for ways to solve the multiple problems leading to deforestation and degradation of forested ecosystems stressed one or another type of governance arrangement as the best way to address the problem. “The” problem, according to many analysts, was the “tragedy of the commons”, which was so dramatically articulated by Garrett Hardin in a 1968 article in *Science* that it became the basic way that college graduates thought about regulation of forests, fisheries, and water resources. [Sandler \(1992\)](#), for example, clearly articulated the position that overexploitation of shared natural resources is inevitable, and privatization or state management are the only viable alternatives.

In their analysis of multiple development failures, [Pritchett and Woolcock \(2004\)](#) argued that many development assistance staff members and public officials had been trained that there were core solutions to the problems of development – and that in many cases, *the* solution turned out to be a major problem in implementing effective policies. Yet, the solutions for forest management can differ considerably based on the nature of forests and type of change taking place. For instance, reforestation can occur in a variety of ways, whether in plantations, as agroforestry on private farms, as secondary forests on clear-felled land, or as modified natural forests experiencing an increase in tree density ([Meyfroidt and Lambin 2011](#)). The drivers of forest degradation and deforestation can also differ considerably based on location, forest type, history, socioeconomic conditions, and additional context-dependent factors ([Berkes 2007](#); [Geist and Lambin 2002](#); [Nagendra 2007](#); [Southworth and Nagendra 2010](#)). Institutional and/or cultural context can also be critical in impacting forest change ([Geist and Lambin 2002](#); [Ostrom and Nagendra 2006](#)). Thus, factors such as the number of actors, their configuration, involvement in decision-making and monitoring, and variations in power and equity can vary substantially between locations, further shaped by institutional structures that influence decision-making outcomes and implementation of decisions ([Ostrom 2007](#)). Historically, social scientists have, unfortunately, seen their primary responsibility to be presenting the patterns of social and ecological interaction in a simple fashion due to a deep misunderstanding of the biophysical sciences that are incorrectly presumed to always be simplified pictures of real-world phenomena (see, for example, [Sugden 1986](#), 3).

Thus, any proposed institutional design would need to work well in very different social and ecological environments to effectively deal with a range of varied challenges. Although it may seem obvious that flexibility and adaptation should be essential components of such a design, these criteria are not stressed in the academic literature. For some time, government ownership was contrasted with private ownership as the two “ideal” forms of land ownership to ensure long-term protection. Recently, decentralization of formal management control and community control of forests has been added to the list of preferred solutions. All of the preferred solutions have succeeded in some settings. But successes have been matched in most cases with well-known failures. It is hard to know exactly why the policy literature has been so dominated by panacea thinking, but Andrew Sugden speculated about this puzzle back in 1986 when he stated:

Most modern economic theory describes a world presided over by *a government* (not, significantly, by governments), and sees this world through the government’s eyes. The

government is supposed to have the responsibility, the will and the power to restructure society in whatever way maximizes social welfare; like the US Cavalry in a good Western, the government stands ready to rush to the rescue whenever the market “fails”, and the economist’s job is to advise it on when and how to do so. Private individuals, in contrast, are credited with little or no ability to solve collective problems among themselves. This makes for a distorted view of some important economic and political issues. (1986, 3; emphasis in original)

Before we turn to a discussion of how polycentric systems may enable aspects of preferred solutions to be used together in efforts to protect the long-term sustainability of diverse social-ecological systems, we will quickly review three of the “solutions” that have dominated the thinking of academic policy analysts who have frequently created models of resource systems but now conduct empirical research of the operation of these models in practice.

2.1. Government as the solution

Among the most frequently recommended is the need for interventions by national governments so as to achieve reforestation. Michael Williams (2003), for example, has undertaken a massive study of the world history of deforestation and concludes that we know much less about “what brings deforestation under control” than we know about the dynamics of reforestation. Williams recommends, however, “the need for strong government institutions to implement stated policies and resist elite groups who have traditionally pursued the exploitation of the forest” (2003, p. 498). Many others have called on national governments to take the lead in reversing these dynamics (see Deacon 1995; Rice 1989; Rowe et al. 1992).

The success or failure of government initiatives at natural resource management depends on a number of factors, prominent among which is the level of support provided to local governments. For instance, despite Canada’s taking a prominent role in the North American region in terms of climate change, by ratifying the Kyoto Protocol, the United States appears to have achieved substantial progress in recent years with the formation of an Alaska Climate Change Sub-Cabinet and the initiation of climate change adaptation planning in seven other U.S. states, as well as local adaptation in a number of locations ranging from large cities like New York to smaller cities such as Keene, New Hampshire (Wilbanks and Kates 2010). Rabe (2007) demonstrates that American states have engaged in climate policy to a far greater extent than Canadian provinces, establishing and enforcing emission reduction policies, targets, and standards. He attributes this in part due to the fewer resources and initiatives available for Canadian provinces to tackle climate change, in comparison to their American counterparts. The initiatives of local states, and the availability of an enabling national atmosphere, are critical if national governments are to be able to take positive steps toward protecting the environment. Thus, the United States border state of Arizona has taken a number of cross-boundary initiatives with the Mexico border region of Sonora aimed at mitigating the impacts of climate change and increasing the regional resilience of this important cross-national location (Wilder et al. 2010; York and Schoon 2011). Regional initiatives by groups of U.S. states and innovative cross-border collaborations between U.S. states and Canadian provinces have also been developed in recent years in response to challenges of climate change (Benson 2010).

National and state governments are important actors in encouraging reforestation, but they are not the *only* organizations that foster more rapid rates of reforestation. In tropical developing countries, organizations such as the Consultative Group on International Agricultural Research (CGIAR) has worked with research institutes, NGOs, community organizations, farmers, and local and national governments, seeking to collaborate to improve agricultural productivity in ways that do not further impact the forest. Experiences from multiple countries indicate that programs tended to be more effective when trust was established between all parties involved, and the impact of power inequities were minimized during negotiations, so that the opinions of the least powerful stakeholders were also taken into consideration rather than mandating top-down processes of “knowledge transfer” (Clark et al. 2011).

In the United States, both national and state governments have purchased extensive land devoted to forest regrowth. In Canada, more than 92% of forest land is owned by the Crown, while in the United States about 43% of forest area is under public ownership (FAO 2010a,b). In addition, special districts, such as conservancy districts, also play an important role in protecting open lands as well as forested lands. Many NGOs, such as The Nature Conservancy, have also taken a strong lead – both in bringing attention to the issue of protecting forested land and in protecting land themselves. Land trusts mobilize resources to purchase land from private owners and either protect it themselves or assign it to a national or state governmental forestry agency. Once NGOs are established and registered, it is then possible for private owners of land to use various forms of conservation easements to assign future development rights to such organizations. The private owners continue to use the land for their own purposes, but they have forgone the possibility of selling land for clearance and development in future years.

Another private strategy for preserving forested land and promoting regrowth is actually through “development” when a developer buys a large section of land, divides some of it into private plots for housing, and turns the rest of the land over to a private housing association that has a strong incentive to protect jointly owned forested land. These kinds of common interest housing developments are sometimes called condominiums, cooperatives, planned communities, or intentional communities and have become much more prevalent during the past quarter of a century, especially in fast-growing cities such as Mumbai and Cairo, where both space and greenery are at a premium (Falzon 2004; Kuppinger

2008), and even within the United States, where condominiums are becoming much more frequent (see Fleischman et al. 2010).

Thus, while strong centralized governments may appear to be the dominant force directing reforestation at a national scale, in actuality the impact of national governments is often mediated, enhanced, or deterred through actions conducted by a diversity of other actors. The important input and influences of local governments, NGOs, and private actors are often inadequately represented in policy arguments. Local communities also play a powerful force in determining the location and extent of forest recovery, as discussed further in a following section.

2.2. Decentralization as the solution

Given the difficulties in achieving effective engagement of citizens in the governing of local commons, decentralization has frequently become a recommended policy (see OECD 1997). In an effort to assess the impact of decentralization policies, Andersson and Ostrom (2008) analyzed the effect of decentralization on forest governance performance among a sample of 300 local governments in Bolivia, Guatemala, and Peru. These three countries are particularly relevant cases for a comparative study of decentralization because all three share many essential biophysical, socioeconomic, historical, and cultural characteristics, but they differ in regard to their decentralization policies. Bolivia, Guatemala, and Peru are relatively poor with large rural and indigenous populations, significant natural resources, high proportion of forest cover, and frequent land-use related disputes. All three countries differ a great deal, however, when it comes to the degree of decentralized governance structure in each country's natural resource sectors even though all have locally elected mayors. Guatemala would have the greatest amount of regulatory power that a national government assigns to its local governments. Bolivia would have assigned a moderate level of regulatory powers to local government (Andersson and Gibson 2007), while Peru has devolved virtually no local decision-making power to its local governments in the natural resource sectors.

Bolivia and Guatemala passed reformed forestry laws in 1996. These were the first efforts to decentralize several tasks and responsibilities in the forestry sector from central to municipal governments. Even with this reform, however, Bolivian municipalities are not authorized to collect any taxes on forestry activities, to charge user fees for services produced, or to impose fines on individuals who are caught disobeying the government laws and regulations (see Pacheco 2007). In contrast, Guatemalan municipalities may own, manage, and even rent out their forests. Within municipal and communal forests, Guatemalan municipalities are authorized to regulate and tax forest use, as long as the local rules do not contradict the national forestry law. In Peru, governance responsibilities were not decentralized at all. The central and regional governments retained complete formal control over the natural resource sectors' decision-making process.

To obtain sufficient data about local government institutions and actions, Andersson and Ostrom (2008) draw on personal interview data with local governance actors in a random sample of 100 municipal governments in Bolivia, Guatemala, and Peru (these data are described in detail in Andersson et al. 2006, 2009). The interviews were conducted with the elected mayor to gather information regarding the mayor's policy priorities, staffing arrangements, relationships with central and nongovernmental agencies, and relationships with natural resource users and citizens at large. In addition, the research teams collected structural and socioeconomic information for each municipality, originating mostly from subnational census data and national forestry sector databases. Andersson and Ostrom (2008) draw on the data from this study to analyze the effects of institutional factors – including national decentralization policy reforms – on a series of forest governance outcomes at the local level. The outcome variables included the importance given to natural resource governance as measured by the proportion of the municipal budget assigned to such activities, the proportion of staff working on natural resource governance issues, and the mayor's perception of the relative importance of natural resource sectors compared to other sectors. The independent variables included the extent of formal decentralization, the amount of central government transfer, municipal income, population density, the mayor's level of education, and the frequency of meetings with local groups as well as central government agencies about natural resource management issues. They first examined which variables had an impact on the percentage of the municipal government personnel who were officially assigned to work with issues related to natural resource management. A second complementary dependent variable was the recorded view of the mayor related to the political priority of natural resource governance for his administration. They found that the two variables with a strong positive influence on both dependent variables was the level of central funding made available to a local community and the number of meetings held with local organizations. The formal level of decentralization had no impact on either dependent variable.

This analysis thus revealed that the interactions between actors at three different levels of governance were more important for deciding a mayor's allocation of staffing to natural resources than the formal legal structure. The financial transfers from the central government to the municipal government in the area of natural resource governance, and the level of political pressure from local community-based organizations and non-governmental organizations working on local resource management on the municipalities had the most impact and not whether decentralization was officially recognized. The linkages among levels of government capture important incentive structures related to political accountability and did affect the local mayor's political commitment to natural resource governance, while the formal decentralization structure had no impact on the budgetary allocation to natural resource governance.

Thus, formal decentralization reform did not provide a good explanation of intercountry or intracountry variation in local commitments to natural resource governance. The results also suggest that the characteristics of local institutional arrangements, which govern the interactions between municipal authorities on the one hand and local groups and central government actors on the other, provide powerful explanations to the variability in local commitments to natural resource governance – regardless of the formal structures of governance at the national level.

2.3. Community-based forest management

In reaction to other efforts to reform governance, and given the substantial evidence that communities are frequently able to manage their own forests successfully, community-based forest management has been increasingly recommended in recent years as another solution to the problem of deforestation (Altrichter 2008; McCarthy 2006). Some types of community-based forest management have proven very effective in providing local residents with incentives for sustainable forest management, resulting in forest regeneration in many parts of the world (Bray 2010; Southworth and Nagendra 2010). Yet, as Tole (2010) points out in her recent review, many programs of decentralization were largely designed with the somewhat naïve belief that social capital and trust could be generated in heterogeneous, stratified, and unequal societies in response to directed interventions by bureaucrats, NGOs, or local leaders. Lessons from more than two decades of such implementations have shown that this is very rarely true. Thus, ill-designed community forest management has led to many instances of social capture and increased aggregation of wealth and influence in the hands of local elite (see, for example, Adhikari 2005). This appears to be exacerbated in cases where state governments intervene through the imposition of inappropriately designed conditions that increase transaction costs and further exacerbate existing inequities (Sundar 2000; Nayak and Berkes 2008).

In a study of diverse communities in Mexico, Leticia Merino Pérez (2004) analyzed the factors that work together to improve the likelihood that local communities – who have already been assigned considerable autonomy to create their own governance structures – will actually design effective institutions for managing forest resources. She studied forestry resources in six communities located in three states in Mexico: Michoacán, Oaxaca, and Quintana Roo. Merino demonstrates that the population density of the users of a forest is not a key determinant affecting resource degradation. She digs into a wide diversity of factors that could potentially explain the different rates of deforestation observed among the six communities. And, she investigates the relationship among local, regional, and national factors. Instead of finding a single element as the primary cause of a community's successful or unsuccessful effort to manage forest resources, she finds a complex set of factors that together affect the incentives and behaviour of citizen-users so as to lead to a better-quality forest.

The communities in Merino's study illustrate that well-working local institutions can manage local forests when effective social capital has been built over time within a community and when the interests of the more powerful members of the community are aligned with the effective management of forest resources. Local governance is, however, always embedded in and affected by regional and national policies. Merino finds that the regional and national regulatory systems have not encouraged community forestry in Mexico.

Effective rules and incentives passed at regional and national levels are more the exception than the rule in Mexico. If anything, government policies have generated more incentives that work against the effective management of forests, than incentives encouraging sustainable development. When not an active negative factor adversely affecting responsible local management, state and national laws have simply overlooked the capacities of local users to develop effective rules, monitor them, and impose graduated sanctions that let users know that infractions are observed without engendering an overreaction to their imposition. Merino's study demonstrates that local communities can develop the capabilities for effective management of forests over time, but that the skills and knowledge needed for these challenging activities are not uniformly held by all local communities within one country.

2.4. Simple solutions are not to be recommended

National, political, and fiscal guidelines do not act in isolation to influence forest change. Instead, they often play a prominent role in shaping the level of participation by local politicians, who play an increasingly important role in new and emerging formulations of collaborative and/or decentralized governance. Along side, alliances and networks at the local level also impact trajectories of decision-making and change. As mentioned above, for instance, Andersson and Ostrom (2008) find that the actions taken by mayors of large municipalities in Bolivia, Guatemala, and Peru are shaped by factors emanating at national and local levels. Nationally, mayors are more likely to take positive action for forest management if they acquire greater fiscal resources, and lobbying from local interest groups such as community forest cooperatives also seems to increase the likelihood of mayors' ranking of forests as a priority area for action.

Governments can play a critical role in providing technical support, and monitoring compliance. Thus, Fuller (2006) compares national strategies for monitoring forest change in Brazil and Indonesia using satellite remote sensing. Brazil, with its greater technical capacity to conduct real time, fine resolution monitoring of forest change through satellite imagery, has been able to incentivize private landowners to maintain a large proportion of forest land within their boundaries, and monitor compliance. In contrast, Indonesia has been spectacularly unsuccessful in reducing large-scale forest clearing because of the lack

of transparency and reliable monitoring.

At the same time, it would be incorrect to jump to the conclusion that governments should not play *any* role in forest management beyond that of service providers whose role should be restricted to activities such as technical support, oversight, and monitoring. Well designed, strategically networked, and carefully implemented interventions by governments have also played an important role in forest conservation in many parts of the world, including South Asia (Nagendra 2010) and Latin America (Bray 2010). In Bhutan, for instance, supportive government policies and intensive engagement with community forestry by government-appointed extension agents have been critical in ensuring relatively high levels of economic, social, and gender equity in this country as compared to other countries in the region (Buffum et al. 2010). In the United Kingdom, the Wild Bird Index, which is based on national monitoring of population trends, has been used by the government to provide an indicator of sustainability, leading to changes in farming practices and policies aimed at reversing the declines in farmland species (Balmford et al. 2005). Such approaches need to be formulated at a national level, but are based on data provided by bird enthusiasts and NGOs, and can only succeed when properly implemented at a local level by farmers and local landowners.

Brondizio et al. (2009) provide another effective illustration of the manner in which the relationships between governance arrangements and forest conditions are not simple one-level phenomena. They discuss the challenges faced by a nationally owned park – the Xingu Indigenous Park in Brazil. While forest cover within this national park has been largely maintained, the park was encircled by deforestation on all sides, and protecting forests within the boundary from incursions became a major challenge for the 14 indigenous tribes who are resident there. The tribes have responded to this challenge by forming horizontal linkages between themselves and other ethnic groups claiming land rights in watersheds adjacent to the park in order to reestablish forest connectivity in the larger landscape within which the protected forest patch is embedded. Simultaneously, they have built vertical linkages at multiple levels, with municipal governments, national NGOs, and through campaigns to raise regional, national, and international awareness, in collaboration with international celebrities such as the popular singer Sting. Without such extensive networks across multiple scales, the sustainability of the park would have been extremely questionable. These authors argue that the KISS (Keep It Simple, Stupid) approach followed by many social scientists and policy analysts has been extremely detrimental to the sustainable management of complex social-ecological systems such as forests.

2.5. Human impacts on forests is a multilevel phenomena

While a love of complexity for its own sake is certainly not to be encouraged, there is much to be learnt from a careful study of ecological systems where diversity, complexity, and scale are considered to be elements integral to a careful design of appropriate frameworks for management (Gibson et al. 2000; Reed and Bruyneel 2009). While most ecologists would be horrified by the thought of a simple categorization of all forests into three broad, analytically homogeneous categories, many social scientists have ignored the rich diversity of forest institutions, instead categorizing and analyzing them in three categories, of private, community, and government (see, for example, Blair 1996; Grafton 2000). Further, while governance is crucial, it is only part of a larger picture (Clark et al. 2011). Thus, we need to step back and examine forests as social-ecological systems with complex, context-dependent, adaptive outcomes interlinked to nested ecological states (Ostrom 2010). This does not mean that governance is not important; it should, however, be considered as a piece of a larger puzzle. Thus, it is critical to get rules in place to match the local and national social-ecological and cultural setting, and to enable adaptive modifications (Ostrom 2005). It is also equally critical to facilitate effective polycentricity, treating it as a useful way of getting flexibility, interlinkages, adaptation, and resilience into the system rather than the challenge that it is often considered.

3. A polycentric approach to the problem

Colleagues associated with the Workshop in Political Theory and Policy Analysis at Indiana University have developed the concept of polycentricity over the years for the analysis of a variety of collective-action problems. Most collective problems do involve finding ways of providing diverse goods and services at multiple scales. Let us briefly review the origin of the term. Although derived from urban research, the origins of the use of the term “polycentricity” have important implications for the governance of forest ecosystems as well.

During the 1950s, massive criticism was leveled at metropolitan areas across the United States and Europe due to the large number of small-, medium-, and large-scale governmental units operating in the same metropolitan area. Many scholars thought this was chaotic. Vincent Ostrom, Charles Tiebout, and Robert Warren wrote a classic article in 1961 entitled “The Organization of Government in Metropolitan Areas: A Theoretical Inquiry”. Drawing on the rich tradition of public sector development in the United States, the authors urged readers to think of the public sector as a polycentric *system* rather than a monocentric *hierarchy*. In a later essay, Vincent Ostrom (1999, 57) defined a polycentric order as “one where many elements are capable of making mutual adjustments for ordering their relationships with one another within a general system of rules where each element acts with independence of other elements.” The early theoretical work on polycentricity indicated that metropolitan areas that were characterized by a mixture of very large-, medium-, and smaller-scale organization outperformed those served by very large or very small units alone (see McGinnis 1999 for an overview).

Polycentric governance tends to reduce opportunistic behaviour in forested and urban settings, even though no institutional arrangement can totally eliminate opportunism with respect to the provision and production of collective goods. Allowing citizens to form smaller-scale collective consumption units encourages face-to-face discussion and the achievement of common understanding. Creating larger collective consumption units reduces the likelihood of strategic free-riding behaviour of the wealthy. Larger units also can more effectively cope with goods and services that have large-scale effects and real economies of scale.

Further, the complexity of many natural resources requires sophisticated multitier or polycentric governance systems rather than a reliance on a single type or level of governance (McGinnis 1999). Actors who try to govern a complex resource face a variety of incentives that often complicate collective efforts and subsequent outcomes. The more complex a resource is, in terms of the types of goods and services that it provides, the more challenging it is to craft a well-tailored set of institutional arrangements that offset the incentives to overharvest. Some actors may be tempted to shirk from their contributions to the governance arrangements by not attending meetings or not paying the membership fees. Others may actively try to weaken the rules so that they can use the resource with fewer constraints. A robust governance system recognizes the multiscale aspects of natural resource governance as well as the presence of perverse individual incentives, and seeks to cope with them (Futemma et al. 2002).

3.1. The working parts of a polycentric system

When citizens and their officials establish organizations with the authority to decide how to manage a resource, what time and monetary contributions are required, as well as the authority to sanction those who do not contribute resources, they organize *provision or collective consumption units*. Many, but not all, provision units have the formal status of a government established at a local, regional, or national scale. Governmental units may be general-purpose or organized as a special district or regime for the purpose of providing one or a limited range of collective goods. Private associations that plan the use of a resource and can also sanction, or even expel, those who do not contribute their share of resources to provide for a collective good, may also serve as collective consumption units. Sports leagues and housing condominiums are two types of private associations that provide collective goods for their members.

Other forms of collective consumption units include farmers who organize themselves to manage an irrigation system or a common pasture; a national agency that monitors the investment or production processes of private firms to protect consumers against fraud or ecological damage; a local, national, or international government that provides services of diverse types; or even an illegal cartel of private corporations that decide on the amount of output they will jointly produce. Thus, provision units exist at all scales and in both public and private spheres. Participants can, and do, craft a diversity of rules that help them overcome the free-rider problem by deciding who is included and must contribute resources and who is excluded and how to exclude them. Further, if the provision system continues to develop, participants (or their representatives) are likely to devise rules that specify allowable forms of access and use, methods for monitoring behaviour and sanctioning violators of rules, and ways of resolving conflict.

These systems often do not resemble the textbook versions of either a government or a market composed of strictly private-for-profit firms – especially when participants have constituted their own self-governing units. Thus, scholars drawing on traditional conceptions of “the market” and “the state” have not recognized them as potentially viable forms of provision organization and have either called for their consolidation into a centralized government (as metropolitan reformers continue to do) or ignored their existence (as many resource economists have done). It is a bit ironic that many vibrant self-governed institutions have been ignored in an era of ever greater democratization. As discussed above, efforts to “decentralize” governmental arrangements frequently do not recognize the importance of complex polycentric arrangements and think instead of a single government at some level taking charge of a policy arena.

As the physical scale of a resource changes, so do the types of collective goods that a resource offers to users (ranging from private goods of fuelwood and local mushrooms at the micro scale to global public goods of maintenance of a stable forest gene pool or storing carbon in trees to stabilize the climate). Users tend to be most interested in goods and services generated at a local level and take less notice of those generated by larger scales. The threat of major climate changes is the result of that lack of attention that citizens around the world have paid to the effect of their actions on the global atmosphere. Because of the strong actions of many environmental groups, more citizens are now paying attention to the global scale. Citizen awareness and action, however, are not sufficient to solve the problem of global climate change but are important in influencing national governments to change policies toward use of carbon-generating processes.

To govern a process that can provide incentives to users to safeguard the long-term delivery of such a variety of goods requires more than financial resources and accountability mechanisms at a single level of governance. Most scholars agree that large variations in policy outcomes exist within countries that have decentralized their governance of public goods and services. Little or no consensus exists, however, about which factors explain this variation. Many extant empirical studies do not go beyond the boundaries of local governments to examine why some local units perform better than others. Nevertheless, the processes enhancing effectiveness of a governance system are usually larger or smaller than the internal dynamic of any particular governmental administration. A key to effective governance arrangements lies

in the relationships among actors who have a stake in the governance of a resource and not just one level of government. The social capital that citizens can create by linking with each other, with NGOs, and with governmental actors at diverse levels is essential for effective feedback, learning, and crafting of new and better solutions (Ostrom and Ahn 2009).

By considering the interaction between actors at different levels of governance, it is possible to contribute to a more nuanced understanding of the variation in diverse governance outcomes in the management of common-pool resources based on the needs and interests of citizens. We have learned that citizens do play an essential role in the governance of common-pool resources and that efforts to turn over all of the responsibility for governing these resources to external experts are not likely to protect them in the long run. The complexity of the resources at local, regional, national, and global levels does require complex governance systems involving citizen input in diverse fashions.

3.2. Challenges to polycentricity

A key finding of empirical field research is the multiplicity of specific rules-in-use found in operational settings related to the provision and production of collective goods. One of the most important types of rules is *boundary* rules, and the definition of boundary rules poses perhaps the most important challenge to polycentricity. They determine who and what is in and out of a provision organization. Provision units face considerable biophysical constraints when the good is a natural common-pool resource such as a groundwater basin, a river, or an air shed. Such resources have their own geographic boundary. Matching the boundary of those who benefit and those who contribute with the boundary of a resource is a major challenge. It may be impossible in a highly centralized regime. Further, common-pool resources may themselves be nested in an ever larger sequence of resource units such as a micro watershed, which is nested in a system of ever larger watersheds that eventuates into a major river system such as the Rhine or the Mekong River.

In Brazil, Nepstad et al. (2006) report that indigenous lands occupy five times the area covered by protected parks in the Brazilian Amazon, and contain much larger, less fragmented patches of forest than protected areas. Thus, they suggest that the Brazilian government will not be effective at long-term protection unless they develop regional conservation strategies that incorporate indigenous lands and government-protected areas, and also attempt to address the requirements of recent migrant communities. Such an approach has been utilized to address the challenge of wildlife conservation elsewhere, in the Nepal terai plains. As with many other countries, the protected area system in Nepal only covers a few large forest patches that have become increasingly isolated over time due to increased land use pressure in the surrounding region. Wildlife does not recognize park boundaries, and the settlements in the vicinity of protected areas began to face increasing problems of wildlife attacks – another thorny instance of boundary rules being different for humans versus for animals.

Wildlife conservation requires the existence of large, well-connected forest patches for species to persist and perpetuate. Given the context of high population densities and high levels of poverty and forest dependence in this region of Nepal, it was not feasible to consider expanding government-protected areas to provide a solution to this issue. Indeed, this is a challenge faced by many parts of the world, especially in peopled forests. Conservation biologists, aid agencies, and policy analysts instead turned to the use of spatial landscape analysis techniques to identify priority forested areas connecting parks that required conservation (Wikramanayake et al. 2004). The Western Terai Landscape Complex was implemented during the late 1990s and early part of this century in order to increase forest connectivity and restore forest cover within a large 7000 km² landscape containing two parks, several government forests, and a large number of villages. A number of forested patches in the intervening landscape were restored through community forestry and social development programs (Heinen and Shreshtha 2007). In this context, polycentric forest governance was thus very effectively utilized to solve boundary problems and enable effective forest restoration and conservation planning at multiple scales, utilizing the strengths and capacities of multiple institutions.

In another context in the Nepal middle hills, the leasehold forestry program has been successful in protecting and restoring several small patches of extremely degraded land. Yet a lack of attention to regional planning has contributed to continuing deforestation at the landscape level, with many of the leasehold and community forest user groups who have protected “their” forests increasing their usage and extraction of other, less protected forests in the vicinity (Nagendra 2007). Thus, while policy-makers have largely focused their attention on polycentric governance in the plains, possibly because of the presence of charismatic large mammals such as the tiger and elephant, the lack of attention to boundary problems in the hills has created significant challenges for sustainable forest use at a regional scale.

4. Polycentricity to address emerging global environmental challenges

In addition to deforestation, several emerging policy issues emanate at the international level, but impact at the national and local levels. The concept of polycentricity is also theoretically relevant to understanding these issues. We will provide a very brief overview of how the concept of polycentricity helps in the analysis of climate change and the closely related international effort to reduce greenhouse gas emissions through degradation and deforestation (REDD).

4.1. Climate change

The problem of averting massive climate change is indeed a global problem of collective action since

millions of actors affect the global atmosphere and all benefit from reduced greenhouse gas emissions (Cole 2008; Sandler 2004). Similar to other collective-action problems, everyone affected benefits from reduced risks of severe climate change whether or not they pay any costs, since beneficiaries cannot be excluded. Thus, many analysts call for institutional solutions at the global level (Miller 2004; Wiener 2007). Few see the relevance of a polycentric approach to this problem. Greenhouse gas emissions are, however, the result of actions taken at multiple scales. The positive externalities of reduced greenhouse gas emissions are also distributed across scales – from the household to the globe (Ostrom 2010). Nested externalities occur when actions taken within one decision-making unit simultaneously generate costs or benefits for other units organized at different scales.

Some relevant decisions affecting greenhouse gas emission are taken within a household as to what car to purchase, or to use public transportation, and what investments to make regarding power consumption within individual homes. These decisions do have small effects on the global atmosphere, but they have relatively larger effects at a smaller scale in regard to better health achieved by using bicycles or walking instead of driving to do errands. Family expenditures allocated to heating and electricity may be reduced when investments have been made in better construction of a building, reconstruction of existing buildings, investments in solar panels, and other investments. Decisions about heating in both public and private buildings account for more than 70% of the electricity used and almost 40% of greenhouse gas emissions in the United States (Fuller et al. 2009). Investments in better waste disposal facilities and to reduce pollution levels also generate local benefits as well as helping on global emissions. Given that many of the actions generating greenhouse gas emissions are taken at multiple scales, activities to reduce emissions can also be organized at multiple scales ranging from households to the globe (Kates and Wilbanks 2003).

Dietz et al. (2009) have identified seventeen actions that can be taken within a home or a business facility that can cumulatively have a major impact on carbon emissions. Thus, retrofitting buildings to add insulation, solar photovoltaics, and more efficient heating systems is an important strategy that can be taken at a local level that may generate a long-term savings to a family or a firm that takes such actions to reduce energy costs as well as reducing greenhouse gas emissions. Using various forms of competition among households and groups, and feedback as to who is doing the best of reducing energy use, is a strategy for reducing emissions that is increasingly being adopted by local communities, college campuses, small cities, and utility firms around the country (Kaufman 2009). University efforts to stimulate competition among campus dormitories to see who can reduce electricity consumption are proving to be effective (Peterson et al. 2007).

Methods for developing reliable city-scale greenhouse gas inventories have also been developed and tested (Hillman and Ramaswami 2010). These are being used by many of the large number of cities in multiple countries that have pledged to reduce GHG emissions consistent with the Kyoto Protocol. In the United States alone, the mayors of 1026 cities have now joined the U.S. Conference of Mayors' Climate Protection Agreement (2010) to reduce GHG emissions of at least 5% relative to 1990 levels.

Multiple cities have started to initiate a variety of "green" initiatives that are prominently displayed on their home pages on the Web. The city of Toronto, for example, has established an "environmental portal" that announces more than a dozen current city policies, related publications, and meetings that are focused on climate change. The city has supported a number of renewable energy projects including major investments averaging around \$100,000 each for building rooftop gardens, solar photovoltaic panels on houses, and solar water-heating systems. The city also funds smaller projects to support neighborhood efforts to enhance the forested areas of local parks, local gardens, and for organizations at the local level that are working with communities to hold planning meetings to discuss better bicycle paths and other activities that can be undertaken at a small, neighborhood scale.

4.2. Reducing emissions through degradation and deforestation (REDD)

The basic concept of the REDD and REDD+ initiatives are to encourage countries to reduce national carbon emissions associated with deforestation and degradation, in exchange for financial incentives provided through carbon credits. A first step for this would be to provide baseline assessments of national-level forest biomass and carbon stocks, after which changes in carbon stocks can be monitored over time. Using a baseline level of carbon emissions, which can be calculated either from historical data or based on future projections, reductions in the baseline levels of emission can then be valued in terms of carbon credits.

While this may seem like a fairly straightforward procedure, the technical challenges associated are immense. The first step, to provide baseline assessments of national forest biomass and convert this into carbon stocks, is fraught with difficulty. The most reliable way to do this is a destructive approach that involves harvest, drying, weighing, and combustion of above ground biomass. Obviously, this destructive approach can only be applied to specific, small-sized sample locations, and some attempts at extrapolation need to be conducted to derive national-level estimates. Scaling up is often done using a combination of forest inventories and remote sensing, yet these often provide estimates at the global or national scale, or at best, at the scale of broad forest or biome categories within a country (Gibbs et al. 2007). Yet, these are not the levels at which forest governance is conducted. Reduction of emissions through deforestation and degradation is only possible at the country level if there is concerted effort at regional and local levels of governance (Toni 2011). Emission displacement and leakage can take place across country borders, which can be especially hard to monitor: thus, cross-scale international initiatives

are also essential to address these issues.

In addition to a shift in investment pathways, financial rewards for forest protection to financial incentives (and disincentives) must be interpreted and implemented at the level of local governments. This requires the development of relatively objective, unbiased approaches to identify and appropriately reward those locations where there is protection and sustainable management. The current system of monitoring at the national and international level does not provide an easy way of doing this across the world. Some countries like Brazil and India have put in place spatially explicit national-level systems for tracking deforestation through satellites, yet the use of such advanced technologies is rare in most economically developing nations. And even within these countries, there are calls for monitoring to provide data at greater spatial and temporal resolutions for better linkages with forest governance than is currently the case.

Polycentric approaches to track forest change hold great scope for the effective implementation of programs such as REDD+. A recent study of forest change in five countries conducted by [Nagendra and Ostrom \(2011\)](#) shows that local users can provide extremely accurate predictions of change in tree density in forests. In contrast, repeated measurements from forest plots that represent the "gold standard" of scientific studies are time taking and expensive, and thus difficult to conduct at a number of locations. In areas where local forest users are present, they can provide very accurate, rapid, and low-cost information on areas of forest degradation and regrowth that can then be associated with changes in tree density and forest cover provided through satellite monitoring. Such a multilevel approach to forest monitoring can have a number of associated benefits, providing triangulation and validation of the satellite assessments and of evaluations by users, both of which can be prone to bias and error under certain conditions. When integrated with the use of publicly available temporal views of forest cover from Google Earth, they can also provide ways to ensure greater transparency. Such approaches can also enable local users to be integrated into the process of forest monitoring and distribution of financial incentives that can otherwise be susceptible to corruption and elite capture ([Chellam et al. 2010](#)).

Monitoring forest users and sanctioning offenders may also be best done through a combination of local efforts by communities and national and regional inputs by government. Thus, previous research conducted by us in Nepal and India ([Ostrom and Nagendra 2006](#)) finds that both local communities and national governments are able to act for forest protection and regeneration. Yet, national governments typically tend to approach protection through guards, guns, and fences, which result in substantial conflict with local communities, and which may not be sustainable in the longer-term. Communities, in contrast, often conduct monitoring locally, and enforce this through a combination of social and financial sanctions. These approaches can be effective at lower cost, and engender less conflict when compared to the exclusionary approaches deployed in many government parks. Recent studies by [Coleman \(2009\)](#) and [Coleman and Steed \(2009\)](#) strongly corroborate this, finding that a major variable affecting forest conditions is the investment by local users in monitoring. Further, when local users are given harvesting rights, they are more likely to monitor illegal uses themselves.

Such incentives may vary substantially depending on local context and forest type. In locations where communities are highly dependent on forest products and services, their incentives to monitor will be higher. This can lead to more effective monitoring, but this depends on security of tenure. Thus in Nepal, for instance, many communities in the middle hills protect their forests effectively, but with leakage in terms of greater deforestation of adjacent national forests where tenure vests with the government ([Nagendra 2010](#)). In order to adequately monitor and tackle such challenges of leakage, there is a need for over-time studies of forest change (using approaches such as satellite remote sensing) at broader spatial scales to complement local-scale monitoring by communities.

Further, as [Chhatre and Agrawal \(2008\)](#) point out, it is much more difficult for communities to combat degradation and deforestation in larger forest areas. In larger forests, there may also be the problem of more than one user group. Thus, [van Laerhoven \(2010\)](#) has compared forests where single user groups are present with those used by multiple groups, finding a significantly lower level of organized activity when multiple user groups were authorized to use the *same* forest. Thus, the type of governance system needs to be matched to the spatial scale of the forest, among other things. Such lessons for polycentricity are not restricted to forests, of course. For instance, [Gutiérrez et al. \(2011\)](#), in a study of 130 comanaged fisheries in a range of countries, find that while protected areas are capable of successful, sustainable management, this is more likely when comanagement regimes are established that draw on the strengths of local communities, and when there is strong leadership within these communities.

Polycentric forest governance may also alleviate concerns about the distribution of financial incentives through programs such as REDD and REDD+, specifically, whether this will result in further exacerbation of financial inequities and elite capture. [Kaimowitz \(2008\)](#) examines the prospects for REDD in Mesoamerica, which is a region of the world where local institutions are strong, and forest management policies are well developed and advanced. Despite a strong enabling atmosphere, previous experience with the disbursement of financial rewards as Payments for Ecosystem Services (PES) seem to indicate that they had largely benefited the rich in the past in Costa Rica. In response to such criticisms, specific attempts have been made to focus on economically disadvantaged families in recent years, and indigenous and low-income communities and families have benefited in a few specific locations ([Kaimowitz 2008](#); [Pagiola 2008](#)). In Mexico, some scholars conclude that payments have been primarily made to poor indigenous communities (as summarized in [Kaimowitz 2008](#)) while other scholars argue that

the models for payment are influenced by market mechanisms, state regulations and subsidies, and social movements mobilized by local activists, with competing agendas (McAfee and Shapiro 2010).

Thus, in many countries where PES programs are deployed, forests at risk have multiple claimants for financial incentives, many of whom act at different levels. Balancing their claims requires adequate consideration of polycentricity. For instance, Sierra and Russman (2006) recommend that government agencies conduct spatial prioritization of high-risk areas to identify locations that need to be prioritized for funding, in addition to considering local criteria that specify socially acceptable pricing for PES schemes in Costa Rica, while Pagiola (2008) describes ongoing programs that identify especially disadvantaged districts for implementation of PES schemes in Costa Rica. Agrawal et al. (2011) highlight the importance of regional networks of social movements such as FECOFUN in Nepal, and Via Campesina in Central America, sub-Saharan Africa, and South and Southeast Asia that have provided a forum for small farmers to participate in and potentially influence the outcomes of national and regional debates. Johns et al. (2010) recommend a three-tier fund to deal with the multiple types and levels of institutions associated with combating degradation and deforestation. This includes a government fund, primarily for capacity building, with non-market-based support from international aid, supplemented by funds for local and indigenous communities and private landowners acting as stewards of forest resources.

Other concerns have been raised, pointing to the likelihood of large-scale financial payments channelled through national governments to lead to recentralization of control over forests, reversing decades of progress in ceding at least partial control of forest management to local communities. Toni (2011) examines this in Brazil, and finds that when institutional capacity and polycentricity (which he examines as a combination of the legal framework that regulates the distribution of competences among government levels, and the balance of power among different government levels) is strong, REDD can lead to further effective decentralization; however, when institutional capacity is weak, dangers of nationalization can be real.

Since any large-scale international programs such as REDD will be bound to have substantial social and institutional impacts, an evaluation of such change must be integrated into long-term monitoring programs. Thus, Richards and Panfil (2011) recommend that REDD programs should incorporate social impact assessments of benefits and costs to local communities. These authors state that community-monitoring protocols need to form an important and necessary component of such assessments. Yet, at the same time that local assessments are essential, they argue that there is a need for standardization of methodologies and terminologies, such that assessments made in different areas can be compared. This can only be done through collaborations between scientists/experts and local communities, to develop mutually agreed-upon, common approaches to assessment that can enable comparisons of findings at regional and national scales.

Finally, significant concerns have been expressed by some scholars that policies such as REDD can result in creating incentives for leakages in deforestation from countries with stronger environmental practices to tropical countries where environmental protection practices may be weak (Lambin and Meyfroidt 2011). If a country reduces its levels of extraction of forest products without a corresponding decrease in consumption, then the resources required must necessarily be harvested elsewhere (Berlik et al. 2002). The use of remote sensing satellites can provide a very useful, cost effective, routine, and potentially standardizable approach for global monitoring for REDD (Agrawal et al. 2011).

Thus, careful consideration of polycentricity and the development of multilevel, integrated social-ecological assessments therefore hold significant potential for addressing some of the major challenges outlined for REDD in the coming years.

4.3. Polycentric governance of other natural resource commons

Forests are one component of commonly managed natural resources, and polycentric approaches to governance hold importance for other commonly held natural resources including grazing lands and ground and surface water. In the United States, for instance, most rangelands are privately held, but the impact of rangeland degradation goes beyond private boundaries, impacting wildlife and bird populations, and affecting watershed quality (Bryner 1998). Federal policies and programs to regulate the extent and intensity of grazing have been bitterly resisted by local rangers. In contrast, citizen groups and coalitions between rangers and environmental groups have been successful at crafting and applying rules to limit grazing, with increased local acceptance, and substantial reduction in levels of conflict in areas where conflict levels were so high that the use of guns and threat of bombs was frequent. The management of these rangelands has moved closer to polycentricity, with the development of complex networks of actors, and an adaptive system without a single dominant authority (Ostrom 2005).

Devising effective polycentric rules for the management of access to groundwater is a much more challenging task, as the assignment of boundary rules becomes especially problematic in this situation. When the system is relatively bounded, as for instance when the resource unit is a lake, then identification of the users, extractors, and polluters is relatively straightforward. When the resource is larger, and more difficult to observe and monitor – for instance, with a groundwater basin – substantial investment in scientific monitoring is required, but in addition, this process of monitoring needs to be transparent, accepted as fair, and open to the possibility of challenge by all.

Blomquist and Ostrom (2008) provide a detailed description of the manner in which groundwater users in California reacted to problems of extreme water scarcity in the twentieth century. Groundwater

extractors, with the help of legal and technical representatives, negotiated settlements and agreements in several groundwater basins across the state. They agreed to modify and reduce levels of extraction and pumping, with the aim of reaching mutually acceptable solutions to a common problem, in order to avoid a judgement by the court (Blomquist 1992). These agreements differed between basins, with modifications to accommodate local interests. Over time, adaptive revision of the original agreements was also conducted, for instance to allow for the possibility of basin recharge, not considered when the original judgements were developed, during a period of drought and extreme groundwater scarcity. Thus, adaptive, locally specific, polycentric governance systems were very effectively used in Southern California for groundwater governance. While the decision-making process used for making and changing rules was largely judicial, negotiation and finalization of rules was done by local users in a time-consuming manner that placed a premium on building consensus or near-consensus between users. In this context, using the judiciary rather than the legislature enabled users to develop sets of rules that were adapted to fit the hydrological, social, and institutional characteristics of each basin, and adapt these over time, rather than being forced to adopt uniform, inflexible blueprint solutions across all basins (Blomquist and Ostrom 2008).

In Australia, in contrast, the Crown declared ownership of all groundwater in the twentieth century (McKay 2005), and there are multiple government agencies that generate data on water availability and usage, with different definitions of terms and data sources leading to major challenges of coordination and information availability (Vardon et al. 2007). While groundwater usage has increased considerably, effective management is still lacking. At least in part, this can be traced to the lack of involvement of users in monitoring or finding solutions to this problem, and the excessive reliance on state and national agencies for monitoring and decision-making (Marshall 2004).

Developing polycentric approaches to the management of common property in countries can take a very different path in countries like India, where informal water economies are dominant, and the market, legal, and legislative interventions employed in other formalized water economies such as in Europe, Australia, or the United States are more difficult for local communities to access or shape (Shah 2007). In countries dominated by informal water economies, the transaction costs of monitoring and sanctioning excess water usage are so high that the possibilities for government legislation of water use are limited.

Thus in the western Indian states of Gujarat and Rajasthan, a combination of circumstances that includes private extraction of groundwater, the development of water markets, and inaction by the state government, have led to the rapid depletion of groundwater levels (Shah 2000). Local NGOs and religious organizations, on the other hand, were able to effectively work with communities in hundreds of villages to limit groundwater usage and work collectively to recharge groundwater. Crucially, technical innovations devised by farmers in one village were disseminated to other locations and adapted to fit local contexts, facilitated by the strong communication networks already developed by these social and religious organizations. Many of these approaches built on traditional institutions of water management that had been active in these areas for centuries, but damaged by widespread privatization and the establishment of groundwater markets. Some of these institutions have since been co-opted by the state and diminished in efficacy, but other movements have spread to a number of states in India (Shah 2007). State governments can have an important role to play in this, not by making rules about water withdrawal that they are in a limited position to enforce, but rather by the strategic pricing and regulation of electricity to tube wells in rural areas (Shah 2007). Further, state subsidies and government programs need to be carefully devised so that they can help, rather than attempt to co-opt and effectively damage such ground-based movements, as has happened on occasion.

5. Some concluding thoughts

While the policy literature of the last half of the nineteenth century focused on the need for developing simple solutions to challenging problems related to the overuse of forests and other common-pool resources, policy analysts are slowly recognizing the need to study the diversity of ecological and social conditions that characterize most resource systems. Fewer academic researchers are positing simple, optimal solutions to the challenging problems of allocating diverse forms of ownership to forest users operating at multiple scales.

Solutions need to be matched to ecological and social conditions so that participants have incentives to govern subunits of complex systems in a sustainable manner. We have stressed the importance of polycentric systems, but do not see polycentricity as a single optimum solution. Polycentric systems enable resource users and managers to relate to the multiple scales of ecological functioning that exist related to most forested regions in the world.

Multiple empirical studies carried out in the last several decades have provided strong evidence that simplicity does not characterize ecological and social systems and should not be the primary criteria for judging governance arrangements. It is encouraging to read recent studies, such as Molnar et al. (2004, 19), which stress that "community conservation is clearly not a panacea for biodiversity conservation any more than are public protected areas . . . they can be complementary." Encouraging further research on the multiple scales involved in forest resources and how diverse institutional arrangements have been designed by users, NGOs, and public officials to become effective partners in complex polycentric systems is an important next step in understanding how and when polycentric governance enables more effective, long-run performance.

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