What policies improve forest cover? A systematic review of research from Mesoamerica

**Abstract**

Despite many studies of the drivers of deforestation, few syntheses have been conducted of the effect of public policies on forest cover. This is problematic because policy is the primary tool that society can use to change outcomes, yet we lack information on the conditions which lead to successful policies. To address this deficiency, we conduct a meta-analysis of case studies of the impact of public policy on deforestation and reforestation in Central America and Mexico, drawing on a set of 159 studies. This region has recently experienced high rates of forest cover change and is well studied, providing a strong sampling frame. For each study, we record the reported change in forest cover, along with the scale and location of the study, the types of policy evaluated, and other relevant information. Some policy types are strongly associated with positive or negative forest impacts, though important gaps remain in our understanding. Nearly all studies of payment for ecosystem services indicate an association between payments and improvements in forest cover (88% of cases), however this evidence derives from only two countries (Mexico and Costa Rica), both of which have more clearly defined property rights and stronger governmental institutions than other countries in the region, raising questions about generalizability. Community-based management is associated with positive impacts on forest cover in 81% of cases, whereas protected areas are associated with positive impacts in 66% of cases. Studies of social and agricultural policies were rarer and more likely to be associated with negative outcomes. Agricultural subsidies were associated with negative forest outcomes in 86% of cases, raising the possibility that reducing agricultural subsidies could be an effective strategy for improving forest cover. Most studies do not adequately identify either causal effects or the mechanisms associated with policy change, and few studies examine interactions between policy types. The results of this review imply that, while some policies are more likely to make positive contributions than others, policymakers should remain cautious about the body of evidence supporting the effectiveness of policies for reducing deforestation.

*Highlights*:

* We conduct a meta-analysis of case studies linking policies to forest cover change in Mesoamerica.
* Public policy effects on forest cover in Mesoamerica are poorly understood, yet few forest cover change studies address the effects of policies.
* Payments for ecosystem services and community-based management are most commonly associated with positive forest impacts, but have been studied in few contexts.
* Protected areas have more mixed results, with two-thirds of cases reporting positive outcomes.
* Our results associating agricultural subsidies with forest loss show the relevance of studying diverse policy types for reducing deforestation and forest degradation.

*Keywords*: policy effects; deforestation; tropical forest cover change; payments for ecosystem services; community-based management; meta-analysis

# 1. Introduction

Reducing deforestation and forest degradation in the tropics (REDD+) is an emerging priority in the global environmental agenda (see Agrawal, Nepstad, and Chhatre 2011). For REDD+ to induce changes in forest management, countries must create or change policies in ways that lead to desired effects for forests. Yet it is not clear whether existing research provides answers about which policy options may lead to improvements in forest management under which circumstances. A large literature on policy options for REDD+ focuses primarily either on evaluating REDD+ readiness activities (Sunderlin et al. 2014) or on theoretical models of REDD+ policies, which often assume that financial incentives will be an effective tool for forest conservation regardless of national and local differences (Angelsen and Rudel 2013, Lubowski and Rose 2013). Few systematic studies have examined what past forest policies can tell us about the potential efficacy of different options (but see Busch and Ferretti-Gallon (2017)). This paucity of studies reflects a longstanding focus on drivers of deforestation rather than on the evaluation of policy impacts (Rudel 2008a). Yet without information on what has succeeded in the past, it will be difficult for policy-makers and advocates to select policies that are likely to work in the future.

We aim to remedy this lack of practical knowledge by conducting a meta-analysis of case studies that examine the impact of policy on forest cover changes in Mesoamerica, made up of Central America and Mexico. Our primary objective is to assess the body of evidence available in the many studies of deforestation in Mesoamerica to understand what forest policies are most likely to contribute to reducing emissions from deforestation and forest degradation in this region. Mesoamerica has recently undergone high levels of forest cover change, is well studied relative to many other forested regions, and has played host to innovative policy experiments. It thus represents a most likely case (George and Bennett 2005) for finding robust evidence about the impact of policy. Furthermore, the relative similarity of the forest trajectories of countries in this region means that intra-regional comparisons are likely to be meaningful (Rudel 2005). While our findings are intended to be directly relevant for policy-making in Mesoamerica, they also identify areas in which further research is needed within the region and may provide some suggestions for similar studies in other parts of the world.

*1.2 Approaches to studying tropical deforestation*

Many discussions of REDD+ proceed from the assumption that a newly designed global payments for forest-based ecosystem services program will be a cost effective tool for reducing carbon emissions (Stern 2007). In simple terms, these discussions assume that forest conservation is an economic problem and that if landowners are compensated for the opportunity costs of conservation, they will willingly conserve. Several substantial research traditions call this assumption into question or raise the possibility that other policy options may be more effective. Since there is a long history of attempts to limit deforestation, there is potential to develop more effective policies that draw on the insights of these research traditions.

Land change science has focused on using remotely sensed data and Geographic Information Systems technology to quantitatively track changes in land use and identify drivers of change. Early land change science studies often assumed that forest cover changes would be associated with economic and demographic drivers such as poverty and/or overpopulation, yet a series of systematic reviews challenges this view. These studies show that agricultural conversion, often for export-oriented commodities, has long been a leading cause of forest loss, while poverty and overpopulation have at best weak and context-dependent associations with land cover change (Geist and Lambin 2001, Hosonuma et al. 2012, Rudel et al. 2005, Angelsen and Kaimowitz 2001, Carter et al. 2015). Although this literature contains only limited policy evaluation (Rudel 2008a), the important role of export-oriented agriculture illuminated by this tradition highlights the potential for agricultural policies to play a key role in land cover change.

By contrast, researchers in the common pool resource tradition have focused on the ways that local governance can contribute to deforestation and forest conservation (Gibson, McKean, and Ostrom 2000, Tucker 2010). This approach uses a mixture of case studies, field experiments, and remote sensing of land cover change (Moran and Ostrom 2005, Poteete, Janssen, and Ostrom 2010). Results emerging from this research have demonstrated that groups of local people working together can effectively conserve forests under certain circumstances. In fact, such local-scale management is at least as effective at forest conservation as more centralized approaches (Gibson, Williams, and Ostrom 2005, Coleman 2009, Chhatre and Agrawal 2008). Attempts to take advantage of this knowledge to design community-based natural resource management and decentralization programs have yielded mixed results (Coleman and Fleischman 2012, Dressler et al. 2010, Ribot, Agrawal, and Larson 2006, Ribot and Larson 2005, Tacconi 2007). Nonetheless, this research points to the important role of interactions between local institutions and broader policy designs.

In contrast with the views of many REDD+ policy designers who see government action and international cooperation as keys to reducing forest loss, many scholars in the political ecology tradition see these as primary causes of forest destruction (Brannstrom and Vadjunec 2014, Robbins 2012). International market pressures and the economic and political demands of government elites are implicated in forest destruction in many parts of the world for extraction of rents associated with timber harvest and cash crop expansion. Government officials in such cases cooperate with and/or encourage destructive activities that bring short-term enrichment to elites through commodity exports, and/or alleviate political pressure by encouraging disempowered groups to move to sparsely populated hinterlands (Dove 1993, Peluso 1992, Hecht and Cockburn 2011, Dauvergne and Lister 2011, Fleischman, Loken, et al. 2014). In this view, REDD+ and the associated payments programs are yet another attempt to turn forests into commodities which can be sold by political elites at the expense of both ecosystem health and the rights of forest dependent people.

The somewhat divergent claims of these three research traditions raise concern that simple policy blueprints may not be universally applicable. One way to determine what policies are most likely to be successful is to study the conditions under which they have worked—or failed—in the past. Numerous studies of forest policies exist; thus, an obvious way to synthesize the information therein is to conduct a meta-analysis. Unfortunately, the complexities of forest policy and the multitude of methods used to study it mean that formal statistical meta-analysis can only be applied to a small subset of the available studies of deforestation (see Busch and Ferretti-Gallon 2017). In keeping with an emerging literature in social-ecological systems, we instead apply a meta-analysis of case studies approach (Cox 2014, 2015, Geist and Lambin 2001, Ostrom, Gardner, and Walker 1994, Poteete, Janssen, and Ostrom 2010, Rudel et al. 2005, Rudel 2008b, Young et al. 2006, Fleischman, Ban, et al. 2014). This approach allows us to utilize information drawn from a much larger set of cases than Busch and Ferretti-Gallon (2017), who only examine cases that use spatially explicit econometric methods.

# 2. Methods

We follow techniques for conducting a meta-analysis of case studies that have been developed in previous studies of social-ecological systems and land change science (Cox 2014, 2015, Geist and Lambin 2001, Ostrom, Gardner, and Walker 1994, Poteete, Janssen, and Ostrom 2010, Rudel et al. 2005, Rudel 2008b, Young et al. 2006). We reviewed several of the largest scholarly databases using a systematic search string, which included search terms for countries in Mesoamerica, common types of forest conservation policies, and key forest policy research traditions (for information on the search string and databases used see page 1 of Open Data). To broaden the scope of our study, we included databases that search grey literature to consider relevant cases found in conference proceedings, scientific reports, and dissertations. The first author reviewed the abstracts of all the resultant studies and selected papers that link a public policy to a change in forest cover in one or more Mesoamerican countries. We eliminated all studies that did not link a change in forest cover to a specific public policy in Mesoamerica.

For the purpose of this study, we considered a case to be a documented relationship between a policy and forest cover change in a single country. Some studies contained multiple cases. For example, Morse et al. (2009) examined both the 1996 Costa Rican forestry law and environmental service payments. Because the study included two public policies, we coded it as two cases. Likewise, there may be multiple studies concerning the same policy, such as Carr (2008) and Suter (2012), both of which measured forest cover in Sierra del Lancandón National Park in Guatemala. Finally, some studies included data from similar policies implemented in multiple countries and thus each country was coded as a separate case: for example, Hayes (2007) studied common-property forests in both Honduras and Nicaragua.

Our outcome of interest is change in forest cover. We reviewed abstracts to determine whether cases had a positive, negative, or neutral forest cover outcome. As changes were reported in several different ways, we considered an outcome positive if there was a decrease in deforestation rate or increase in forested land area. We recorded a negative outcome if the policy was linked to increased deforestation rate, decreased forested area, or increased fragmentation. A neutral effect was coded anywhere the deforestation rate did not change, the forested area remained constant, or no net change was observed.

Our primary independent variable is the type of policy. Several policy tools may influence conservation decisions. Some directly attempt to promote conservation, whereas others do not, but may influence conservation behavior. We classify these into broad categories as follows. Protected areas are any tracts of land designated as protected by national or state governments. Payments for ecosystem services refer to Pigouvian incentive programs (Pagiola, Landell-Mills, and Bishop 2002). We designate community-based management policies as those that promote or establish community-based collective forest management. A widely studied example of community-based management is ownership and management of forests by *ejidos* in Mexico. Many community-based forestry programs in Mesoamerica aim to bring economic benefits to communities, and thus have a market component. We classified these programs as community-based management whenever the primary policy mechanism described was communities working together, whether to make decisions about land or to invest in timber production. In contrast, community-based programs including Pigouvian incentive payments were classified as payment for ecosystem services. Similarly, cases of community-conserved areas were classified as community-based management and not as protected areas.

We classified any direct forest sector regulations, such as logging bans or deregulated timber transport, as forestry regulation. We classified agricultural subsidies, often through markets or technology, as policies that promote specific types of agriculture, such as industrialized monocultures, shade coffee, or livestock pastures on deforested lands. Socioeconomic policies are those which aim to generate income, alleviate poverty, or improve quality of life. Diverse examples include rural assistance programs and policies promoting alternative livelihoods to forest resource extraction (excluding those that were specifically built around community-based management). Land tenure policies encompass a variety of government-mediated changes in property right regime or land tenure that were not included in the above categories, such as privatization of forest or provision of more secure property rights.

# 3. Results

## 3.1 Summary Data

The initial literature search yielded a database of 2387 abstracts. Systematic review of these abstracts left us with 159 articles in which 206 cases were identified documenting a relationship between a public policy and forest cover change in Mesoamerica.

We excluded 2229 cases that did not document a relationship between forest policy and land cover change. Many of these studies measured either public policy impacts or forest cover change, but not the other. Other studies were excluded because they were reviews, relied on highly aggregated data, or examined vague policies (such as neoliberalism or agroindustrialization) that could not be traced to specific government actions.

 The final dataset included 23 dissertations, 10 reports, 7 books, 6 conference proceedings and 113 journal articles in 69 journals. This sample of cases can be found as a table in the Open Data file associated with this publication. 70% of cases took place in Mexico and Costa Rica. However, when we normalized the number of studies per country by units of forest area, Mexico had far fewer studies than most other represented countries with only 0.15 studies per 1000 km2 (Table 1). Although Mexico has by far the largest amount of forest area in the region, it appears that many areas within Mexico are understudied. Two countries had the highest ratio of policy cases per unit forest area; Costa Rica and Guatemala are both small countries that are well studied. There have been an increasing number of publications that fit our criteria since the early 1990s; however, it appears that the number of annual publications may be leveling off at around 15 per year in recent years (see Figure 1).

Literature on forest cover change is widely dispersed across journals dealing with conservation, development, geography, and human environment interactions. Only 4 journals contributed 4 or more cases to the dataset: *Conservation Biology* (5), *Applied Geography* (4), *Human Ecology* (4) and *World Development* (4). Of the 206 cases, almost a third studied protected areas (n=63). Land tenure, community-based management, market-based conservation, and agricultural subsidies all represented between 11-17% of the cases (n=36, 31, 26, and 22, respectively). Cases of socioeconomic development and forest sector regulations together only encompassed 13% of the total (8%, 17 and 5%, 11 respectively).



**Figure 1. Number of publications by year of publication, including all cases that fit our inclusion criteria. Each case linked a policy to a forest cover outcome in a country in Mesoamerica. Peer-reviewed journal articles as well as grey literature are represented.**

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| **Table 1. Case studies relating policy to forest change according to number of cases by country and type of policy addressed.** |
|   | Total/ country | Studies/ 1000 km2 forest per country | Agricultural Subsidy | Community- based Management | Forest Sector Regulation | Land Tenure | Payments for Ecosystem Service | Protected Areas | Socioeconomic | % total studies/ country |
| Belize | 1 | 0.1 | - | - | - | 1 | - | - | - | <1% |
| Costa Rica | 46 | 1.7 | 3 | - | 4 | 2 | 15 | 19 | 3 | 22% |
| El Salvador | 1 | 0.4 | - | - | - | - | - | - | 1 | <1% |
| Guatemala | 24 | 0.7 | 3 | 3 | - | 7 | - | 11 | - | 12% |
| Honduras | 14 | 0.3 | 1 | 3 | 1 | 4 | - | 3 | 2 | 7% |
| Mexico | 99 | 0.2 | 13 | 23 | 6 | 15 | 11 | 20 | 11 | 48% |
| Nicaragua | 12 | 0.4 | - | 1 | - | 4 | - | 7 | - | 6% |
| Panama | 9 | 0.3 | 2 | 1 | - | 3 | - | 3 | - | 4% |
| Total/ policy type | 206 | - | 22 | 31 | 11 | 36 | 26 | 63 | 17 | - |
| %/ policy type | - | - | 11% | 15% | 5% | 17% | 13% | 31% | 8% | - |

## 3.2 Policy Effectiveness

Overall, we saw two policy types with largely positive forest cover effects, but also noticed mixed results for two other policy types. For a detailed breakdown of forest cover results, see Figure 2. .

 

**Figure 2 Effect of each policy type on forest cover (positive cases are aggregated above the axis, negative below). Different fills correspond to different countries. Cases with no effect are listed below the bars.**

### 3.2.1 Payments for Ecosystem Services

All the positive payments for ecosystem services cases were from two countries: Mexico and Costa Rica, which happen to have the greatest governmental capacity and the clearest property rights for forest land, both likely prerequisites for successful payments programs. This is consistent with the recent review by Busch and Ferretti-Gallon (2017). They found only five spatially explicit econometric studies of the impact of payments for ecosystem services on forest cover. All five of these studies reported positive results, and despite the global reach of their literature review, all five of the cases were from Mexico and Costa Rica. It is thus not clear if this policy type would be associated with similar success in countries with weaker governments and more conflicts over forest ownership. Among the cases we reported, several methods were used to causally link land cover changes to payments for ecosystem services and to account for potential leakage and additionality concerns. Leakage describes deforestation of lands not under contract to compensate for protecting forest through a payments for ecosystem services program. Additionality refers to the effect of a policy on an outcome beyond a baseline expected outcome in the absence of the policy intervention (Gillenwater 2012). Alix-Garcia, Shapiro, and Sims (2012) and Scullion et al. (2011) attempted to measure additionality and found modest total avoided deforestation using a matched controls difference in differences method. Other studies, including Robalino and Pfaff (2013), Sanchez-Azofeifa et al. (2007) and Robalino et al. (2008), found low avoided deforestation as a result of payment programs but found improvements in impacts over time.

### 3.2.2 Community-Based Management

Fortmann (2014) studied community forest concessions in Guatemala's Maya Biosphere Reserve using the difference in differences method and reported that this policy was effective in reducing deforestation among all types of concessions. This method attempts to emulate an experimental design by measuring the difference in a control group and treatment group effect in a natural setting. Barsimantov (2009) and Barsimantov and Kendall (2012) used econometrics and reported that both common property tenure and community forestry are generally related to lower deforestation. DiGiano, Ellis, and Keys (2013) looked at privatization of Mexican *ejidos* that owned forest and concluded that the more communal the ownership of the land, the lower the deforestation.

By contrast, Bonilla Moheno et al. (2013) showed negative forest results, concluding that at the municipality level “virtually all deforestation has occurred in areas dominated by *ejidos.*” However, *comunidades agrarias*, another form of collective land ownership that is more common among Mexican indigenous communities, were associated with improvements in forest cover. The study relied on low-resolution and highly aggregated data and did not include land under active forest management. Most of the cases were in Mexico, which is an unusual country globally by virtue of the extent and success of its community-based forest management (Bray et al. 2003). Conclusions drawn from Mexico may not be as applicable in countries without this unusual history. Additionally, interactions with other policies may affect outcomes, particularly as many of the studied community-based management programs were in or near protected areas, received payments for ecosystem services, or were associated with land tenure reforms.

### 3.2.3 Protected areas

Many of the cases in this category examined multiple policies in interaction with protected areas, and most did not account for the additionality of protection. Among the cases that accounted for additionality, Andam et al. (2008) Andam (2008), and Andam, Ferraro, and Hanauer (2013) used quasi-experimental methods to estimate additionality of the protected areas system in Costa Rica, finding about 10% avoided forest loss and less than 20% were associated with reforestation. Figueroa and Sanchez Cordero (2008) and Figueroa et al. (2011) looked at aggregate data for dozens of Mexican protected areas, and found a similar success rate to our study. They used an innovative effectiveness index that included percentage of area transformed, rate and absolute extent of change, and comparison to non-protected area. Both papers also reported on other variables that contribute to the effectiveness of protection included migration, strength of governance, and agricultural land use change.

### 3.2.4 Agricultural Subsidies

The few positive cases of agricultural subsidies studied incentives to search out alternate livelihoods (Schmook 2008) and mixed-vegetation agroforestry systems utilizing native species (Chargoy Zamora 2004). The latter example demonstrated that in the case of shade coffee, policies that promote agroforestry may also be positive for forests.

Two main examples of subsidized agriculture with associated negative forest outcomes were livestock production and Mexico’s PROCAMPO rural assistance program, which provides payments to farmers based on land area cultivated. Multiple papers studied policies such as bank lending, subsidized credits or provision of titles to incentivize cattle production in Central America at the expense of forest cover (Ibrahim, Porro, and Mauricio 2010, Ledec 1992, Arroyo-Mora et al. 2005). PROCAMPO was likewise linked to deforestation (Klepeis and Vance 2003, Klepeis 2003); although, Chowdhury (2006) reported that the policy reduced deforestation at the parcel level, highlighting a need for cross-scale analyses.

### 3.2.5 Other Policy Types

Compared to the four previously discussed policies with clear discernable patterns, which composed 70% of the studies we found, the remaining 30% of the cases examined forest regulation (5%, n=11), socioeconomic development programs (8%, n=17), and land tenure policies (17%, n=36). No clear pattern emerged for these kinds of policies. Whereas 45% of cases of forest regulations and 41% of cases of socioeconomic development programs were associated with positive outcomes, in both instances the small sample size leads us to be hesitant to draw conclusions. The effect of land tenure reforms in this dataset was ambiguous, and most cases (63%) were published more than ten years ago. We were not able to discern why some cases led to improved forest cover and some did not, in part because of the wide variety of policies captured under this term (Robinson, Holland, and Naughton-Treves 2014).

# 4. Discussion

Our results demonstrate that some types of policies have a more positive track record than others in Mesoamerica: studies of payments for ecosystem services, government protected areas, and community-based management show that all these policies are often associated with positive forest cover outcomes. The association between these policies and positive forest impacts is somewhat surprising given substantial controversy over the potential for each of these types of policies to be effective. Of these three, government protected areas are the least associated with positive outcomes, implying that protected areas are perhaps not as reliable as many people think, and the strategies chosen for implementing them could be very important for their potential success. Our finding that government protected areas provide inconsistent performance that is potentially inferior to that of community-based management is consistent with other recent studies . Reasons why some protected areas were more effective than others were not evident from our findings, and this should be a research priority.

We also find that agricultural subsidies are strongly associated with declines in forest cover, which, while unsurprising, points to a potentially underutilized policy tool, i.e., reducing subsidies that favor land conversion could potentially be as powerful a means to protect forests as directly subsidizing forest protection. Forest sector regulations, such as bans on harvesting certain kinds of timber, restrictions on shifting cultivation, or requirements that timber harvesters obtain permits, have often been the focus of forest policy analyses. Several countries in this region have put such policies in place. Thus, it is surprising to find so few studies of this important policy type in this region. It may be that these policies are helpful in maintaining forest quality, but have little impact on forest cover, however this is an area where further research is needed.

Some evidence showed community-based management and protected areas together work to protect forest cover, whereas one policy alone will not (Ellis and Porter-Bolland 2008, Cardenas Hernandez 2008, Baylis, Honey-Rosés, and Ramírez 2012). Other cases showed payment programs in conjunction with either protected areas or community-based management were successful (Honey-Rosés, Baylis, and Ramirez 2011, Fagan 2014, Morse et al. 2009, Cortina Villar et al. 2012). Furthermore, many other outcomes, including protection of biodiversity and provisioning of rural livelihoods, are of great importance in forest management. Grima et al. (2016) classified a payments for ecosystem services scheme as “partially successful” if it met the program goals yet had a tradeoff in terms of social, environmental, or economic outcomes. Their tiered approach reduced successful cases in their study by 30%, suggesting that if we had done a similar correction we would have found a less positive outcome.

Our findings are constrained by the data collected by past studies and may underreport weak or negative outcomes. Although Mesoamerica is a very well-studied region, most cases we located did not measure both our independent and dependent variables, and even those that did rarely employed designs that enabled strong causal inference or accounted for leakage and additionality. Taken together, the evidence from these studies does not enable us to understand the conditions under which certain policy types are more or less likely to be effective, suggesting that even if evidence suggests that some policies are frequently successful, our knowledge of the efficacy of forest policies is weaker than widely understood.

The inferences we draw here may raise several questions. First, as noted above, 70% of our cases are drawn from Costa Rica and Mexico, and this concentration is even higher for payments for ecosystems services and community-based management. These two countries also happen to be among the wealthiest and most politically stable in the region, with the greatest government capacity and a much longer history of secure property rights. Their success is encouraging, yet there are reasons to think that results may be poorer in countries where property rights systems are less well defined.

Within Mexico, our cases are heavily concentrated in a few important but not necessarily representative sub-regions, and they include few studies from regions such as the Sierra Huasteca in east-central Mexico; the dry forests of much of the central and northern parts of the country; and the extensive tropical forests in and around the Isthmus of Tehuantepec in Oaxaca and Chiapas or in the Lacandón region of Chiapas. Costa Rica and Mexico are global pioneers in the use of payments for ecosystem services, and indeed, a recent global review found that the only spatially explicit econometric studies of payments for ecosystem services in the world were from these two countries (Busch and Ferretti-Gallon, 2017).

Second, we rely on published reports and thus inherit the limitations of existing studies. As noted above, most studies of forest cover change do not have designs which enable them to make strong causal inferences, and most do not deal effectively with questions of additionality and leakage. Many studies do not clearly identify the causal processes that lead to outcomes, and thus it is not clear, for example, why many protected areas effectively protect forests, but some do not. Furthermore, a strong likelihood exists that published reports are subject to various forms of publication bias, although the degree and extent of such biases in this literature have not been documented. It is interesting to note that the most successful policy in our dataset, payments for ecosystem services, is also the most recent policy to be initiated in the region, which makes it difficult to discern whether there has been sufficient time for the policy to be fully tested. Mexico is scaling back its payments program, raising questions about long-term sustainability (Enciso 2015). Several policy types have not been extensively studied in the region, including direct forest sector regulations and socioeconomic development programs. It is not clear if this lack of literature is because these policies do not have important impacts, or because they have not attracted scholarly attention.

Third, there is a lack of interaction in our research both between types of policies and between outcome measures. Many locales are affected by multiple policies simultaneously; a community in the buffer zone of a biosphere reserve may be an example of both a protected area and community-based management, and that same community may be the recipient of payments for ecosystem services, agricultural subsidies, and socio-economic development programs. Research designs that sort out the effects of these diverse programs are not present in our dataset: fewer than 25% of the studies examine interactions between policy types. Among these cases, we observed mixed results of the main policy tools we have examined.

Taken together, our results provide valuable support for the widespread presumption in the REDD+ literature that market-based payments for ecosystem services approaches to conservation can be successful. Indeed, we found no negative cases. As such, our results do not support the pessimistic view of market-based approaches held by many political ecologists. At the same time, we did not gather data on non-forest cover outcomes such as economic equity and political sovereignty that may be of concern to political ecologists. Our study also supports critiques of the REDD+ literature from other theoretical traditions. Unsurprising in light of the enthusiasm for community-based conservation in the common-pool resources literature, community-based conservation has nearly as strong a record as payments for ecosystem services approaches (albeit with similar qualifications, since Mexico is generally considered an unusually strong case for community-based forest management – see Bray et al. 2003), lending support to claims that community-based management deserves a central role in REDD+ policy making (Rights and Resources Initiative 2014). Consistent with studies of the drivers of land use change from the land change science community, which identify expansion of commercial agriculture as one of the most important drivers of global forest loss, agricultural subsidies were strongly associated with negative outcomes. Reductions or changes in these subsidies may be a powerful tool for forest conservation, and discussion of this is not widespread in REDD+ discourse.

# 5. Conclusion

Our work demonstrates mixed evidence for the effectiveness of different policy options for REDD+. Our evidence highlights three kinds of policies that appear likely to be effective in this region: payments for ecosystem services programs, community-based management, and protected areas (in rank order of % positive cases). Many outcomes of protected areas studies show failure to protect forests, yet the reasons for this are often poorly defined. Furthermore, we find that agricultural subsidies are frequently associated with forest loss, providing a fourth option for improving forests: reducing or redirecting subsidies that incentivize forest clearing. Finally, we find little evidence upon which to base judgment of whether forest sector regulations, land tenure reforms, or economic development programs help or hinder forest protection. In a heavily studied region of the world, the clear majority of studies of forest cover change do not focus on policy evaluation. Those studies that do often suffer from weak designs that do not isolate causal effects and that ignore interactions. Given these limitations, policy-makers should keep in mind that our results are not necessarily representative of their own specific cases.

Future studies to inform decision-making research should address several weaknesses in existing literature. First, attention needs to be paid to research that measures causal effects and identifies causal mechanisms, as well as continuing work that reports associations between policies and land use. The large number of studies we found that either examine land use change or policy, but not both, show the potential to greatly expand the number of studies examining policy-land use linkages. Second, studies need to explicitly account for the additionality of policy impacts and the potential for leakage of land cover change into nearby areas. Third, studies should address gaps within the regions and policy types studied. There are few studies of policies other than protected areas, community-based management, and market-based instruments, and outside of Costa Rica and some areas of Mexico, most of the region has seen little study. Fourth, further study is needed to understand the interactions between multiple outcomes, including not only land cover but also livelihoods and biodiversity protection. Finally, further understanding is needed of the interactions between different policies, as well as between policies and contextual variables such as governmental capacity, property rights regimes, and biophysical conditions.

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