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Local Institutions, Extractive industries, and the Stewardship of the Forest Commons: Evidence from Mexico, 1990-2017

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Local Institutions, Extractive industries, and the Stewardship of the Forest Commons: Evidence from Mexico, 1990-2017

A dissertation submitted in partial satisfaction
of the requirements for the degree
Doctor of Philosophy in Political Science

by

Cesar Benshuni Martinez Alvarez

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ABSTRACT OF THE DISSERTATION

Local Institutions, Extractive industries, and the Stewardship of the Forest Commons: Evidence from Mexico, 1990-2017

by

Cesar Benshuni Martinez Alvarez
Doctor of Philosophy in Political Science
University of California, Los Angeles, 2022
Professor Michael L. Ross, Chair

The protection of ecosystems is one of the most effective strategies to address multiple environmental issues, including climate change and biodiversity loss. Moreover, these territories provide fundamental ecological services and represent the livelihoods for millions around the world. Hence, their conservation is fundamental to realize key development goals. Scholars in the social sciences have long studied the economic and societal drivers of environmental degradation, particularly deforestation. According to an influential strand of research, led by the work of Elinor Ostrom, local users of common-pool resources are sometimes able to effectively steward their natural resources without the intervention of states or markets. The presence of adequate mechanisms of governance, for example norms of resource use, devices to monitor and sanction behavior, and autonomy in local decision-making, are essential to explain why some of these groups are more successful than others.

In my dissertation, I study the case of Mexico to shed light on the relevance of different institutional and environmental factors in the ability of local communities to steward their natural resources. Mexico offers an ideal setting to study these questions for two reasons. First, rural communities own most of the country's land, including the majority of its ecosystems. Moreover, over the last three decades, the rural areas of Mexico have experienced a series of political and economic transformations that have impacted these communities.

In the first chapter, I find that rural communities with long-standing indigenous po-

litical institutions experience lower levels of environmental degradation—measured with the average rate of tree cover loss—than those without them; the presence of higher levels of collective action is a possible mechanism for this relationship. However, in the second part of the chapter, I show, leveraging a natural experiment in Mexico, that political reforms aiming to politically recognize these institutions may not be effective at improving communities' ability to steward their natural resources, particularly forests.

In the second chapter, I explore the role of reforms to increase the territorial autonomy of rural communities through the provision of certified land titles. I show that a policy that provided both public and private land rights to these communities in the 1990s and early 2000s (the PROCEDE) was associated with higher rates of tree cover loss in the years leading to it, mostly among communities without long-standing indigenous institutions and with scarcity of arable land for agriculture. These findings suggest that land reforms that offer private goods in communal settings may affect intra-community political dynamics and, therefore, have mixed impacts on the protection of the forested commons.

Finally, in the last chapter I study how external actors impact communities' livelihoods. Specifically, I analyze the impacts of exposure to mining concessions on a wide array of community-based outcomes. The mining industry has expanded considerably in Mexico since the early 1990s, affecting hundreds of communities in the process. The results of this chapter show that exposure to these concessions is associated, in the short-run, with a decrease in the levels of economic activity; in the long-run, extractive industries lead to a higher demand for private goods (individual land titles) in affected communities; moreover, by depressing some of the key drivers of deforestation, these projects are also associated with a small decrease in the annual rate of tree cover change in the medium-term.

In terms of data, in my dissertation I employ high resolution satellite imagery to measure with precision the deforestation trajectories of thousands of resource systems in Mexico, as well as other ecological variables at the community-level. In addition, I use previously untapped administrative data to explore different types of communal political behaviors. I also leverage different sources of variation in the independent variables, using staggered differences in differences and a geographic regression discontinuity.

The dissertation of Cesar Benshuni Martinez Alvarez is approved.

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CHAPTER 1

General Introduction

Local Institutions, Extractive industries, and the Stewardship of the Forested Commons: Evidence from Mexico, 1990-2017

The stewardship of common-pool resources, including forests, watersheds, biodiversity, a well-functioning atmosphere, among others, lies at the core of many substantive issues in environmental politics. From the local to the planetary levels, collective action is one of the most consequential driving forces that affect the well-being of the Earth. For decades, a vast and influential academic research program has investigated what makes some groups more successful at managing their common-pool resources, what is the role of internal institutions of governance, and how can governments support these efforts (Ostrom, 1990; Agrawal and Goyal, 2001; Agrawal et al., 2002; Cumming et al., 2020).

In particular, the work of Elinor Ostrom and her colleagues transformed our understanding of collective action and debunked previously held—and erroneous—conventional wisdom. In her vast scholarship, Ostrom demonstrates that common property is not equal to open access; many societies across different countries and time periods have been able to sustain cooperation arrangements that allow them to effectively steward their forests, watersheds, and other commons, even without the intervention of states and markets (Ostrom, 1990; Ostrom et al., 2002; Ostrom, 2010, 2014).

Central to the academic literature on the commons is the role of local institutions. For example, in her foundational work, Ostrom outlined seven design principles that account for the group-level variation in the protection of the commons; these include, among others, clarity in the boundaries of the resource system and the ability of the community to design and implement their own norms of governance (Ostrom, 1990). Across different disciplines and methodological approaches, scholars have emphasized the relevance of these institutional devices, including the definition of who is entitled to use the commons, sanctions of defective behavior, and mechanisms to monitor other community members.

For many years, the study of the commons centered on individual case studies or small-N analyses of a few resource systems. This approach is useful to understand the complexities of the institutional arrangements governing the commons and the societal drivers of their success (Ostrom et al., 2002). Methodologically, it requires in-depth knowledge of the case and careful qualitative insights. Moreover, quantitative approaches are not suitable for many settings, as these require detailed institutional and behavioral data, which is difficult to collect for a large number of cases displaying enough variation in the dependent variable (Hajjar et al., 2016). Examples of central research efforts to collect and analyze in-depth data on the commons include De Moor et al. (2016) among others.

Nonetheless, recent advances in causal inference methodologies and satellite imagery technologies have transformed the study of the political economy of the forest commons. New data sources, for example the Global Forest Watch data (Hansen et al., 2013), allow researchers to track the trajectories of deforestation at the national and subnational levels with a very high level of precision (Kopas et al., 2018; Sanford, 2021; Pailler, 2018; Baragwanath and Bayi, 2020). Moreover, initiatives such as the Metaketa have focused on improving the internal and external validity of research on the management of common-pool resources, including similar field experiments across multiple countries (Slough et al., 2021; Cooperman et al., 2021; Christensen et al., 2021; Buntaine et al., 2021).

Despite the progress in our understanding of what makes some communities better able to successfully steward their commons, there are still a few key gaps in this important area of research. First, meso-level theories on the political economy of the commons are relatively less developed compared to the micro-level foundations and macro-perspectives.

Regarding the former, lab-in-the field designs are suitable to make causal claims and tease out mechanisms at the individual level, but are difficult to generalize. As mentioned above, initiatives like the Metaketa improve considerably the external validity of field experiments, as the treatments are similar across countries. More of these efforts are needed to improve the theoretical foundations of the study of the commons.

On the other hand, some macro-level analyses have taken advantage of improvements in satellite technology to evaluate the performance of different land tenure regimes and the conservation potential of land held in common—for example indigenous lands (Garnett et al., 2018; Sze et al., 2022). Although their global focus allows researchers to make general claims about the relative effectiveness of the commons, it also makes more difficult to test specific theories about the political and societal drivers of that performance.

A second gap relates specifically to the existing meso-level studies of the commons. In most cases, their main goal is to employ novel econometric tools to test some foundational hypotheses about the commons. Nonetheless, their theoretical contribution is somewhat less clear. For example, multiple authors have provided evidence that the titling of indigenous lands is causally associated with lower levels of deforestation. However, we know relatively less about why this is the case. Indigenous groups could differ from non-indigenous ones in their written and oral norms of resource use and appropriation, their devices for intra-group cooperation, and their attitudes towards the environment. All of these factors could, in turn, explain differences in the ability of communities to steward their natural resources, but most of the existing research rarely addresses them.

Moreover, sociological and anthropological accounts suggest that policies that reform communal land tenure are highly contested. Specific patterns of historical development condition how these groups appropriate institutions such as secure property rights. Hence, instead of being monolithic entities, communities are politically complex polities, with some members supporting these and other policies and others rejecting them. However, these issues are mostly absent from the empirical study of the commons.

Finally, as mentioned by several scholars, most of existing scholarship tends to focus on drivers of sustainability at the community level, with less attention to the role of external actors. Economic external actors include, for example, private landowners, large extractive corporations (mining and energy companies), and manufacturers. They can also be political, including local, state, and federal authorities, as well as bureaucracies. Scholars in the social sciences have shown that these actors are crucial to shape policies and regulations that are likely to affect the ability of communities to steward their natural resources.

In Latin America, for example, recent work has shown that governments employ land tenure policies, including land redistribution and property rights titling, with various political purposes (Albertus, 2015). Nonetheless, most of the current literature does not incorporate these insights into the analysis of the community-based land use.

In summary, there are three important gaps in our understanding of the local political economy of the commons. First, for decades, most of the work in this area of research was based on individual qualitative case studies, which have been foundational in theory-building, but are difficult to generalize. More recently, advances in satellite technologies and causal inference quantitative techniques allowed for experimental and quasi-experimental designs, which has improved our understanding of the commons; however, in many cases, scholars have focused on testing foundational hypotheses about the commons and less on explaining what mechanisms account for those relationships.

Finally, there has been less attention to studying the relationship between communities and external actors, as these are mostly seen as part of the background and not as key drivers of community-based land use decisions. It is important to mention that a key reason behind these gaps is the lack of fine-grained institutional and behavioral community data, which is quite difficult and costly to generate for a large sample.

In my dissertation, I study the case of Mexico to shed light on why some groups of common-pool resources are better able to successfully steward their natural resources. In doing so, I contribute to address some of the research gaps mentioned above. As I will explain in the three empirical chapters, Mexico represents an ideal case to do so for various reasons. First, although many countries have decentralized land management to local communities, in Mexico they represent 51% of the country's total surface, including the majority of its ecosystems. This makes the country a natural laboratory to study the land use trajectories of thousands of individual resource systems over time (Bray et al., 2003; Bray and Merino-Pérez, 2004; Bray et al., 2005; Bray and Merino-Pérez, 2007; Bray, 2013; Merino Pérez, 2014; Merino-Pérez, 2004).

Second, the sweeping political and economic reforms of the last thirty years have transformed the Mexican countryside (Cornelius and Myhre, 1998) and represent an important source of variation in key institutional and economic variables that affect communities' ability to steward their resources. Starting with the erosion of the import-substitution model and the democratization process at the federal level, the successive governments reformed the land tenure of the country through a massive titling program, created a new structure of agrarian justice, and reformed key farming subsidies programs (Cornelius and Myhre, 1998; Magaloni et al., 2019). In addition, the creation of the first environmental policies in the history of the country paved the way for new community efforts to protect their commons (Bray et al., 2005).

However, at the same time, numerous challenges to the livelihoods of these communities emerged, including illegal activities from organized criminal organizations and the expansion of extractive industries, for example mining and large-scale agriculture.

For the purposes of my dissertation, I focus on three factors that affect the ability of communities to steward their natural resources: (1) indigenous political institutions and their recognition by state authorities, (2) the implementation of land tenure security reforms, and (3) the expansion of extractive industries.

A growing area of research in environmental studies shows an association between indigenous institutions and the stewardship of natural resources (Garnett et al., 2018; Dawson et al., 2021). Most of the empirical work has centered on assessing the role of secure land tenure on reducing the levels of deforestation. Nonetheless there is much less evidence about what mechanisms may explain this association and what is the role of state recognition of other types of political institutions beyond secure property rights.

For example, do we observe differences between indigenous and non-indigenous lands because of other geographic factors that differ between them? Or is it because some indigenous communities have more pro-environmental land use preferences? Or is it because of other political behaviors—such as their potential for collective action—that are also associated with the management of the commons?

Moreover, land tenure customary practices represent only one of the many different political institutions that differ among indigenous communities (Magaloni et al., 2019). Scholars have found that these groups have different patterns of political representation, mechanisms to elect their leadership, and decision-making practices. As in the case of land tenure reforms, the recognition of these by state authorities is crucial for the full realization of these goals (Ostrom, 1990). However, they have received less scholarly attention than issues of land tenure.

To address these questions, in the first chapter of my dissertation I employ two sources of variation in the presence of indigenous political institutions and their recognition by the state. First, I use the location of historical indigenous localities—those existing by the end of the colonial period—as an approximation for the presence of long-standing traditional institutions (Robinson, 2007). Then, I employ a difference-in-means to compare: (a) the rates of accumulated deforestation—employing satellite imagery; (b) the percent of the community's total surface that its members decided to hold in common, as opposed to individual parcels; (c) the number of community forestry enterprises; and (4) the probability of applying to federal conservation programs. The last three variables measure different aspects of communal collective-action potential that could be mobilized to steward the commons. As a robustness check, I reduce some of the imbalance between treated and control groups employing a propensity score matching algorithm.

The second part of the empirical analysis aims to understand whether the recognition of these institutions by state authorities affects communities' ability to steward their natural resources. To do so, I leverage a natural experiment in Oaxaca state in southern Mexico. In 1995, the local assembly officially recognized the use of indigenous electoral procedures (*usos y costumbres* in Spanish) in 73% of the state (Eisenstadt, 2007). After the reform, all of Oaxaca's 570 municipalities fell into two categories: (a) those ruled by political parties and (b) those which transitioned to indigenous electoral governance.

This constitutional change created an exogenous source of variation in the state recognition of traditional electoral institutions, as some historical indigenous communities had their institutions officially recognized by the state's government and others did not.

The setting allows me to estimate a geographic regression discontinuity, using the distance to the border between governance regimes as the running variable and the annual rate of tree cover loss as the main outcome variable. In doing so, I estimate the local average treatment effect of official recognition of indigenous governance on deforestation.

The findings from this chapter suggest that the presence of long-standing traditional political institutions is associated with lower levels of environmental degradation. Moreover, villages with these institutional structure tend to have higher levels of collective action potential than communities without it, suggesting this could be a potential mechanism behind this relationship. However, the analysis of the natural experiment in Oaxaca state shows that state recognition of some of these political institutions may not be effective in bolstering the ability of communities to steward their ecosystems. A crucial key reason for this is the nature of the reform, driven by state and local politicians' electoral considerations, with little input from communities themselves.

In the second chapter, I revisit the role of secure property rights on communities' land use trajectories. The main research question is, what is the effect of increased land tenure security on the ability of communities to steward their natural resources? To shed light on this issue, I study the impacts of a massive titling program rolled out from 1994 to 2016 in

Mexico—the PROCEDE / FANAR, one of the most relevant economic policies of the early 1990s (De Janvry et al., 2015). This policy certified the external and internal boundaries of the community, providing its members with two distinctive types of goods: (1) public goods, in the form of more community boundaries and (2) private goods as titles to individual parcels (or *certificados de derechos parcelarios* in Spanish).

From a methodological perspective, although communities self-select into the program—and hence the treatment assignment was not as-if random—the staggered implementation of this policy provides some leverage to estimate the effects of secure property rights on land use and tenure. To do so, I employ an event studies model, with the lags and leads around access to the PROCEDE program as the independent variables. The annual rate of tree cover loss is the main outcome. In addition, I explore how exposure to more secure land tenure affects the probability of communities holding an assembly to transition to full—private—land ownership and their levels of economic activity.

This paper has two findings. First, the PROCEDE, a policy that offered mixed-goods to community members, affected land use mostly before its implementation. As a long and complex reform that required multiple steps and community assembly votes, even the expectation of access to individual parcels transformed previously customary practices of communal land use, increasing the rates of tree cover loss in the years prior to its implementation. This reform also increased the probability of communal land privatization in the medium-run. Second, PROCEDE had heterogeneous effects in different types of communities, as most of these impacts were driven by villages with relative scarcity of fertile soils for agriculture and without long-standing indigenous institutions. In contrast, communities with abundance of arable lands and with long-standing traditional institutions did not experience any change before or after its implementation.

Finally, the last chapter of the dissertation focuses on the role of external actors on the stewardship of the commons. As mentioned above, most of the existing literature on the management of common-pool resources tends to focus on the relevance of internal institutions and mechanisms of governance. Instead, there has been less attention to the role of local and national governments, private firms, and other individuals and groups in the ability of communities to steward their ecosystems (Bebbington et al., 2018).

In the last chapter, I specifically evaluate how exposure to one type of extractive industries—mining concessions—affects the livelihoods of communities along economic, political, and environmental lines. During the early 2000s, the so-called super commodity boom resulted in a large expansion of foreign direct investment in Mexico's mining sector (De la Fuente et al., 2017). A large proportion of these concessions overlapped with lands belonging to *ejidos* and *comunidades agrarias* (Perez et al., 2021).

I employ the quasi-random timing of these investments to estimate a staggered difference-in-differences design. The main outcome variables reflect three different aspects of communities' livelihoods: (a) nighttime luminosity and (b) agricultural subsidies per square kilometer as proxies for economic activity; (c) number of individual parcels per square kilometer and (d) linear probability of privatization as measures of political behavior; and (e) the annual rate of deforestation as a measure of environmental change.

The findings from this chapter suggest that mining concessions have powerful impacts on the livelihoods of communities, weakening their economic and political foundations. On the one hand, rural communities exposed to one of these investments experienced a sharp decrease in their levels of economic activity, measured with nighttime luminosity, as well as in the amount of subsidies per square kilometer they receive from the federal government. On the other, exposure to treatment is also associated with a higher demand for private goods within the community (individual parcel property titles), but not with a higher likelihood of communal land privatization. Finally, by depressing some of the key drivers of deforestation in Mexico, mining concessions are associated with a small, but statistically significant reduction in the rate of tree cover loss in the long-run.

Taken together, my dissertation provides two contributions to the study of the commons. First, the literature on the political economy of common pool resources has been based upon individual qualitative case studies, lab-in-the field experiments, and, more recently, field experiments. My work contributes with a meso-level theory that provides more nuance to some of the conventional wisdom ideas about the commons.

In my work, I found that the specific content and implementation of reforms aiming to increase land tenure and political standing for these groups are crucial for their success. Moreover, there are important sources of heterogeneous effects explaining variation in the outcomes. Specifically, the findings in my first chapter show, in contrast to conventional wisdom, that a political reform with the nominal goal of expanding and recognizing indigenous electoral institutions did not have an impact on how communities manage their resources. Its electorally-centered nature is a key reason behind this null effect.

Something similar occurs regarding reforms to increase land tenure security. Previous research tends to conceptualize them as binary variables, with little attention to how different components of these policies may affect communal behaviors. However, as the case of the PROCEDE in Mexico shows, the specific content of these reforms is very important; in contrast to other examples in the region, in Mexico the government provided two types of goods, public and private. The analysis shows that for certain communities, the expectation of access to these private goods is associated with higher levels of deforestation and a higher probability of privatization of community lands.

Importantly, these impacts are concentrated mostly among communities without long-standing indigenous institutions and without fertile land scarcity, suggesting that incentives to parcel land and take advantage of private goods may be driving patterns of land use change. In summary, my dissertation contributes to the existing literature by taking into account the political complexity of two types of reforms to strengthen the territorial and political autonomy of local communities. In one case, I show that the politically-driven implementation of one of these policies diminishes its effectiveness in empowering communities. In the other, the provision of both public and private goods resulted in the expansion of deforestation prior to the reform among certain communities.

A second contribution is the role of external actors on the ability of these groups to steward their natural resources. Scholars have studied how activities such as illegal mining affect ecosystems; however, other types of impacts, including economic and political, have received less attention. Given the close interactions between institutions, land use decisions, and societal variables, it is crucial to understand these together. Hence, in the third chapter, I point out to a paradoxical consequence of extractive industries. On the one hand, there is a clear short term economic disruption and a medium term political change within communities; on the other, these two affected deforestation patterns, but in the opposite way of what I expected initially.

According to the Intergovernmental Panel on Climate Change, the agriculture, land, and land use sector accounts for approximately 25% of all carbon emissions in the world; this is larger than the entire transportation sector, for example. Forest are, therefore, essential to address global climate change. Their relevance, nonetheless, goes well beyond this issue, as these ecosystems provide crucial ecological services and represent the basis for the livelihoods of hundreds of millions around the world.

Despite the increasing relevance of environmental issues in political science, agriculture, ecosystem stewardship, and land use change have lagged behind relative to other topics such as energy and transportation. The politics of deforestation differ substantially from other sources of carbon emissions, in particular given the crucial political role of that land still plays in many parts of the world. Different areas within the discipline have addressed specific dimensions of this puzzle, ranging from the political economy of land reforms to the study of the management of common-pool resources.

In my dissertation, I analyze the Mexican case to shed light on one aspect of the politics of land use in the Global South: the drivers of successful community-based land use management. As such, it is the first stage of a broader research agenda aiming to employ a wide array of data sources and methodologies to study the challenges and opportunities of community-based stewardship of natural resources.

CHAPTER 2

Traditional Governance and the Stewardship of the Commons: Evidence from Mexico

The preservation of global ecosystems is a fundamental component in the efforts to address environmental problems, such as climate change and biodiversity loss. A vast strand of research in the social sciences has shown that local communities can steward their ecosystems effectively even without the intervention of states and markets. What makes some of them better able to do so than others? In this chapter, I advance two arguments. First, I posit that the presence of long-standing political institutions of indigenous governance is associated with less environmental degradation (tree cover loss). Second, however, certain types of politically-motivated changes in the relationship between states and indigenous communities could diminish their ability to steward their natural resources. To test these theoretical claims, I analyze the deforestation and collective action trajectories of more than 16,000 rural communities in Mexico, employing satellite imagery and previously untapped administrative records. I also analyze a quasi-natural experiment in Oaxaca state, where the 1995 constitutional reform created an exogenous source of geographic and temporal variation in the recognition of indigenous electoral procedures for approximately 70% of the state's municipalities. This paper contributes to understanding what makes communal tenure of natural resources work; in addition, it expands the quantitative research on legal pluralism and indigenous politics in Latin America.

Keywords: *indigenous politics, traditional institutions, constitutional reforms, forest conservation, Mexico, community-based forest management*

2.1 Introduction

The preservation of global ecosystems is a fundamental component in the efforts to address environmental problems such as climate change and biodiversity loss. According to the Intergovernmental Panel on Climate Change, the world's forests hold an important potential as sinks of carbon dioxide; however, as a result of the expansion of the agricultural frontier and urban sprawl, the Agriculture, Land Use and Land Use Change sector (AFOLU) emitted 12 Gt of carbon dioxide equivalent (CO_2e) in 2010; this was larger than the entire transportation sector (Pachauri et al., 2014). Indigenous peoples play a crucial role in stewarding the world's biodiversity, as approximately 40% of the unaltered ecosystems of the Earth are located in indigenous territories (Garnett et al., 2018). Over the past few years, some national governments and international organizations have legally recognized the tenure of land by indigenous peoples and have promoted the communal use of forests through different policies (White and Martin, 2002).

Several academic studies have consistently shown the advantages of doing so, in both socioeconomic and environmental terms (Erbaugh et al., 2020; Tseng et al., 2021; Dawson et al., 2021; Agrawal, 2003, 2007). Certification of communal lands is associated with lower deforestation rates and poverty in Brazil (Baragwanath and Bayi, 2020), Nepal (Oldekop et al., 2019; Bluffstone et al., 2020), Kenya (Okumu and Muchapondwa, 2020), Ethiopia (Gebreegziabher et al., 2021), and Colombia (Vélez et al., 2020).

A long-standing strand of research in political science and economics, in particular the work of Elinor Ostrom, has shown that strong institutional frameworks, particularly the presence of effective norms of resource use and appropriation, allow some communities to successfully administer their lands without the intervention of states or markets (Ostrom, 1990; Ostrom et al., 2002; Ostrom, 2002; Agrawal et al., 2002; Agrawal, 2007; Baynes et al., 2015). However, despite the increasingly strong agreement that the decentralization of natural resources governance works, there are still a few important gaps in our understanding of why and under what circumstances.

First, there is still a disconnection between the theoretical claims and the empirical tests emerging from this literature. Whereas research from case studies is quite rich in terms of depth and detail, most of the quantitative work has focused on one particular form of state recognition of indigenous groups—access to secure property rights over land. As a result, most of the existing literature has not addressed other forms through which the state can affect the governance of common-pool resources (CPR), including, in particular, the recognition of indigenous autonomy in political decision-making. Second, in doing so, this strand of research has not incorporated some valuable insights from other areas of political science, for example the study of indigenous politics. Finally, although scholars have claimed that indigenous governance is beneficial for the preservation of ecosystems, there is less research on the mechanisms that link these two variables.

Hence, the main theoretical gap I address in this paper is about the role that indigenous political institutions and their recognition by the state have on the stewardship of the commons.[1] I advance two arguments. First, I posit that the presence of traditional forms of governance, defined as a set of long-standing formal and informal rules that define a polity and differ from the "mainstream" legal framework, have a direct and positive association with the sustainable use of forested lands, as they favor stronger intra-community ties. Second, however, politically-motivated reforms that alter the relationship between the state and indigenous communities may have unexpected, deleterious effects on the commons if they induce political instability and conflict in the short run.

Testing the empirical validity of these hypotheses is complicated for a few reasons. First, indigenous political institutions and their official recognition by the state do not tend to change over time or space, which implies little variation in the independent variable. Second, there is a clear overlap between communal tenure of land and indigenous political institutions. Most areas that governments around the world have devolved to local communities are indigenous (White and Martin, 2002), which makes it difficult to disentangle the specific

[1] In this paper, I employ the terms *indigenous governance* and *traditional governance* interchangeably, although there are some important theoretical differences between them.

effects of both institutional variables.

To address these challenges, I study the case of Mexico, a country with a long history of social forestry that offers a uniquely suitable setting to analyze the relationship between traditional governance of the commons. In the aftermath of the Mexican Revolution (1910-1920), the postrevolutionary regime redistributed 102 million hectares of land to more than 32,000 rural villages, known as *ejidos* and *comunidades agrarias*, a form of land tenure with colonial and pre-colonial precedents. This system, which is currently still in place, allows me to analyze the land use trajectories of thousands of well-defined resource systems with quite different environmental outcomes (Bray, 2013).

Moreover, despite the identical constitutional standing of these thousands of rural villages, they differ considerably in terms of their governance frameworks, in particular their institutions for resource use and appropriation. Hence, this setting displays substantial variation in the dependent and independent variables under analysis.

Finally, there is substantial variation at the subnational level in the second key variable of interest: the recognition of indigenous political practices by state authorities. In 1995, the local assembly of Oaxaca state in south Mexico officially recognized indigenous electoral mechanisms in 73% of its municipalities as part of a broad constitutional reform. The newly created border between the *usos y costumbres* (or "traditional") and the *partidos políticos* (or "mainstream") municipalities cut along forested lands that faced identical *ex ante* environmental degradation pressures. This created a quasi-exogenous source of variation in the recognition of indigenous political practices.

My empirical strategy has two building blocks. First, in a descriptive exercise, I employ the location of indigenous townships at the end of the colonial period as an approximate measure of long-standing traditional political institutions. Second, I leverage the aforementioned natural quasi-experiment in Oaxaca state. Specifically, I estimate a geographic regression discontinuity to analyze how deforestation changed at either side of the border before and after the implementation of the constitutional reform in the short, medium, and long-terms, using an approach similar to Díaz-Cayeros et al. (2014) in Oaxaca and Baragwanath and Bayi (2020) in Brazil. I do so for the full sample of forests in the state, as well as different subsamples: communal lands in indigenous territories, non-indigenous territories, and non-communal lands.

This paper has two key findings. First, communities with long-standing traditional institutions show lower rates of deforestation and higher levels of collective action. Second, however, the implementation of politically-motivated reforms on indigenous autonomy can have unexpected and deleterious consequences for the ability of these communities to steward their forested commons, particularly in the short-term, as it is associated with increasing levels of political instability and conflict.

In terms of the contributions of this study, from a theoretical perspective, I propose specific reasons why traditional governance is associated with the stewardship of the commons—the levels of collective action. In addition, I emphasize that some politically-motivated reforms can hinder—instead of support—the indigenous governance of ecosystems. From a methodological point of view, the fine-grained dataset I employ allows me to test more nuanced hypotheses about the role of different institutional and political variables on the use of forested land and other community-level variables. This paper also contributes to the literature on the commons beyond the role of indigenous governance, as I am able to empirically test some other hypotheses about the relevance of specific factors on collective action and environmental outcomes. Finally, I contribute to the extensive literature in political science about indigenous politics, emphasizing outcomes that previous research has not, particularly around environmental issues.

The paper proceeds as follows. In the second section, I discuss what we know about the role of indigenous political institutions on environmental governance. In the third section, I present my theoretical framework and the observable implications of the paper, centered on the role of traditional political institutions and their recognition by the state on the stewardship of the commons. Then, in the fourth section, I describe the background of the Mexican case, with particular attention to the constitutional reform in Oaxaca state in

1995. The next section explains my empirical strategy. The sixth section presents the data, methods, and results of the study. The last section concludes.

2.2 Literature Review

The commons, a type of good that includes forests, watersheds, fisheries, and the atmosphere, has attracted considerable attention in the social sciences (Ostrom, 1990, 2002; Baynes et al., 2015). Their non-excludable and rival nature implies that individuals have strong incentives to appropriate as much of them as they can, which, in turn, could lead to depletion. For this reason, CPR systems are usually a laboratory on collective action and cooperation. In contrast to previous conventional wisdom, the work of Ostrom shows that resource exhaustion is only one of the possible outcomes of managing the commons. Strong institutions of resource use, effective norms of monitoring, mechanisms of compliance, and access to secure property rights—some of Ostrom's design principles—allow some of these groups to engage in successful cooperation, which, in turn, enables them to steward them sustainably (Ostrom, 1990; Agrawal, 2003).

Despite the widespread support for the idea that communal tenure of land favors sustainable decision-making (Tseng et al., 2021), there are still a few gaps in our understanding of why this happens and under what circumstances. First, there is an important disconnection between the theoretical insights and the empirical tests of this literature (Agrawal et al., 2002; Epstein et al., 2020). A strand of research based on case studies and comparisons of a small number of cases has produced in-depth insights about why some communities are better able to engage in successful collective action than others (Villamayor-Tomas and García-López, 2018). Scholars have emphasized the relevance of variables such as intra-community ties, traditional forms of authority, social capital, and multi-level systems of governance as determinants of the sustainable use of the commons (Baynes et al., 2015).

A conclusion from this vast literature is that, although the effective stewardship of the commons starts with secure land tenure, it does not end there. Other political characteristics of these communities also influence the extent to which they are able to engage in sustainable behaviors (Pagdee et al., 2006; Wollenberg et al., 2007; Sethi and Somanathan, 1996; Pinkerton, 1989; McKean et al., 2000; Brewer, 2012; Kashwan, 2017; Finley Brook, 2016). However, most of the quantitative empirical analysis of the commons has focused on evaluating the impact of access to land tenure security through the certification of property rights (Tseng et al., 2021). There are a few exceptions to this trend. For example, the studies of the Metaketa Initiative evaluated interventions to improve the monitoring capabilities of the participating communities, as well as other aspects, such as their capacity to negotiate with economic corporations (Slough et al., 2021; Christensen et al., 2021).

The relative lack of clearer theories of change and causality frameworks is another area of opportunity in this strand of observational research (Agrawal et al., 2002; Cumming et al., 2020). This is the result, in part, of the bundled nature of communal management of land. Across the world, places that administer forests and watersheds communally tend to be quite different from those that do not. In particular, many of the groups that have been able to successfully steward their forests under communal frameworks are indigenous; therefore, the presence of traditional forms of governance is an important source of selection bias, which complicates making inferences about the management of the commons (Gilmour, 2016; Garnett et al., 2018; Charnley and Poe, 2007; Maffi, 2005).

Moreover, in countries as diverse as India, Honduras, Mexico, Tanzania, Nepal, Peru, and Brazil, governments decentralize land use decisions as a form of political recognition and compensation of indigenous communities (Kashwan, 2017; Bray et al., 2012, 2005; Nygren, 2005; Oldekop et al., 2019). Hence, this overlap between communal tenure of land (group-based versus individual or state-owned) and the presence of traditional governance complicates the identification of causal effects of both variables, as these tend to occur together frequently.

Scholars in environmental studies have analyzed the specific effects that indigenous political institutions have on the stewardship of the commons. For example, according to Trosper (2002) and Monterroso et al. (2019), indigenous communities have extensive and in-depth knowledge of their lands that make them ideal stewards of forests and other ecosystems. In addition, Garnett et al. (2018), Nolte et al. (2013), and BenYishay et al. (2017) show a clear overlap between priority areas for conservation and indigenous territories, suggesting that securing access to property rights and supporting the political rights of these populations are essential for the preservation of global ecosystems. In addition, a growing number of studies show that indigenous forests with land security exhibit lower levels of deforestation than non-certified lands (Vélez et al., 2020; Baragwanath and Bayi, 2020; Garnett et al., 2018).

However, despite these important improvements in our understanding of the relationship between indigenous institutions and the commons, the literature is relatively underdeveloped on the reasons why the indigenous stewardship of ecosystems works. In a recent literature review on the topic, the authors propose different reasons why indigenous peoples are successful at preserving their commons; however, most of these are associated with their communal tenure of land, instead of their political and decision-making institutions (Dawson et al., 2021). Another strand of research in political science can offer valuable insights to address this gap. Numerous scholars show that institutions of indigenous governance impact political and economic outcomes (Van Cott, 2010). For example, Baldwin (2016, 2019) finds that traditional chiefs in Sub-Saharan Africa (Zambia) are instrumental for the distribution of economic resources at the local level.

The study of indigenous political institutions in the Mexican context has two main take-aways. First, communities with strong traditional frameworks of governance tend to have better levels of goods provision and negotiation capacity with the state. Elizalde (2020) argues that municipalities with more complex pre-Hispanic political institutions had higher rates of land redistribution after the revolution, a process that involved bargaining with federal authorities regarding the historical claims of that group to a specific territory. Moreover, according to Díaz-Cayeros et al. (2014), localities ruled under *usos y costumbres* in Oaxaca state have higher rates of public services provision. The presence of social norms of mutual help (such as the *tequio* or community-oriented work) and elite rotation are some of the reasons behind this relationship.

Second, however, other scholars have pointed out that politically-motivated reforms to the relationship between indigenous communities and the state can have certain deleterious effects (Benton, 2009, 2011). For example, Eisenstadt (2007) and Eisenstadt and Ríos (2014) show that electoral conflicts increased after the 1995 constitutional reform in Oaxaca state, particularly among indigenous communities.

A common theme across the literature on CPR and the research on indigenous politics is the key role of state recognition of indigenous rights and practices. Regarding the former, according to one of the cardinal design principles of Elinor Ostrom, the official recognition of the resource system boundaries by external authorities is an essential condition for local governance to positively affect the use of ecosystems (Ostrom, 1990).

In terms of the latter, scholars on indigenous politics in Latin America point out to the fight for autonomy as one of the main drivers of political activity among indigenous groups (Yashar, 1999, 2005; Trejo, 2012); hence, the complex and changing relationship with the state becomes a politically mobilizing force. The literature is more or less clear regarding the expected effect of providing secure titles; however, we do not have enough theoretical guidance about how changes in the political relationship between the state and communities may affect the extent to which these are able to steward their commons.

Finally, the third gap in the study of the commons that I address in this paper relates to methods and data. This literature has produced a vast array of theoretical statements, but few clear causal frameworks (Cumming et al., 2020). This is the result, in part, of the enormous complexity of resource systems, which escape straightforward generalizations and are highly dependent on the context. However, the lack of data is another reason.

Although progress in satellite technologies has made measuring environmental outcomes easier, the quantitative tests of many of the theoretical statements of this literature require in-depth and detailed records of communal behaviors and institutions, which are difficult to collect for large samples. Despite these challenges, there are some outstanding data-collection efforts, for example from CIFOR[2] and De Moor (2008, 2009); De Moor et al. (2016). While in the first case the authors organize a multi-country effort to collect institutional and political data on forest communities, the second one is based on archival research. More of these efforts are needed to make valuable inferences on how institutional change affects environmental outcomes.

In summary, local communities can play a key role in preserving ecosystems of global value and, in doing so, contribute to mitigate the causes of climate change and other forms of environmental degradation. Despite the vast literature on the drivers of successful local management of the commons, there are still some important gaps in our understanding of what makes some of them better able to engage in sustainable behaviors than others.

First, most of the existing quantitative analyses on CPR have focused on estimating the impacts of land tenure forms and property rights on environmental outcomes. In contrast, there has been less attention to investigate other political institutions that matter according to the literature. The role of indigenous governance and its recognition by state authorities is one of such factors. This is particularly relevant given that many of the areas that have participated in initiatives of natural resources decentralization are also indigenous. Finally, although satellite technologies have made the study of the commons easier, many theoretical insights of this literature require in-depth knowledge about the specific case and detailed behavioral and institutional data at the community-level, which are often expensive and difficult to collect for a large number of localities.

2.3 Theory and Observable Implications

I advance two arguments. First, I hypothesize that communities with long-standing indigenous political institutions should have lower levels of environmental degradation than those without such governance frameworks, as such political institutions favors higher levels of collective action. A key assumption of this hypothesis is that more potential for intra-group

[2]Center for International Forestry Research

cooperation is related to the more sustainable stewardship of the commons. Second, the links between indigenous peoples and the state should also influence their ability to administer their natural resources. Hence, reforms to the political autonomy of indigenous groups could either reinforce the institutional and social processes that make indigenous communities successful stewards of the commons or introduce political instability that diminishes the ability of the community members to act collectively.

The main dependent variable I analyze in this paper is the *sustainable stewardship of the commons*. A vast theoretical strand of research aims to define this term (Kruseman et al., 1996; Köhl et al., 2020). In general, the definition of sustainability is highly contested and complex. Instead of choosing one specific measure of this concept, I adopt a more comprehensive approach that looks at two different dimensions of the stewardship of the commons, one of those represents an environmental outcome of cooperation and the others specific outputs of collective action potential.

The first dimension conceptualizes "success" in terms of environmental outcomes, specifically the accumulated tree cover loss from 2001 to 2018 as a proportion of a baseline forest cover. This is probably the most direct and objective measure of effective administration of forest resources. Moreover, in contrast to other variables, advances in satellite technologies have resulted in few issues of data availability and granularity for deforestation rates, at least for the most recent periods (Hansen et al., 2013).

The second category of variables I analyze in this paper measure concrete manifestations of collective action. The first subgroup includes the number of communal forestry enterprises per community; these are economic units that exploit wood, manufacture furniture and paper, and promote eco-touristic activities. Hence, these initiatives reflect the extent to which the members of a group have been able to cooperate to leverage their natural resources (Vega and Keenan, 2016; Hernández-Aguilar et al., 2017).

The second subgroup of collective action measures the propensity of rural communities to apply for federal environmental programs, such as the payment for ecosystem services, forestry certification, and commercial logging. According to some scholars, these initiatives not only need the explicit acquiescence of community members to participate, but also require high levels of intra-group cooperation before and after the policy implementation (Alix-Garcia et al., 2018; Perevochtchikova and Ochoa Tamayo, 2012; Corbera et al., 2020; Chai et al., 2021). Finally, the last subcategory of variables to measure collective action potential includes the percent of a community's total surface that its members decided to exploit collectively, as opposed to individually-owned parcels.

My theoretical framework includes two key independent variables: (1) *indigenous political institutions* and (2) *state recognition of indigenous political autonomy*. I define the first one as the set of formal and informal rules that members of a polity design to select their representatives, participate in the public affairs of their community, monitor the behavior of their leaders, distribute and allocate public resources, and sanction certain behaviors; these norms are not only specific to that community, but also differ from the nationwide, "mainstream" political system (Recondo and Gallegos, 2007; Benton, 2011). It is important to mention that such rules do not have to be explicit or even written; neither does the state have to officially recognize them to be effective. As long as the members accept them as legitimate, they are functioning.

The second independent variable, *state recognition of indigenous political autonomy*, refers to the relationship between the state and indigenous peoples, including the specific political rights enshrined in national or local constitutions, the role that indigenous leaders have as intermediaries with the government, and the degree of autonomy in internal decision-making. As mentioned before, although the state does not need to officially recognize local traditional institutions for these to influence social interactions, it can affect them in different ways. Moreover, for indigenous groups across the world, political autonomy and the right to self-determination are key mobilizing political forces.

In addition to the outcomes and the main independent variables, my theoretical framework includes *rules of resource use and appropriation*, which refer to formal or informal norms that determine who is allowed to extract natural resources, under what conditions, and the consequences of defective behavior. These rules include, for example, quotas of tree harvesting, fees for water pollution, and the designation of specific areas for conservation; in addition, many of these norms are informal, for example implicit understandings about legitimate and illegitimate uses of natural resources.

In terms of the relationships among the aforementioned variables, Panel A in Fig. 2.1 shows the somewhat strong consensus in the literature that high levels of collective action are associated with better environmental outcomes in the commons: when community members are able to cooperate with one another, they are more capable of monitoring defective behavior, enforce their rules of resource use and appropriation, and engage in more complex projects that promote ecosystem conservation.

Panels B and C in Fig. 2.1 summarize the main relationships I study in this paper. First, I argue that the presence of traditional governance frameworks are positively associated with the levels of collective action. As mentioned by various scholars in the Mexican case, the rotation of leadership along a hierarchical community-level administration, the presence of communal obligations attached to public office, and the monitoring role of the assembly are some of the reasons why indigenous communities in Mexico have high levels of collective action, which affects political outcomes such as the bargaining positions with the government and the provision of public services (Elizalde, 2020; Díaz-Cayeros et al., 2014). Hence, I argue that this political framework should also impact other variables that depend on intra-group cooperation, such as the management of forests. It is important to mention that *indigenous political institutions* also affect the stewardship of the commons through the creation of distinctive *rules of resource use.*

Finally, Panel D in Figure 2.1 displays the theorized relationship between the second independent variable (*state recognition of indigenous political autonomy*) and the commons. In contrast to the relatively straightforward theoretical association between property rights and the stewardship of forests, the literature is not that clear regarding how changes in the political relationship between communities and the state affects the management of land. I posit two specific hypotheses about this relationship.

First, reforms of indigenous political autonomy can have heterogeneous effects on the commons depending on their nature. On the one hand, it is possible that effective state recognition (for example through constitutional provisions that shield local decision-making from external actors) reinforces the social and institutional processes that make indigenous communities successful stewards of the commons; with less external intervention on local affairs, these groups should be better able to design, enforce, and reform their resource use and appropriation rules. This is also one of Ostrom's eight design principles for successful management of the commons.

Nonetheless, it is crucial to point out that these reforms are in many cases politically motivated by issues other than the political rights of indigenous peoples. Hence, on the other hand, it is possible that such changes in the state-community relationship either reinforce pre-existing political linkages between communities and external actors or generate new ones (Recondo and Gallegos, 2007); in doing so, they could also incentivize instability and conflict. Instead of allowing indigenous communities to design, implement, and adapt their resource use rules, these reforms could strengthen old constraints and add new ones, in addition to undermine the collective action potential of these groups.

Second, I argue that reforms of indigenous political autonomy should affect particularly rural communities with long-standing institutions of traditional governance relative to groups without this framework. As mentioned before, indigenous communities have not only different rules of resource use and appropriation, but also higher levels of collective action and social cohesion. Since they have developed this political and societal features over time in relative isolation from (or in many cases in confrontation with) the state, they should be more sensitive to changes in this relationship.

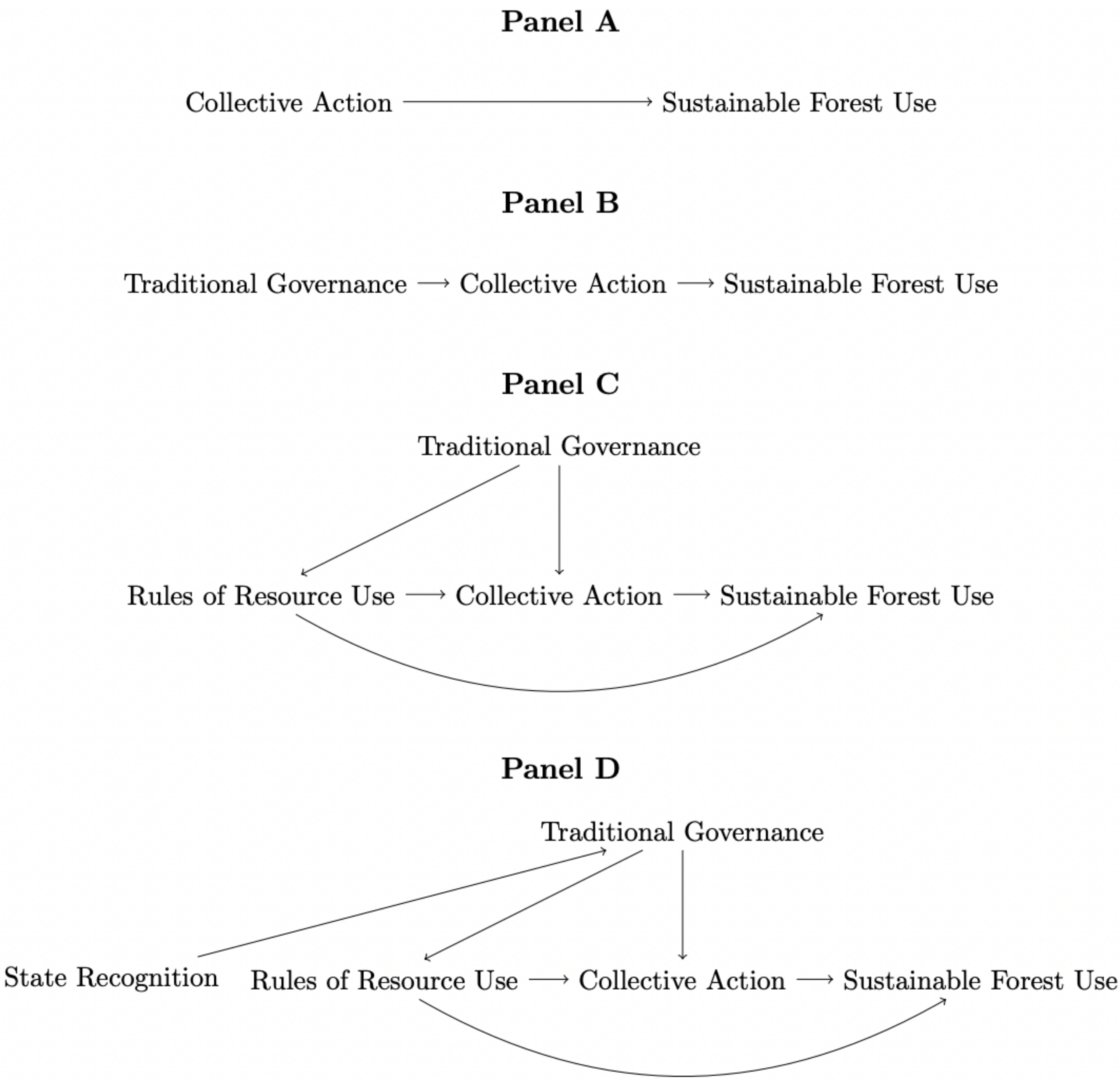


Figure 2.1: **Causal structure of the argument for chapter 1**

In summary, in this paper I posit that communities with indigenous political institutions are more effective stewards of the commons due to their higher levels of collective action and their specific rules of resource use and appropriation. Moreover, although autonomy from external political actors is crucial to realize this potential, reforms to the relationship between communities and the state could be a double-edged sword: these changes could strengthen local decision-making by shielding communities from external pressures, but they can also reinforce old political linkages and generate new ones, which could be detrimental for the management of the commons.

Specifically, I test the empirical validity of four observable implications:

- H1: communities with long-standing institutions of indigenous governance should experience more sustainable uses of forested land—lower accumulated deforestation—than comparable communities without this institutional framework.
- H2: communities with long-standing institutions of indigenous governance should have higher levels of collective action—including more communal enterprises and a higher likelihood to apply for federal conservation programs—than comparable communities without this institutional framework.
- H3: changes in the relationship between the state and communities could have positive (negative) impacts on the commons if such reform reinforces (diminishes) the ability of these groups to cooperate and enforce their rules.
- H4: communities with long-standing institutions of indigenous governance should be particularly sensitive to changes in their relationship with the state.

2.4 Historical Background

2.4.1 Communal Land Tenure and Traditional Forms of Political Governance in Mexican Indigenous Communities

Communal stewardship of natural resources and indigenous customary law have been closely related throughout Mexico's history (Woolley, 2020). This makes the country an ideal setting to study how traditional governance affects the stewardship of common-pool resources. Although the current land tenure system in Mexico has a strong colonial (and even pre-colonial) background, it emerged in its current form after the civil war (1910-1920). The post-revolutionary governments redistributed 102 million hectares of land from 1916 to 1992 to approximately 32,000 rural communities; these are known as *ejidos* and *comunidades agrarias* in Spanish (Morett-Sánchez and Cosío-Ruiz, 2017; Albertus, 2015; Albertus et al., 2016; Cornelius and Myhre, 1998; Bray, 2013; Boyer, 2015).

Both types of rural villages represent a form of "social property" of the land. In terms of their political institutions, the community assembly, or *asamblea comunal*, is the highest deliberative body and has ultimate authority over land use issues. In contrast, the *comisariado ejidal* or the *comisariado de bienes comunales* are the main executive figures, in charge of the daily administration of the community's assets. Finally a watching council, or *consejo de vigilancia*, oversees the activities of the *comisariado de bienes comunales / ejidales*. A key characteristic of these communities is that, although their contribution to the economy, including agriculture, is rather small, they still own the majority of the country's land, including forests and reservoirs for the expansion of urban areas. Nonetheless, the federal government heavily regulates the management of these resources, including land transactions and logging (Lozano Moheno, 2012).

Moreover, although *ejidos* and *comunidades agrarias* have identical legal standing and basic institutional structures, their historical origins are quite different. Landless farmers, mostly former *hacienda* workers, constituted groups that petitioned for land to the government, which divided large landholdings to create most *ejidos*. In contrast, *comunidades agrarias* bargained the government to receive a specific territory, to which they had historical claims (Morett-Sánchez and Cosío-Ruiz, 2017).

Many of them dated back to the (pre-) colonial period of Mexican history, when the Spanish crown created semi-autonomous indigenous townships to both consolidate the remaining indigenous population—decimated by war and disease—and increase their control over the local population (Woolley, 2020; Robinson, 2007; Menegus Bornemann, 1994; Hillerkuss et al., 1995; Pazos, 2004). For most of these groups, there is a close association between their historical identity as a community, ownership over a specific territory (and its resources), religious affiliation, and ethnicity (Caballero, 2017).

Customary law still influences the governance of thousands of indigenous communities across Mexico, particularly regarding the stewardship of their common-pool resources. It is necessary to emphasize that there are many varieties of institutions of traditional governance in Mexico, which are as diverse as the dozens of officially recognized (and unofficial) indigenous peoples in the country.

Nonetheless, there are a few characteristics shared by many of these communities (Gaussens, 2019; Gómez Hernández et al., 2005; Recondo and Gallegos, 2007; Viqueira and Sonnleitner, 2000). First, their decision-making usually involves mechanisms of direct democracy and deliberation within the community assembly. Moreover, elders have an important advisory role, which is sometimes recognized in the form of a council. These mechanisms are particularly relevant for the administration of land and other natural resources; for those indigenous peoples that also own their land communally, the assembly is the ultimate authority on these issues, ranging from the inclusion of new members with land rights and domestic-use logging permits to the conversion of sections of the commons to individual parcels.

Second, the process to select leaders is not only highly participatory, but also implies a rigid process of public service along a hierarchy of office, also known as *sistema de cargos* in Spanish. That is, service at a high level, for example mayor, requires previous experience with lower offices, for example *topil*, in charge of local police. As mentioned by various scholars (Recondo and Gallegos, 2007), this system reinforces some socioeconomic inequalities, as public officials are responsible for funding communal events, including religious festivities, which can be quite expensive. Across many communities of Mexico, these positions include the *comisariado de bienes comunales* or the *consejo de vigilancia*, in charge of the administration of the community's territory and natural resources.

Finally, the third component of traditional governance in Mexico is role of social norms for mutual help; community members are expected to display pro-social behavior, usually in the form of labor, known as *tequio* in some regions of Mexico. Given that the state is sometimes absent in these communities, such mechanisms are essential to ensure the provision of key public goods and services, including roads, bridges, and sanitation (Díaz-Cayeros et al., 2014). The *tequio* is also fundamental for forest-related activities, including the formation of brigades to extinguish fires, reforestation campaigns, and the operation of community forestry enterprises, among many others.

2.4.2 Indigenous Autonomy as a Political Issue in Mexico: the 1995 Constitutional Reform in Oaxaca State

From the late 18th to the late 19th, the role of indigenous communities, in particular their ownership of part of Mexico's land, was one a contentious political issue. One faction (the Liberal Party) aimed to privatize most of Mexico's territory, including the land of civil and religious corporations, to create a class of small farmers. The other (the Conservative Party) sought to maintain the privileges of the elites and the Catholic church and preserve the status quo. By the end of this period, the government of dictator Porfirio Diaz (1876-1910) grabbed millions of hectares of land from indigenous communities and offered them to foreign extractive industries, such as oil and mining, as well as powerful agricultural landowners (or *hacendados*). This massive dispossession became one of the key grievances that led to the Mexican Revolution in 1910 (Boyer, 2015; Santiago and Santiago, 2006).

Indigenous communities have also retained some of their political institutions despite of centuries of tumultuous change and exploitation. Along with the restoration and redistribution of land that happened during the hegemonic party rule, the regime implicitly recognized some of indigenous peoples' political norms, as long as they stayed under the PRI umbrella. According to various scholars, the party built strong connections with indigenous leaders, favoring some *caciques*, to whom the PRI gave a high degree of autonomy, in exchange for order and votes. Hence, during most of the 20th century, many indigenous communities in Mexico experienced a form of "indirect rule" (Recondo and Gallegos, 2007).

Nonetheless, the economic and political crisis of the 1970s and 1980s eroded this status quo; as explained by Yashar (2005) and Trejo (2012), indigenous protests became more common in the last third of the 20th century, a process that culminated in the *Zapatista* uprising in Chiapas state—southern Mexico—on January 1st 1994. At the national level, this event reignited discussions about the role of indigenous peoples in the country, which culminated in the (mostly symbolic) reform of the constitution that recognized the multicultural nature of the Mexican state. Similar political debates occurred in other Latin American countries; moreover, the recognition of indigenous peoples' rights through the International Labor Organization Covenant 169 provided an additional basis for multiple social movements that aim to increase the autonomy of indigenous peoples across the world.

Although the armed stage of the indigenous movement in Chiapas ended relatively quickly, the relationship between the state and indigenous peoples in Mexico is still quite contentious (Eisenstadt, 2007). Moreover, this population is much poorer and marginalized than the rest, facing considerable barriers for education, employment, and access to public services, among many others.

In this national and international context, the local assembly in Oaxaca state modified article 25 of the state's electoral code in 1995 to officially sanction the election of municipal authorities by *usos y costumbres* (Valdivia Dounce, 2010), or traditional electoral governance. This includes, among other elements, the recognition of the local assembly as the supreme electoral body in a municipality and the creation of lists of candidates without the intervention of political parties. Recondo and Gallegos (2007) offer a quite detailed explanation of the background, implementation, and consequences of this political reform. According to them, the progressive politics of the governor at the time, the fear of the local elites about a possible contagion of the *Zapatista* uprising, and secular changes in the electoral performance of the PRI, especially in rural areas, were among the many reasons that led to this constitutional change in 1995.

As such, both the ruling PRI and the opposition (in particular the PRD, which had separated from it in the late 1980s) had key political motivations to officially recognize *usos y costumbres*. The former aimed to "shield" indigenous municipalities from electoral competition; even if the PRI was not allowed to register candidates, its decades-long linkages with indigenous communities and local leaders would ensure its dominance. The latter sought to create a more advantageous political arena by restricting the influence of the PRI in some of the rural areas of the state (Recondo and Gallegos, 2007). Hence, this constitutional reform was mostly motivated by the political interests of the largest parties, despite the activism and interests of grassroots organizations and representatives of indigenous peoples.

The process leading to the constitutional reform and its implementation were quite politically contentious. In addition to procedural questions, such as the option for indigenous municipalities to register their candidates via a political party, conceptual questions about what constitutes traditional governance and what municipalities had to be included within this framework were two of the main sources of conflict.

As mentioned by Recondo and Gallegos (2007), negotiations among partisan elites resolved both issues. This resulted in political definitions of *usos y costumbres* based more on the equilibrium of different forces than on a pristine notion of what is indigenous and what is not (Recondo and Gallegos, 2007). For example, the temporal frame to qualify a municipality as indigenous range from "ancient times" to "at least three years". In the end, local politicians agreed that the 570 municipalities of the state were classified in two mutually exclusive electoral regimes: 73% corresponding to *usos y costumbres* and the rest denoted as *partidos políticos* (Recondo and Gallegos, 2007). This led, in consequence, to multiple post-reform electoral and societal conflicts, particularly within indigenous municipalities (Eisenstadt, 2007; Eisenstadt and Ríos, 2014).

In summary, the 1995 constitutional reform in Oaxaca state represented a politically-motivated change in the relationship between the state and indigenous communities. Its implementation demonstrated the complexities of terms such as "indigenous" and the difficulties in assigning clear borders between categories of governance that had been historically intertwined (Recondo and Gallegos, 2007).

Moreover, it is a clear example of how political parties and leaders employ agendas such as the political autonomy of indigenous peoples to advance their specific electoral interests, as well as of the unexpected and deleterious consequences that changes in this relationship can bring about. For the purposes of this paper, I consider this reform as an independent variable. The "treatment" is an externally-imposed change in the relationship between state and communities; specifically, by assigning a mutually exclusive category of electoral system, the local assembly induced a process of political change within municipalities, which affected communities, parties, and bureaucracies alike.

2.5 Research Design

A large proportion of the research on communal governance of natural resources has employed case studies and comparisons among a small number of cases. In this paper, I use a quantitative approach to analyze the case of Mexico, a natural laboratory with thousands of resource systems (*ejidos* and *comunidades agrarias*). Nonetheless, identifying the causal effects of traditional institutions of governance and their recognition by the state on land use decisions is challenging for at least two reasons. First, governments tend to decentralize the administration of natural resources as a response to demands from indigenous peoples (Kashwan, 2017); this implies that many—if not most—of the areas where communal governance of forests is allowed have different political institutions as well. Hence, it is challenging to separate the relative effects of two variables: (1) the specific form of land tenure and (2) the political framework of governance. This is key to understand the relevance of specific factors in the success of local communities.

Second, the relationship between state and indigenous communities is a slow-moving phenomenon that changes little over time. In contrast to land reforms and policies to recognize indigenous land tenure, which have usually clear starting and ending points and well-defined treated and control units, many reforms to the political autonomy of indigenous peoples are piecemeal. Although large-scale reforms do occur, they are less common; the 1995 change in Oaxaca's constitution is a clear example.

To address some of these concerns, my empirical strategy two building blocks. First, to analyze the correlation between traditional governance and the stewardship of the commons, I leverage cross-sectional variation in the presence of long-standing indigenous political institutions across rural villages in Mexico. As mentioned before, not all *ejidos* and *comunidades agrarias* have traditional governance frameworks and not all indigenous peoples have communally-held land. This setting allows me to explore differences in deforestation and collective action trajectories in indigenous and non-indigenous communities, controlling for the specific mechanism of land tenure.

Although there are multiple ways to classify a community as indigenous, I employ a historical approach centered on the longevity of an indigenous polity. As mentioned before, hundreds of these communities date back to pre-colonial and colonial times; from a resource governance perspective, long-term political frameworks are more suitable for successful intra-group cooperation than short-term ones. Hence, I employ a dataset with the geo-coded location of all indigenous townships that existed by the end of the colonial period in Mexico (Robinson, 2007), the earliest available data source.

Specifically, I determine whether a present-day *ejido* or *comunidad agraria* has one or more of these historical localities within their territory; I argue this is a good approximation of the presence of long-standing indigenous institutions. However, this strategy has two caveats. First, I assume a historical continuity from villages in 1800 to present-day communities as political entities; nonetheless, despite the measurement error, I posit this is still a more feasible approximation to my main independent variable than other options. For example, there is no data on the proportion of the population who self-identify as belonging to an indigenous group at the local level in Mexico. Second, the inferences I can extract from this data are exclusively correlational and have no causal interpretation.

The second building block of my empirical strategy employs a regression discontinuity design to leverage the geographic and temporal variation created by the 1995 constitutional reform in Oaxaca. From a cross-sectional perspective, this political change created a border between municipalities with *usos y costumbres* and municipalities with *partidos politicos*. As a result, some indigenous villages ended up in one side of the border and experienced a politically-motivated change in the relationship between the state and indigenous communities, while others were not exposed to this.

Although forested lands in indigenous and non-indigenous villages are quite different, those located in the vicinity of the border have identical potential outcomes—they face the same pressures for deforestation, on average—except for the change in the treatment variable. Hence, forested lands at the *partidos políticos* side of the border are a good counterfactual of the neighboring forested lands at the *usos y costumbres* side. I follow the empirical strategy of other scholars who have analyzed environmental and developmental outcomes in Mexico and Brazil with a similar approach geospatial (Díaz-Cayeros et al., 2014; Baragwanath and Bayi, 2020). Figure 2.2 presents a graphical description of the process of treatment assignment in Oaxaca state.

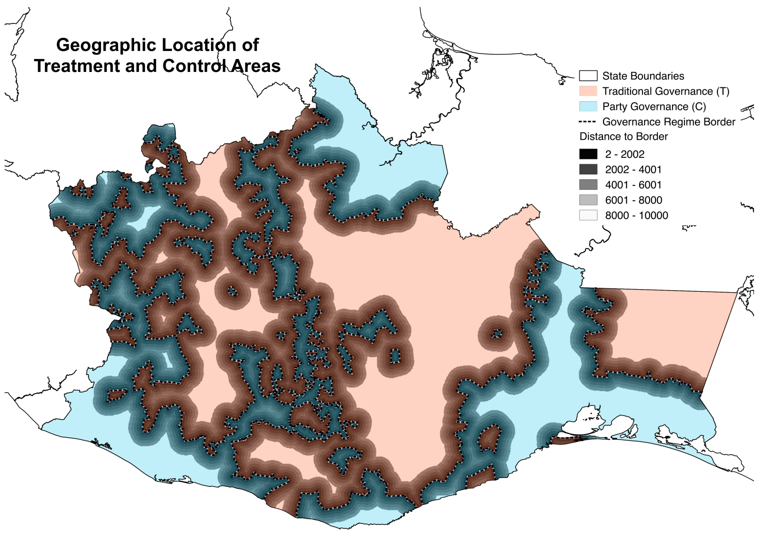


Figure 2.2: **Border between governance regimes in Oaxaca state**

From a temporal perspective, the nature of the reform allows me to test the discontinuity at different points in time (Baragwanath and Bayi, 2020). Given that the literature does not offer clear theoretical guidance with respect to when should we expect a change in the relationship between the state and indigenous communities to affect the commons, I adopt an agnostic approach with various tests. These include a broad before and after comparison, as well as more fine-grained analysis in the short, medium, and long-terms—defined with five year intervals starting from 1995 up to 2014.

As with any other regression discontinuity design, the validity of this quasi-natural experiment rests on three assumptions. First, I assume that the units of analysis cannot sort around each side of the border. If this were to happen, then the variation along the cutoff would not be exogenous to the treatment (and would be related to the choice to sort around the discontinuity), which would diminish the internal validity of the design.

The process of treatment assignment suggests that this was not the case in the 1995 constitutional reform. On the one hand, the local assembly determined in 1995 what municipalities belong to each category of electoral governance. Despite a few instances of changes to this list in the months after the initial negotiation, it has remained remarkably stable. Therefore, all *ejidos* or *comunidades agrarias* in a given municipality received one treatment condition. Moreover, it is important to remember that villages are not allowed to change municipalities—each community belongs to only one municipality. Finally, according to the agrarian legislation of Mexico, communities and individual landowners cannot choose what *ejido* or *comunidad agraria* they are part of. Hence, any given plot of forested land was assigned only one treatment condition (*usos y costumbres* or *political parties*) as a result of the 1995 constitutional reform in Oaxaca state.

A second key assumption of my empirical setting is that the running variable has enough data density around the cutoff. By design, this is not an issue in this paper. Given the unit of analysis (pixels of forested land) and the resolution of the outcome variable data, there are enough observations along the immediate vicinity of the border.

Finally, the third key assumption in any regression discontinuity is that other variables that may affect the main outcome do not "jump" at the cutoff. If this were the case, it would be difficult to disentangle the relative effects of these other factors with respect to the treatment of interest. Scholars have long studied the drivers of land use change in Mexico. These include, for example, proximity to markets, urbanization, and the expansion of the agricultural frontier. In the Supporting Information to this chapter (Figures **2.19** to **2.25**), I show that there are no discontinuities in several geo-physical and economic variables associated with deforestation, including distance to small and large cities, distance to highways, levels of economic activity before the 1995 reform, percent of land corresponding to priority ecosystems, and percent of land suitable for commercial forestry.

2.6 Data Sources and Methods

2.6.1 Cross-Sectional Analysis of Traditional Institutions, Collective Action, and Land Use Change

The unit of analysis in the first building block of my empirical design is the rural community. There are 32,154 *ejidos* and *comunidades agrarias* registered in Mexico. Their corresponding spatial polygons come from the *Padrón e Historial de Núcleos Agrarios* (PHINA) of the National Agrarian Registry (RAN). It is important to notice that there is no geo-referenced data for approximately 8% of these rural villages; intra or inter-group conflict is the main reason why these communities have not been regularized and therefore they are not present in my data. The specific sample I employ in this paper corresponds to rural villages with more than 10% of their surface covered by forest, which I define as *forest communities*. Figure 2.3 shows their geographic distribution.

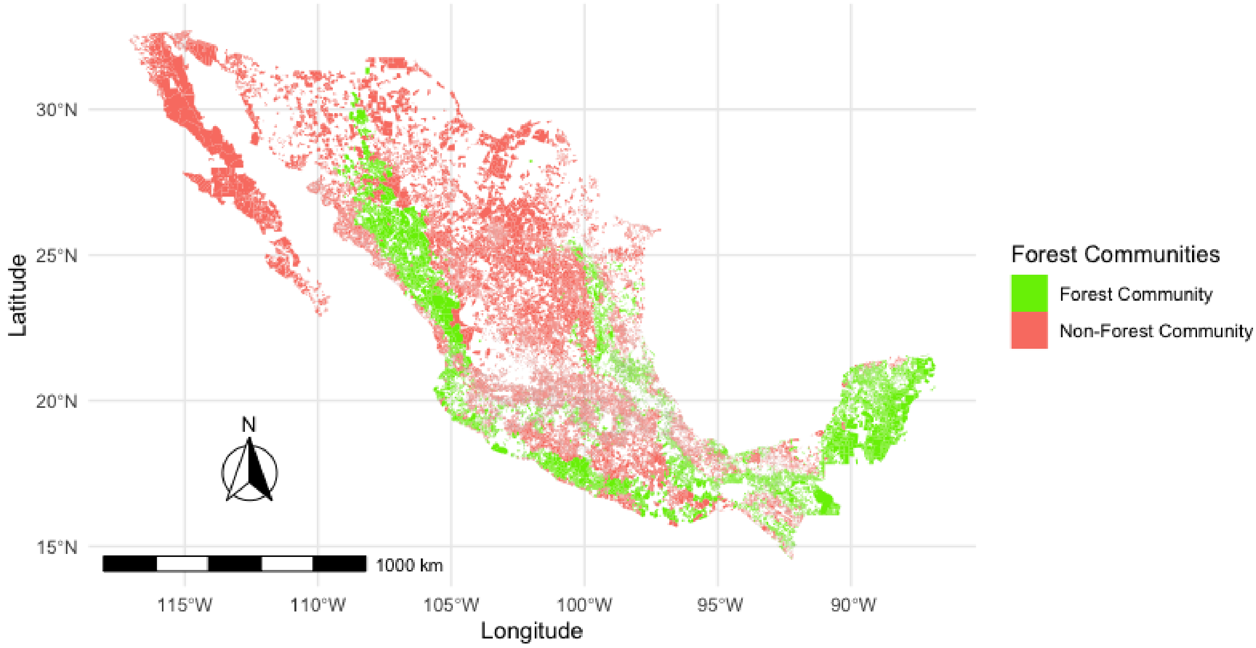


Figure 2.3: **Forest communities in Mexico**

I analyze two sets of outcomes: (1) environmental and (2) collective action. The first group includes the accumulated tree cover loss from 2001 to 2018, measured as the percent of the total forest cover in 2000. The remote sensing data comes from the Global Forest Watch project (Hansen et al., 2013); the authors created aggregate composites of natural vegetation based on satellite imagery with high resolution (the pixels are 30m by 30m). This data is publicly available and ready for statistical analysis without further processing. First, I calculate the percent of the total village's surface covered by forests in 2000. Then, I subtract the percent of forest-pixels lost from 2001 to 2018. The values of this variable go from 0—indicating that the community did not lose any of the forests it had in the baseline year–to 100—which denotes full deforestation.

In addition to this variable, I also analyze the differences in collective action outcomes in indigenous versus non-indigenous communities, including: (1) the probability of successfully applying for any program from Mexico's National Forest Commission (CONAFOR), (2) the amount received from the CONAFOR, (3) the total number of forestry-related economic units in the village, and (4) the initial allocation of communal lands as a percent of the total area of the community at the moment of certification. Each of these variables reflects the potential for collective action within a community. For example, to successfully apply for a CONAFOR program, the members of the community need to approve their participation in the local assembly, in addition to submit a large number of requirements. The data comes from the CONAFOR, the RAN, and the National Statistics Institute (INEGI). For more details about these variables, see the Supporting Information to this chapter (section **2.9.7**).

Finally, the main independent variable is the presence of a historical indigenous township within the current borders of a community. The data comes from Robinson (2007), who geo-referenced all of these settlements as of 1800, based on a historical atlas of the time. Whereas many of them disappeared and others were absorbed by large urban areas (for example Mexico City), many others survived in one form or another. For example, Capulalpam de Mendez in the northern range (*Sierra Norte*) of Oaxaca state was founded in the late XI century and still remains a well-defined indigenous polity.

In terms of methods, given that the treatment is not randomly assigned, I simply compare the difference in means between indigenous and non-indigenous communities across the aforementioned environmental and developmental outcomes with descriptive purposes only. As a robustness check, I also employ propensity score matching to create comparable samples of treated and control units and reduce the imbalance in key variables.

To do so, I use geo-physical variables that predict assignment into the treatment (having a historical indigenous township), including elevation, distance to small and medium cities, and percent of the surface covered by forestry and conservation areas. It is important to mention that this exercise is for correlational purposes only. Figures 2.4 and 2.5 shows the geographic distribution of these historical localities across Mexico.

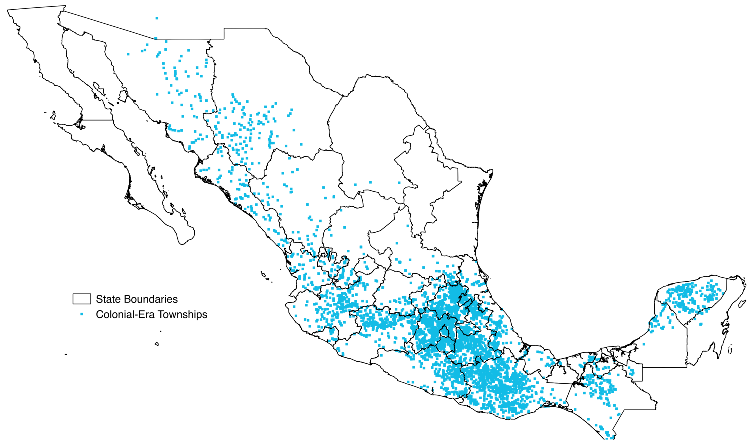


Figure 2.4: **Historical indigenous localities in Mexico**

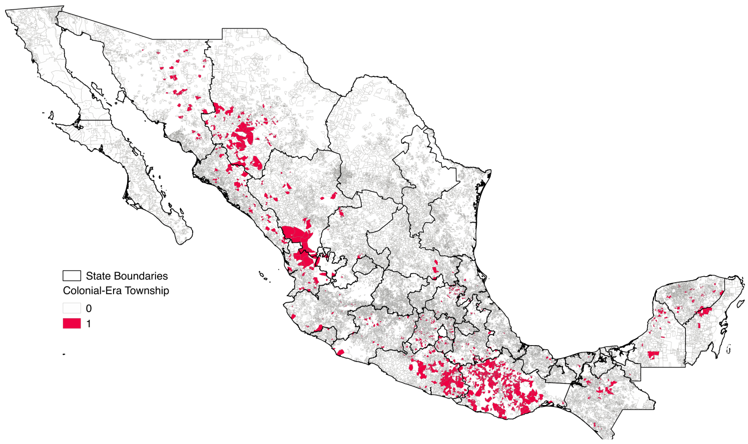


Figure 2.5: **Rural communities with a historical indigenous locality in Mexico**

2.6.2 Quasi-Natural Experiment in Oaxaca state

Following Kopas et al. (2018) and Baragwanath and Bayi (2020), the unit of analysis in the second building block of the empirical design are 10,569 polygons of land of identical shape and size. As in the previous case, the main outcome variable is deforestation, which I calculate as the difference in tree cover loss in year t with respect to *t-1*. The data also comes from Hansen et al. (2013), but it is an earlier version with two key differences: (1) it goes back to 1982 and (2) it has less resolution than the most recent version.

For each one of these 10,569 polygons, I calculate the distance, in kilometers, from their centroid to the border between *usos y costumbres* municipalities and *partidos políticos* municipalities, which is the running variable I employ in the regression discontinuity. The official list of municipalities that belong to each category comes from Oaxaca's Electoral Institute and the corresponding shapefiles come from the National Institute of Statistics and Geography (INEGI).

As mentioned before, one of the key assumptions of any regression discontinuity design is that other variables that may affect the outcome do not "jump" at the cutoff point. To test this assumption, I collect the following variables at the polygon level. First, I use the average nighttime luminosity in 1992 (the earliest year available) as an approximation to the levels of economic activity and population; the data comes from the Defense Meteorological Satellite / Operational Linescan System of NASA.

Second, I also calculate the distance from the polygon's centroid to the closest urban settlement of 5,000 inhabitants or more, as a measure of proximity to agricultural markets. I repeat this procedure for cities of 10, 20, and 50,000 or more inhabitants. The population data comes from the INEGI. Third, as an alternative proxy for distance to markets, I include the distance from the polygon to the closest highway. The data also comes from INEGI. Fourth, it is possible that forested lands located at one side of the border have a higher potential for forestry activities or harbor more biodiversity, which could affect their deforestation rates; to test possible changes in these factors at the cutoff, I also calculate the percent of a polygon's area corresponding to areas suitable for forestry and high in biodiversity. The data comes from the National Forest Commission (CONAFOR).

In terms of methods, I employ a geographic regression discontinuity (RDD) to estimate the local average treatment effect (LATE) of the 1995 constitutional reform on the rate of deforestation. The models I selected have the following characteristics. First, the selection of the bandwidth along the cutoff is one of the most important technical aspects to estimate an RDD. I follow Calonico et al. (2017, 2014); Cattaneo et al. (2019) and employ their procedure to select an optimal bandwidth (the option `mserd` in the `rdrobust` package).

Second, I am agnostic with respect to the functional form of the local regression at either side of the cutoff. Although my robustness checks include polynomials from order 2 to 4, as well as local linear regression, I follow both Baragwanath and Bayi (2020) and Díaz-Cayeros et al. (2014) and choose polynomial 4 as the main specification. Third, to compute the heteroskedasticity robust variance, I employ nearest neighbor matching with three matches. I estimated all the models corresponding to this part of the analysis with the `rdrobust` package in R (Calonico et al., 2017).

As mentioned before, this research setting allows me to explore nuanced hypotheses about the role of state recognition of indigenous autonomy in different types of forested lands and along multiple time frames. I start the analysis by estimating the aforementioned model using the full sample of all forested lands in the state before and after the reform (1982-1994 and 1995-2014). This empirical tests sheds light on how deforestation changes at either side of the border in the post-reform period compared to the pre-refom period.

Then, I continue with the same temporal frame (one RDD for 1982-1994 and another one for 1995-2014), but splitting the data into three different subsamples, each one corresponding to a specific type of forested land: (1) forests held communally in villages with long-standing indigenous institutions, (2) forests held communally in villages without long-standing indigenous institutions, and (3) forests held non-communally.

Finally, given that the literature does not offer clear theoretical guidance as to when should we expect to see the effects of changes in the recognition of indigenous autonomy, I estimate the RDD in subperiods of five years starting with the adoption of the reform: 1995-1999, 2000-2004, 2005-2009, and 2010-2014.

2.7 Statistical Analysis

2.7.1 Cross-Sectional Analysis

The initial take-away from this study is that the presence of historical indigenous townships within the current borders of a community is associated with lower environmental degradation. Communities with long-standing indigenous institutions experienced 2.4% less accumulated deforestation from 2001 to 2018 than rural communities without a historical indigenous township within their borders; this difference is statistically significant at the 1% level and it is equivalent to approximately one third of a standard deviation in the outcome variable—7.8% of tree cover lost from 2001 to 2018. See Fig 2.6

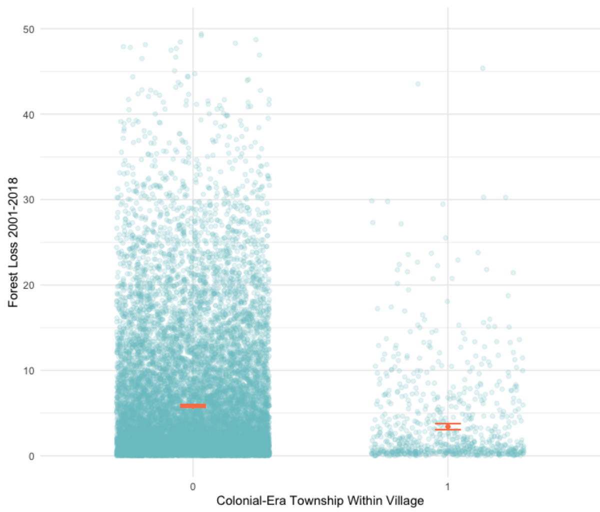


Figure 2.6: **Accumulated tree cover loss from 2001 to 2018**

Moreover, the data shows that communities with historical indigenous townships have also higher levels of collective action than those without them. First, they are 31% more likely to apply for environmental programs from Mexico's National Forest Commission (CONAFOR). This difference in means is statistically significant at the 1% level and it is quite substantial, as it is equivalent to 65% of a standard deviation in this variable. Moreover, communities with historical indigenous localities receive, on average, more funds than non-indigenous communities—1.2 million pesos approximately; this difference is statistically significant at the 1% level and it is equivalent to almost 60% of a standard deviation in the outcome variable. See Figure 2.7 and Figure 2.8.

Second, these communities have established a higher number of forestry-related firms. They have, on average, 0.11 more paper firms, 1.37 more wood firms, 0.56 more furniture firms, and 0.46 more touristic firms. In general, these rural villages have 2.41 forest-related firms than communities without long-standing institutions. All of these differences are statistically significant at the 1%; in addition, the magnitudes of these differences in means are high, ranging from 0.26 standard deviations of the dependent variable for paper firms to 0.42 standard deviations for wood firms.

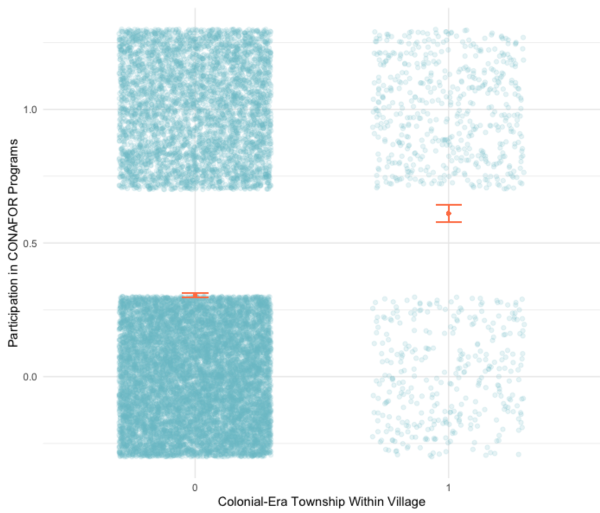


Figure 2.7: **Probability of applying to a CONAFOR program**

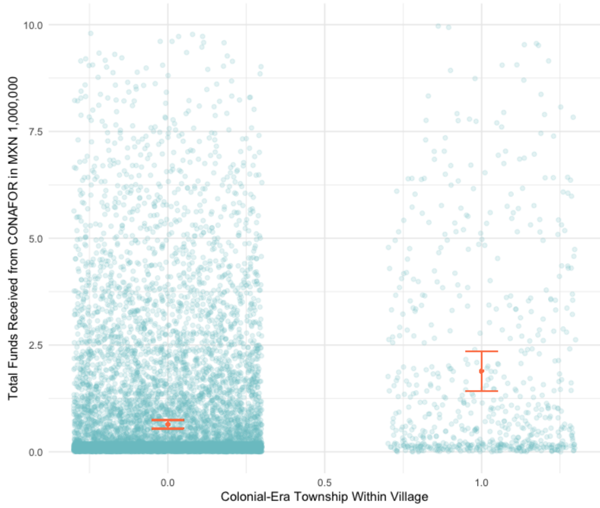


Figure 2.8: **Funds received from CONAFOR**

Finally, communities with a historical indigenous township in their borders had, on average, a higher share of their total surface devoted to communal lands versus individual parcels, compared to rural villages without this institutional framework. The difference between the two groups (35%) is statistically significant at the 1% level and it is equivalent to 0.86 standard deviations of the outcome variabke. See Fig 2.9.

Therefore, the first cut of the analysis shows a strong correlation between the presence of long-standing traditional institutions and the stewardship of the commons. On the one hand, these rural villages exhibited considerably lower levels of environmental degradation. On the other, they are also different from the rest of communities regarding their levels of collective action, as they are more likely to apply for federal conservation programs, have more communal enterprises, and devote more of their land to common areas than villages without this political framework. Hence, the evidence suggests that a possible channel through which traditional institutions affect the stewardship of the commons is through their role in fostering collective action.

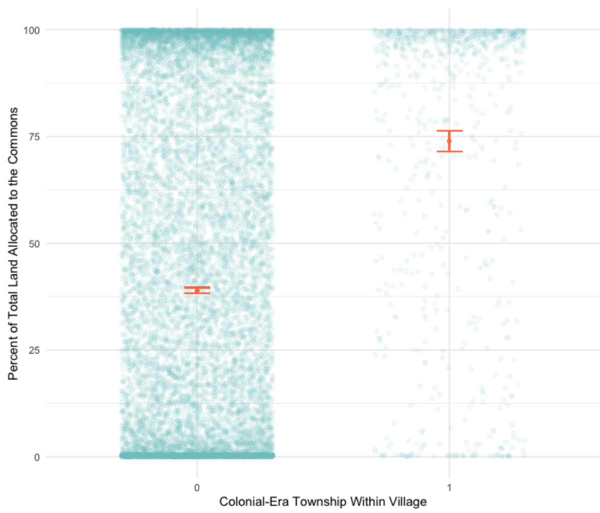


Figure 2.9: **Communal land as percent of total surface**

As robustness checks, Tables **2.2-2.5** in the Supporting Information show the results of linear regression models of (1) the accumulated levels of deforestation from 2001 to 2018, (2) the percent of the community's surface allocated to the commons, (3) the probability of participating in CONAFOR's conservation and commercial forestry programs, and (4) the total number of forestry-related enterprises on the presence of historical indigenous localities. The models include, in addition to the main independent variable, a wide array of geographic, economic, and political controls: (1) total surface, (2) percent of forest cover in 2000, (3) elevation (meters above sea level), (4) the levels of economic activity, (5) distance to urban areas (markets), (6) the total number of intra-community conflicts, (7) the presence of regular communal elections, and (8) whether the corresponding municipality is classified as indigenous by the government. I employ a propensity score matching algorithm to create a more balanced sample of treated and control units. Table **2.6** shows the results of a linear regression model employing these samples.

2.7.2 Geographic Regression Discontinuity Analysis

The second key take-away from this study is that reforms that change the relationship between the state and indigenous communities could have unexpected, deleterious effects on the stewardship of the commons. I divide the analysis of the geographic regression discontinuity in three components. First, Figure 2.10 and Figure 2.11 show that the official recognition of autonomy is not associated with changes in the rates of deforestation either before (1982-1994) or after the reform (1995-2014) for the full sample of forested lands. Hence, the official recognition of indigenous autonomy did not have an effect on the stewardship of the commons in the state at large, as the rate of deforestation is statistically identical at both sides of the border between political regimes.

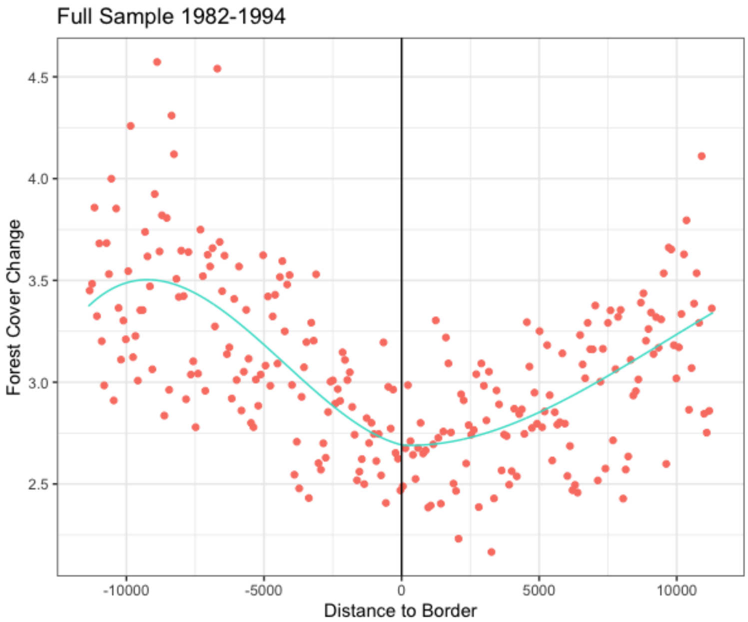


Figure 2.10: **Regression discontinuity for the full sample**. This plot displays the results of the regression discontinuity analysis for all forested areas in the state. Mainstream political parties areas are located to the left of the vertical line at 0, whereas indigenous forests are located to the right of the area. The Y axis denotes the average rate of tree cover loss. The period of analysis is *before the reform*, from 1982 to 1994.

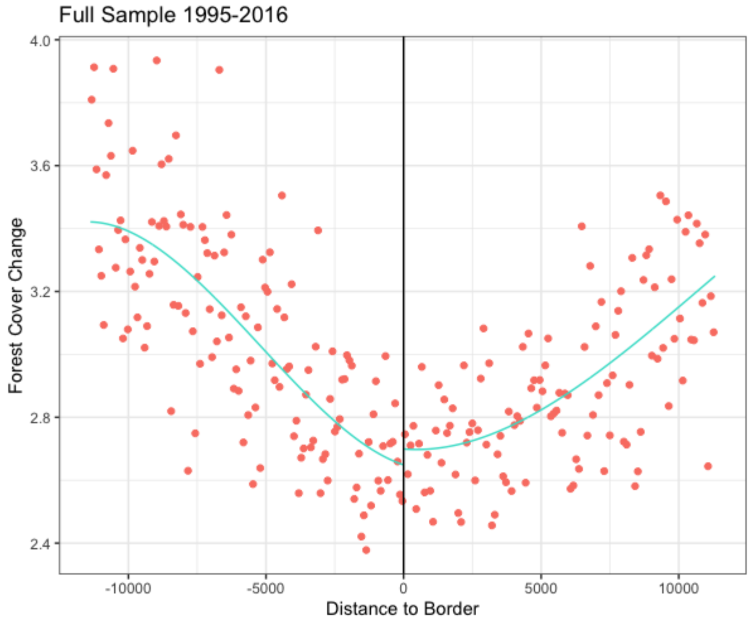


Figure 2.11: **Regression discontinuity for the full sample**. This displays the results of the regression discontinuity analysis for all forested areas in the state. Mainstream political parties areas are located to the left of the vertical line at 0, whereas indigenous forests are located to the right of the area. The Y axis denotes the average rate of tree cover loss. The period of analysis is *after the reform*, from 1995 to 2014.

However, a different pattern emerges when analyzing the deforestation patterns in communities with and without long-standing traditional institutions separately. Figure 2.12 shows that forested lands in *ejidos* and *comunidades agrarias* with historical indigenous townships experienced an *increase* in their rates of deforestation in the period immediately after the 1995 constitutional reform that officially recognized *usos y costumbres* as electoral procedures. This local average treatment effect (LATE) is statistically significant at the 5% level and it is equivalent to 0.26 standard deviations in the outcome.

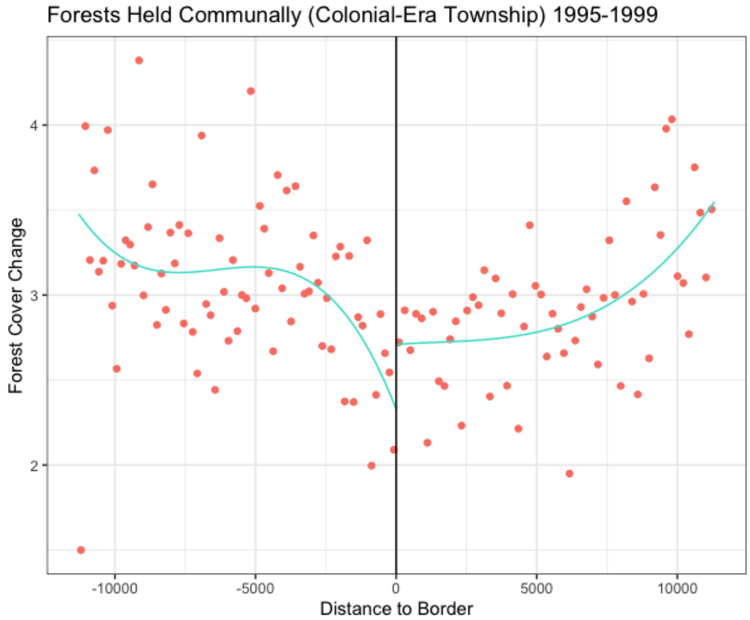


Figure 2.12: **Regression discontinuity for forests located in communities with historical indigenous townships**. This plot displays the results of the regression discontinuity analysis for forested areas in indigenous communities. Mainstream political parties areas are located to the left of the vertical line at 0, whereas indigenous forests are located to the right of the area. The Y axis denotes the average rate of tree cover loss. The period of analysis is *after the reform*, from 1995 to 1999.

However, as Figure 2.13 shows, this effect is short-lived, as these lands experience a decrease in their deforestation rates in the next five-year period. The magnitude and statistical significance of the coefficient is quite similar to that in Figure 3. As Table 2.1 suggests, the designation of *usos y costumbres* as official electoral procedures stops affecting the stewardship of the commons in the medium-term (after 2004) and it is not associated with more contemporary rates of deforestation. Tables **2.7-2.9** shows the coefficients, p-values, and confidence intervals for all the sub-periods of analysis in communally-held lands with historical indigenous institutions.

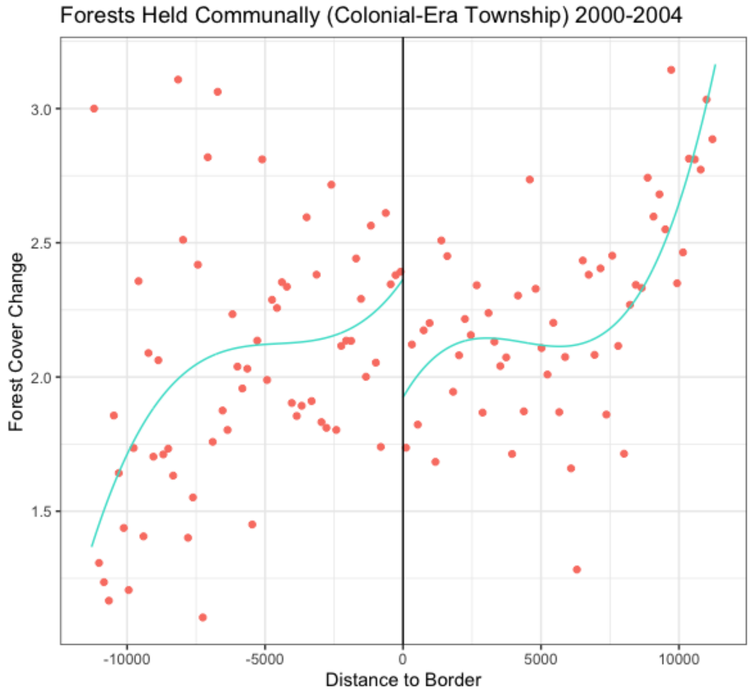


Figure 2.13: **Regression discontinuity for forests located in communities with historical indigenous townships**. This plot the results of the regression discontinuity analysis for forested areas in indigenous communities. Mainstream political parties areas are located to the left of the vertical line at 0, whereas indigenous forests are located to the right of the area. The Y axis denotes the average rate of tree cover loss. The period of analysis is *after the reform*, from 2000 to 2004.

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.147	-0.091	0.463^{**}	-0.485^{**}	-0.034	-0.446
	$(-0.51, 0.28)$	$(-0.36, 0.22)$	$(0.09, 0.97)$	$(-1.01, -0.09)$	$(-0.43, 0.60)$	$(-0.92, 0.002)$
p-value	0.390	0.466	0.018	0.020	0.824	0.051
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.1: **Geographic regression discontinuity for forests held in historical indigenous localities**

Hence, the second cut of the analysis show that the constitutional reform that altered the relationship between indigenous peoples and the state did not affect the stewardship of the forests in communities without historical indigenous townships. The coefficient of the regression discontinuity is not statistically significant for any of the sub-periods of analysis. The same pattern emerges for forested lands that are not communally-held. Tables **2.7-2.9** in the Supporting Information show the results of the regression discontinuity analysis for the three aforementioned samples: (1) forests held in historical indigenous communities, (2) forests held in non-historical indigenous communities, and (3) all forested areas. As Tables **2.10-2.16** in the Supporting Information show, the results are robust to different specifications, including different selections of the bandwidth and different polynomials.

In summary, the findings of this paper suggest that the presence of indigenous political institutions in Mexican rural communities is associated with lower levels of environmental degradation and higher levels of collective action. Nonetheless, the results from the geographic regression discontinuity show that politically-motivated changes in the relationship between the state and indigenous peoples may not be effective at supporting communities in their efforts to steward their natural resources.

Instead, they may even be deleterious towards this end. Lands held communally in places with historical traditional institutions are sensitive to changes in the relationship between indigenous peoples and the state, as they show an initial increase in the rate of deforestation in the years immediately following the reform—followed by a decrease in the subsequent period after the constitutional change. In contrast, lands ruled by a different political framework or a different land tenure system (not communal land) are not affected by this constitutional change in the short or medium-terms.

2.8 Discussion and Conclusion

The preservation of the world's forests is a fundamental piece in the global efforts to address climate change and other forms of environmental degradation. Moreover, millions of people depend on these ecosystems for their livelihoods. Governments and international organizations have supported the decentralization of natural resources governance as a policy solution to encourage the sustainable use of forests, watersheds, and biodiversity. A vast literature in the social sciences has provided empirical support to the idea that local governance of the commons works. However, there are still some important gaps in our understanding of why some communities are better able to engage in sustainable behaviors than others, in particular the role of political institutions.

In this paper, I study Mexico to shed light on the role of traditional political institutions and their recognition by the state on the stewardship of the commons. The country offers a natural laboratory to study the deforestation trajectories of more than 32,000 rural communities, known as *ejidos* and *comunidades agrarias*. Despite their identical constitutional standing, these rural communities have a wide variation in their political frameworks of governance and their specific rules of resource use and appropriation. Moreover, a constitutional reform in 1995 in Oaxaca state offers a good setting to study the effects of changes in the relationship between the state and indigenous peoples.

My findings suggest that traditional institutions of political governance are associated with lower levels of environmental degradation, as communities with historical indigenous townships experienced less accumulated deforestation from 2001 to 2018, measured with satellite imagery. Moreover, my empirical findings show that higher levels of collective action potential among these communities could be a reason why they are good stewards of the forests. Villages with long-standing indigenous political institutions are more likely to form forestry-related firms, apply for federal conservation programs, and devote more of their lands to the commons than villages without this framework.

Nonetheless, the results of the regression discontinuity suggest that changes in the relationship between the state and indigenous communities could have unexpected and deleterious effects on the ability of these communities to steward their commons. Communally-held forested lands in places with long-standing indigenous institutions experienced an increase in the rates of deforestation in the years immediately after the constitutional reform, followed by a similar decrease in the five years afterwards. In contrast, forested lands under different political frameworks (communities without historical indigenous townships) or land tenure mechanisms (non-communally held lands) did not have more or less environmental degradation in any period after the 1995 constitutional reform.

What may explain this apparently puzzle finding? Part of the answer lies in the political nature of this legal change. As mentioned before, the 1995 constitutional reform responded to the political and electoral motivations of multiple actors, including leaders and political parties, whose interests expanded beyond the benefits that indigenous peoples may derive from state recognition. As diverse qualitative and quantitative accounts of this historical process show (Eisenstadt, 2007; Eisenstadt and Ríos, 2014), multiple social and electoral conflicts emerged in the aftermath of the legislative decision to recognize *usos y costumbres* in Oaxaca state.

According to Recondo and Gallegos (2007), the recognition of *tradition* expanded old cleavages and created new ones. Hence, more exacerbated social tensions and widespread conflict may be two reasons why the reform affected the management of the commons in places with long-standing traditional institutions. Moreover, as explained by these scholars, the fiscal decentralization of the 1990s made the access to municipal office much more attractive, which in turn may have enhanced the likelihood of conflict.

Rural communities with long-standing traditional institutions have several characteristics that make them more susceptible to changes in their relationship with the state. First, as the empirical evidence in this chapter suggests, these villages seem to have higher levels of collective action potential, which also implies they are closer intra-group relationships; hence, any externally-imposed changes may be more consequential and far-reaching than for other types of communities. Second, this is particularly relevant for the linkages with the state, which has historically been a source of contention.

2.9 Supporting Information

2.9.1 Cross-Section Analysis (Unmatched Sample)

	Model 1	Model 2	Model 3
Historical Indigenous Locality	-0.94^{***}	-0.74^{*}	-0.10
	(0.23)	(0.35)	(0.17)
Percent Forest Cover 2000	0.12^{***}	0.09^{***}	0.08^{***}
	(0.00)	(0.01)	(0.01)
Elevation	-0.00^{***}	-0.00^{***}	-0.00^{***}
	(0.00)	(0.00)	(0.00)
Distance to Markets	1.26^{***}	2.73	2.45
	(0.31)	(2.02)	(1.31)
Surface (km2)	-0.01^{***}	-0.00^{*}	-0.00^{***}
	(0.00)	(0.00)	(0.00)
Economic Activity (Nighttime Luminosity)	-0.05^{***}	-0.04	-0.01
	(0.01)	(0.02)	(0.02)
Change in Nighttime Luminosity	0.16^{***}	0.10	0.07^{*}
	(0.02)	(0.06)	(0.03)
Indigenous Municipality	0.07^{***}	0.06^{**}	0.02
	(0.01)	(0.02)	(0.01)
Num. obs.	16065	16065	16065
Adj. R^2 (full model)	0.32	0.39	0.57
State Fixed-Effects	N	Y	N
Municipality Fixed-Effects	N	N	Y

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.2: **Outcome: accumulated deforestation, 2001-2018**

	Model 1	Model 2	Model 3
Historical Indigenous Locality	16.77^{***}	13.53^{***}	7.55^{***}
	(1.19)	(1.84)	(1.43)
Percent Forest Cover 2000	0.37^{***}	0.29^{***}	0.45^{***}
	(0.01)	(0.06)	(0.03)
Elevation	0.02^{***}	0.02^{***}	0.02^{***}
	(0.00)	(0.00)	(0.00)
Distance to Markets	41.38^{***}	21.38^{***}	8.86^{*}
	(1.58)	(3.54)	(4.43)
Surface	0.06^{***}	0.03^{*}	0.01^{***}
	(0.00)	(0.01)	(0.00)
Economic Activity (Nighttime Luminosity)	-0.37^{***}	-0.26^{**}	-0.23^{**}
	(0.05)	(0.09)	(0.07)
Change in Nighttime Luminosity	-0.74^{***}	-0.60^{**}	-0.45^{***}
	(0.09)	(0.17)	(0.10)
Indigenous Municipality	-0.06	0.01	0.06
	(0.05)	(0.07)	(0.07)
Num. obs.	16065	16065	16065
Adj. R^2 (full model)	0.37	0.50	0.64
State Fixed-Effects	N	Y	N
Municipality Fixed-Effects	N	N	Y

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.3: **Outcome: percent allocated to the commons**

	Model 1	Model 2	Model 3
Historical Indigenous Locality	0.09***	0.09**	0.07***
	(0.01)	(0.03)	(0.02)
Percent Forest Cover 2000	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Elevation	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Economic Activity (Nighttime Luminosity)	−0.01***	−0.01***	−0.01***
	(0.00)	(0.00)	(0.00)
Indigenous Municipality	−0.00***	−0.00	−0.00*
	(0.00)	(0.00)	(0.00)
Surface (km2)	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Total Conflicts	0.01***	0.01	0.01**
	(0.00)	(0.01)	(0.00)
Regular Community Elections	0.12***	0.11***	0.08***
	(0.01)	(0.02)	(0.01)
Num. obs.	16065	16065	16065
Adj. R^2 (full model)	0.30	0.35	0.49
State Fixed-Effects	N	Y	N
Municipality Fixed-Effects	N	N	Y

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.4: **Outcome: probability of participating in CONAFOR programs**

	Model 1	Model 2	Model 3
Historical Indigenous Locality	1.95***	1.74***	1.40**
	(0.16)	(0.46)	(0.53)
Percent Forest Cover 2000	−0.00	−0.01*	−0.01**
	(0.00)	(0.00)	(0.00)
Elevation	−0.00**	0.00	0.00
	(0.00)	(0.00)	(0.00)
Economic Activity (Nighttime Luminosity)	0.10***	0.11***	0.12***
	(0.01)	(0.03)	(0.02)
Indigenous Municipality	0.01	0.01	0.01
	(0.01)	(0.02)	(0.02)
Surface (km2)	0.01***	0.01*	0.01**
	(0.00)	(0.00)	(0.00)
Total Conflicts	0.21***	0.27**	0.17***
	(0.04)	(0.08)	(0.04)
Regular Community Elections	0.07	−0.07	0.01
	(0.07)	(0.07)	(0.09)
Num. obs.	16065	16065	16065
Adj. R^2 (full model)	0.05	0.06	0.42
State Fixed-Effects	N	Y	N
Municipality Fixed-Effects	N	N	Y

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.5: **Outcome: community forestry enterprises**

2.9.2 Cross-Section Analysis (Matched Sample)

	Deforestation	Pct Commons	CONAFOR	Firms
Historical Indigenous Locality	-0.91^{***}	12.44^{***}	0.10^{***}	1.86^{**}
	(0.25)	(1.63)	(0.02)	(0.58)
Percent Forest Cover 2000	0.10^{***}	0.16^{***}	0.00^{***}	-0.03^{*}
	(0.01)	(0.03)	(0.00)	(0.01)
Elevation	-0.00^{***}	0.02^{***}	0.00^{***}	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Distance to Markets	-2.21^{**}	34.62^{***}		
	(0.68)	(4.50)		
Surface (km2)	-0.00^{**}	0.02^{***}	0.00^{***}	0.00^{*}
	(0.00)	(0.00)	(0.00)	(0.00)
Economic Activity (Nighttime Luminosity)	-0.04	-0.81^{***}	-0.01^{***}	0.18^{***}
	(0.03)	(0.19)	(0.00)	(0.05)
Change in Nighttime Luminosity	0.07	-1.80^{***}		
	(0.05)	(0.35)		
Indigenous Municipality	0.03	0.26^{*}	0.00	0.06
	(0.02)	(0.12)	(0.00)	(0.04)
Total Conflicts			0.00	0.54^{*}
			(0.01)	(0.21)
Regular Community Elections			0.09^{***}	0.12
			(0.02)	(0.62)
Num. obs.	1538	1538	1538	1538
R^2 (full model)	0.41	0.33	0.25	0.03
R^2 (proj model)	0.41	0.33	0.25	0.03
Adj. R^2 (full model)	0.41	0.32	0.25	0.03
Adj. R^2 (proj model)	0.41	0.32	0.25	0.03

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.6: **Linear regression using matched sample**

2.9.3 Matching Quality

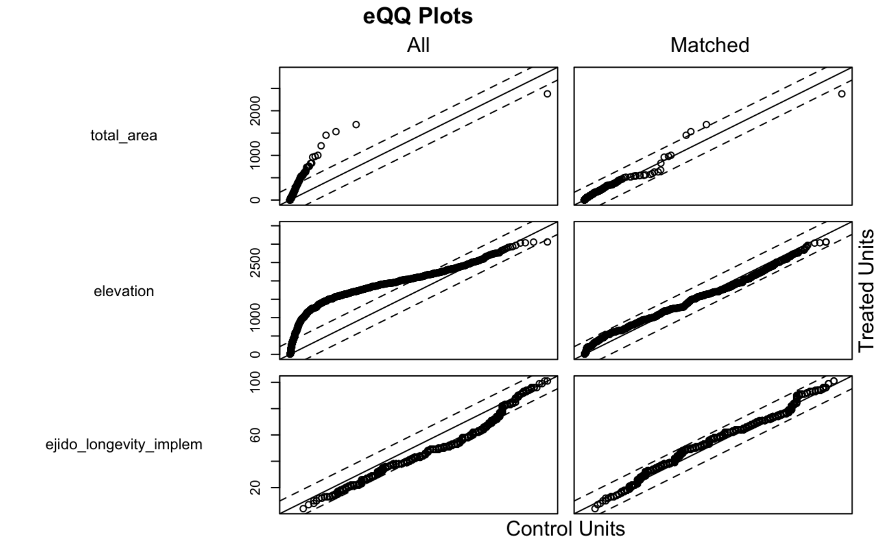


Figure 2.14: **Matching quality: qqplots**

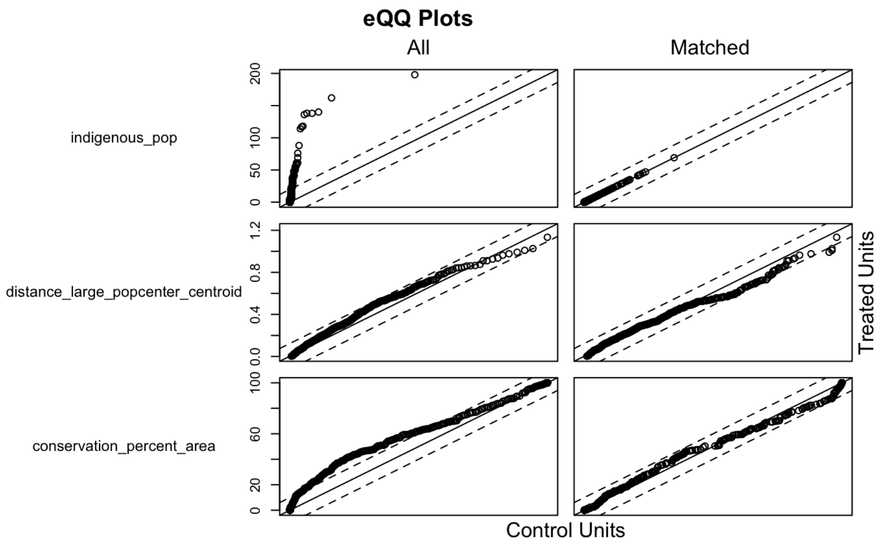


Figure 2.15: **Matching quality: qqplots**

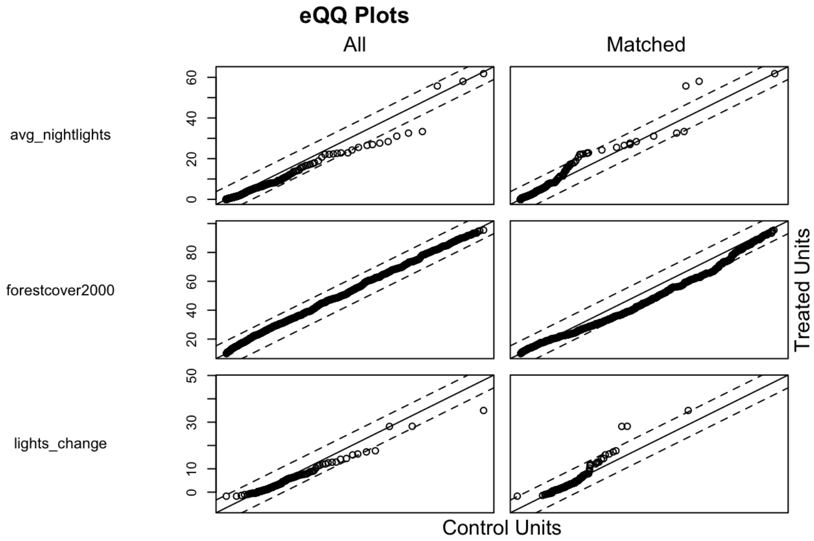


Figure 2.16: **Matching quality: qqplots**

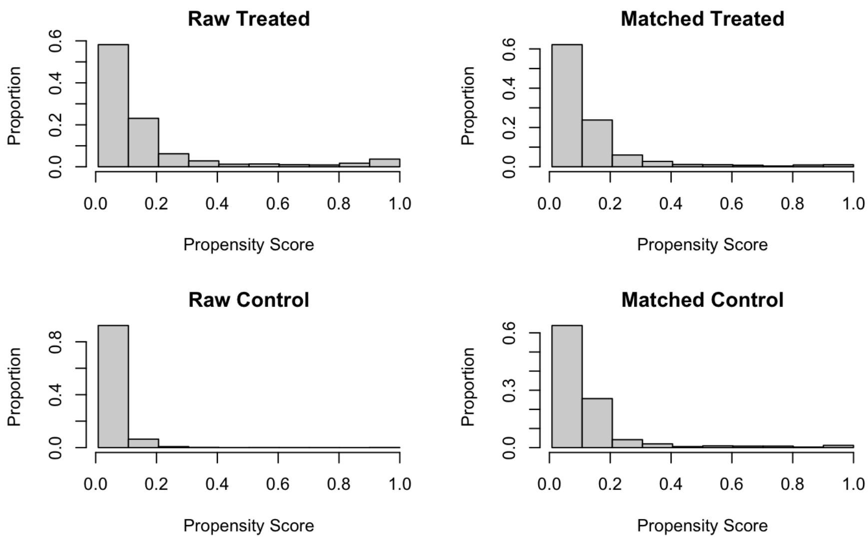


Figure 2.17: **Matching quality: propensity scores**

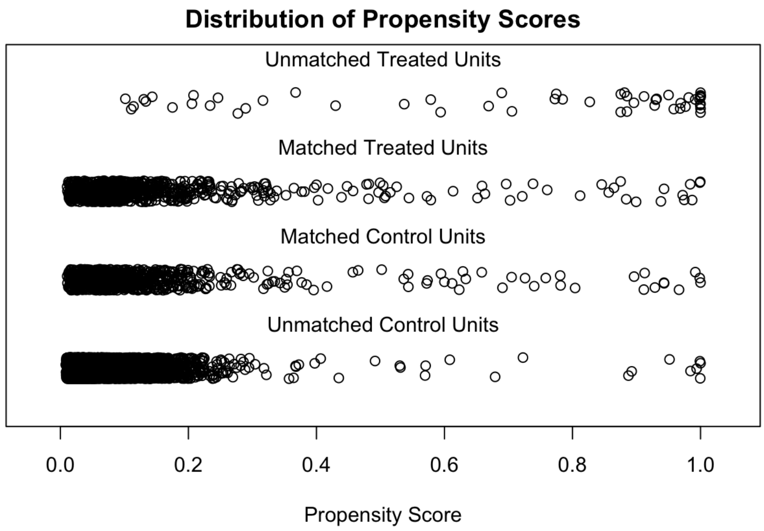


Figure 2.18: **Matching quality: propensity scores**

2.9.4 Regression Discontinuity

2.9.4.1 Main Results

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	−0.147	−0.091	0.463**	−0.485**	−0.034	−0.446
	(−0.51, 0.28)	(−0.36, 0.22)	(0.09, 0.97)	(−1.01, −0.09)	(−0.43, 0.60)	(−0.92, 0.002)
p-value	0.390	0.466	0.018	0.020	0.824	0.051
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.7: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	−0.014	0.018	0.145	−0.021	0.05	−0.103
	(−0.27, 0.21)	(−0.20, 0.22)	(−0.06, 0.38)	(−0.31, 0.23)	(−0.34, 0.37)	(−0.39, 0.17)
p-value	0.825	0.910	0.148	0.786	0.927	0.460
Sample size left	4606	4606	4606	4606	4606	4606
Sample size right	5937	5937	5937	5937	5937	5937
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.8: **Main results of the geographic regression discontinuity for all forested areas**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	0.088	0.101	0.057	0.162	−0.010	−0.066
	(−0.22, 0.36)	(−0.15, 0.31)	(−0.24, 0.33)	(−0.15, 0.48)	(−0.53, 0.39)	(−0.30, 0.42)
p-value	0.656	0.494	0.767	0.315	0.760	0.738
Sample size left	3195	3195	3195	3195	3195	3195
Sample size right	3617	3617	3617	3617	3617	3617
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.9: **Main results of the geographic regression discontinuity for forests held in non-indigenous localities.**

2.9.4.2 Different Bandwidths

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.129	-0.064	0.526^{**}	-0.565^{**}	-0.083	-0.497
	$(-0.504, 0.587)$	$(-0.38, 0.25)$	$(0.04, 1.21)$	$(-1.35, -0.05)$	$(-0.63, 0.76)$	$(-1.13, 0.36)$
p-value	0.881	0.945	0.036	0.036	0.857	0.313
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
Bandwidth	2 km	2 km	2 km	2 km	2 km	2 km
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.10: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Bandwidth = 2km**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.151	-0.079	0.406^{**}	-0.459^{**}	-0.059	-0.464
	$(-0.53, 0.38)$	$(-0.40, 0.35)$	$(0.14, 1.13)$	$(-1.18, -0.10)$	$(-0.47, 0.77)$	$(-1.10, 0.12)$
p-value	0.744	0.894	0.012	0.020	0.634	0.112
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
Bandwidth	3km	3km	3km	3km	3km	3km
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.11: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Bandwidth = 3km**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.191	-0.098	0.314^{**}	-0.393^{**}	-0.006	-0.436
	$(-0.50, 0.32)$	$(-0.38, 0.29)$	$(0.10, 0.99)$	$(-1.05, -0.10)$	$(-0.43, 0.70)$	$(-1.03, 0.04)$
p-value	0.657	0.779	0.017	0.019	0.643	0.057
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
Bandwidth	4km	4km	4km	4km	4km	4km
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.12: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Bandwidth = 4km**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.213	-0.107	0.278^{**}	-0.352^{**}	-0.025	-0.429
	$(-0.50, 0.25)$	$(-0.37, 0.24)$	$(0.40, 0.86)$	$(-0.94, -0.07)$	$(-0.43, 0.61)$	$(-0.95, 0.01)$
p-value	0.510	0.668	0.031	0.022	0.742	0.054
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
Bandwidth	5km	5km	5km	5km	5km	5km
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.13: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Bandwidth = 5km**

2.9.4.3 Different Polynomials

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.091	-0.053	0.598^{**}	-0.540^{**}	0.125	-0.467
	$(-0.54, 0.41)$	$(-0.41, 0.32)$	$(0.14, 1.17)$	$(-1.08, -0.08)$	$(-0.46, 0.76)$	$(-1.00, 0.07)$
p-value	0.786	0.822	0.013	0.024	0.635	0.088
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.14: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Polyonomial = 2**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.052	-0.015	0.694^{**}	-0.659^{**}	0.118	-0.498
	$(-0.56, 0.47)$	$(-0.44, 0.44)$	$(0.16, 1.33)$	$(-1.32, -0.10)$	$(-0.61, 0.82)$	$(-1.20, 0.16)$
p-value	0.866	0.944	0.012	0.024	0.773	0.134
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.15: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Polynomial = 3**

	Before 1995	After 1995	1995-1999	2000-2004	2005-2009	2010-2014
Usos y Costumbres	-0.039	-0.026	0.702^{**}	-0.710^{**}	0.085	-0.49
	$(-0.60, 0.52)$	$(-0.48, 0.42)$	$(0.03, 1.37)$	$(-1.42, -0.05)$	$(-0.71, 0.83)$	$(-1.26, 0.27)$
p-value	0.883	0.899	0.041	0.036	0.870	0.206
Sample size left	1411	1411	1411	1411	1411	1411
Sample size right	2320	2320	2320	2320	2320	2320
BW Type	mserd	mserd	mserd	mserd	mserd	mserd
Kernel	triangular	triangular	triangular	triangular	triangular	triangular
VCE Method	NN	NN	NN	NN	NN	NN

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2.16: **Main results of the geographic regression discontinuity for forests held in historical indigenous localities. Polynomial = 4**

2.9.5 Additional Tests for the Regression Discontinuity

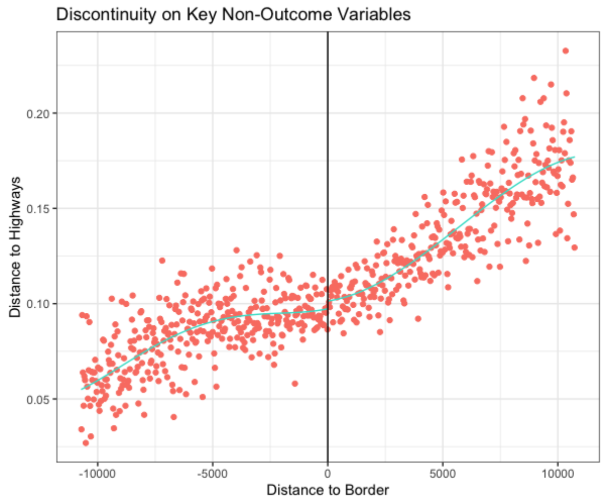


Figure 2.19: **Robustness checks: distance to highways**

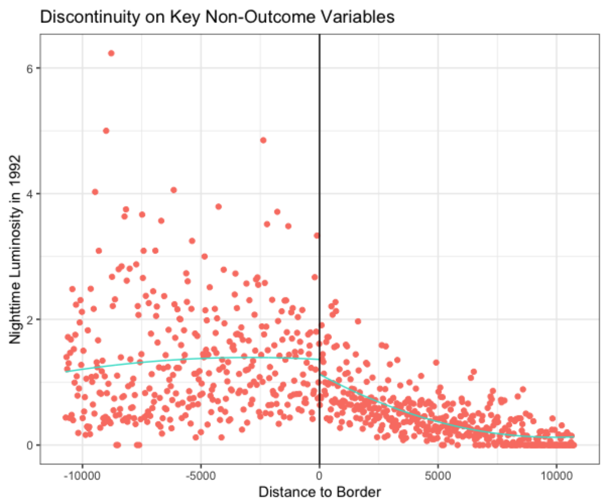


Figure 2.20: **Robustness checks: nighttime luminosity**

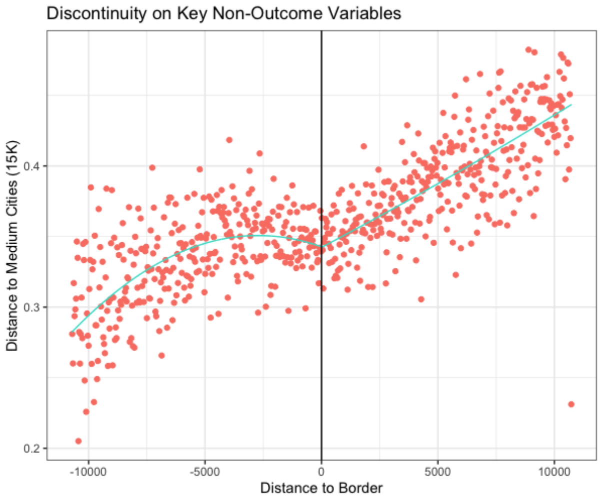


Figure 2.21: **Robustness checks: distance to medium cities**

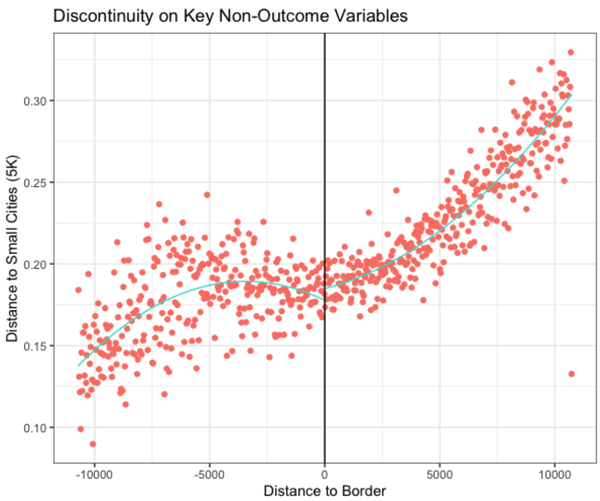


Figure 2.22: **obustness checks: distance to small cities**

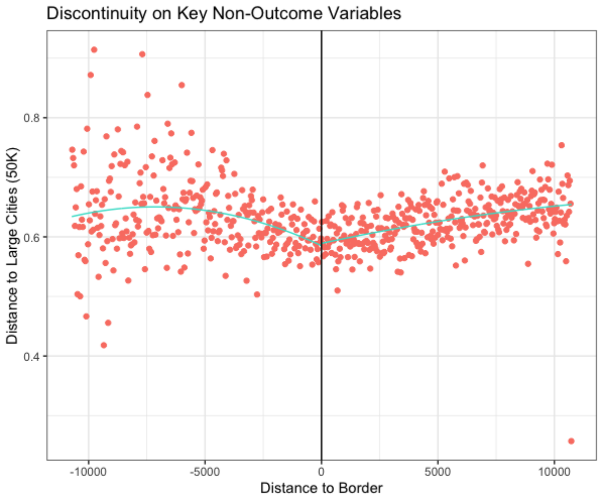


Figure 2.23: **Robustness checks: distance to large cities**

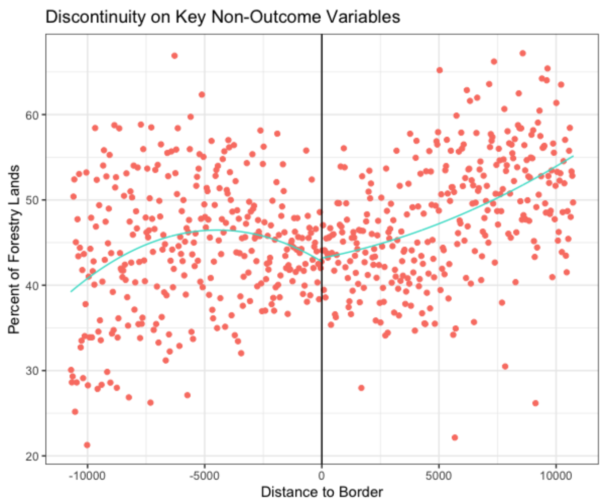


Figure 2.24: **Robustness checks: forestry lands**

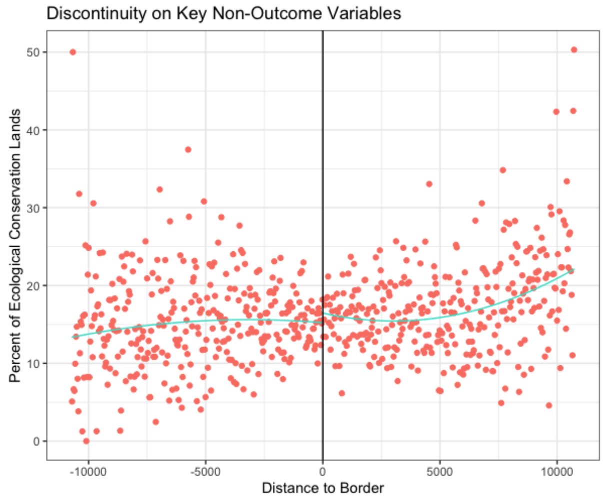


Figure 2.25: **Robustness checks: conservation lands**

2.9.6 Supplementary Data Description

In this section of the Supporting Information, I describe the data sources I employed in the main analysis, as well as some coding and data processing decisions I made.

2.9.6.1 Political Variables at the Community Level

1. **Historical Indigenous Townships**. As mentioned in the main text, I approximate the presence of strong indigenous political institutions with the existence of colonial-era indigenous polities. The main assumption behind this decision is that current forest communities that were able to maintain their status throughout the 19th century have more resilient communal indigenous institutions than those that disappear at some point.

2. **Percent of Village's Total Area Devoted to Communal Lands**. In 1992, the federal government of Mexico implemented a major land reform in the country, that included the regularization of property rights among the approximately 32,000 *ejidos* and *comunidades agrarias* through the PROCEDE. During this process, members of the community allocated a specific share of the village's total land to three specific types of use: (1) private farming plots, (2) communal lands, and (3) urban settlements. The variable I employ in the analysis is the percent of the total area of a village that the community members devoted to communal lands instead of individual farming (*parcelas*) or urban areas (*solares urbanos*).

   To calculate this variable, I employ the community-level polygons of the total surface of the village and the area devoted to the commons. As mentioned in the text, the main assumption behind this variable is that higher proportions of communal lands within a village denote a higher potential for collective action compared to villages with lower proportions.

2.9.6.2 Other Communal Behavioral Measures at the Community Level

1. **Participation in / Total Funds from CONAFOR programs** In Mexico, the implementation of the forest policy corresponds to the National Forest Commission (or *Comisión Nacional Forestal*. In 2007, it consolidated its different programs, ranging from institutional support to improve community governance to financial resources for commercial forestry, into the *PROARBOL*, which in 2013 became the *Programa Nacional Forestal*, or PRONAFOR. In the analysis, I employed individual-level data for all the subcomponents of the PROARBOL and PRONAFOR to calculate two variables: (1) whether the forest community participated in any of these programs from 2011 to 2018 and (2) the total amount received in millions of MXN for all the participation years.

   The main assumption behind both variables is that submitting a successful application requires high levels of coordination among the members of the community; in addition to the technical elements in the application materials (for example having a shapefile of the community's forested areas), CONAFOR requires a relatively large number of documents, the adoption of a certain number of policies, as well as the approval of the community members to participate in the different components of the program.

   The list of subcomponents for the 2011-2018 period includes, among many others: (a) environmental impact assessments, (b) commercial plantations, (c) technification of silviculture, (d) conservation and restoration of soils, (e) management plans for timber extraction, (f) management plans for biodiversity, (g) communal forest nurseries, (h) afforestation, (i) rural participatory assessments, (j) protection against wildfires and plagues, (k) forestry certification, and (l) payment for ecosystem services.

2. **Number of Community Forest-Related Firms**. I employ the National Directory of Economic Units to calculate the number of firms in the forestry sector that communities have created. This cross-sectional data source includes the name, economic sector, and geographic coordinates of all firms in Mexico. Specifically, I count the number of

touristic, wood and timber, paper manufacturing, and furniture firms located within the geographic limits of a community.

2.9.7 Data Sources

Variable	**Description**	**Source**
Tree Cover Loss	Annual rate of forest loss as a percent of the total forested area of a community in 2000	(Hansen et al., 2013)
Wildfire Density (Forestry)	Number of wildfires in areas suitable for forestry per square kilometer	CONAFOR
Wildfire Density (Conservation)	Number of wildfires in areas suitable for ecological conservation per square kilometer	CONAFOR
Historical Indigenous Township	Binary variable that takes the value of 1 if there is a colonial-era indigenous township within the limits of the village and 0 otherwise	Tanck de Estrada
Elevation	Average elevation of the community in meters above the sea level	Digital maps available through the `elevatr` package in R
Forest Cover in 2000	Percent of the total area of a community covered by forest in the year 2000	(Hansen et al., 2013)
Total Area	Total area of the community in square kilometers	National Agrarian Registry
Distance to Closest Urban Center	Linear distance from the centroid of the community to the closest locality of 10,000 or more inhabitants	INEGI
Area Suitable for Forestry	Percent of the community's total area suitable for forestry, according to the categories defined by Mexico's National Forest Commission	CONAFOR
Area Suitable for Conservation	Percent of the community's total area suitable for conservation, according to the categories defined by Mexico's National Forest Commission	CONAFOR
Indigenous Population	Binary variable that takes the value of 1 when there is a locality with more than 10% of its population speaking an indigenous language and 0 otherwise	INEGI
Touristic Firms	Number of firms in the touristic sector that are located within the limits of a rural community	*Directorio Estadistico Nacional de Unidades Economicas* of INEGI
Wood Firms	Number of firms in the timber sector that are located within the limits of a rural community	*Directorio Estadistico Nacional de Unidades Economicas* of INEGI
Paper Mills	Number of firms in the paper manufacturing sector that are located within the limits of a rural community	*Directorio Estadistico Nacional de Unidades Economicas* of INEGI

Variable	**Description**	**Source**
Furniture Firms	Number of firms in the furniture manufacturing sector that are located within the limits of a rural community	*Directorio Estadistico Nacional de Unidades Economicas* of INEGI
Participation in CONAFOR Programs	Binary variable that takes the value of 1 when a community successfully applied to one of the components of the PROARBOL or the PRONAFOR from 2011 to 2018 and 0 otherwise	CONAFOR
Total Amount Received from CONAFOR Programs	Total amount, in millions of Mexican pesos, that CONAFOR granted to a community as part of their PROARBOL or PRONAFOR funds	CONAFOR
Audiencias	Number of hearing requests that communities submit before the Federal Agrarian Attorney's Office to intervene in the solution of intra-community conflicts	Federal Agrarian Attorney's Office
Community Conflicts	Number of intra-community conflicts that were resolved by agrarian judicial authorities, including the following categories: (1) conflicts associated with property rights, (2) conflicts associated with community membership, (3) conflicts associated with the management of the commons, (4) conflicts associated with succession rights, (5) conflicts associated with internal limits, (6) conflicts associated with political governance of the community, and (7) conflicts associated with corruption issues in the community leadership	Federal Agrarian Attorney's Office
Percent Devoted to Communal Areas	Percent of the community's total area that the community members devoted for the commons, as opposed to individual farming plots and urban settlements	National Agrarian Registry
Percent of Communal Areas Converted to Other Uses	Percent of the community's total common area that transitions to either private or urban uses	National Agrarian Registry

2.9.8 Supplementary Figures

2.9.8.1 Average Annual Tree Cover Loss

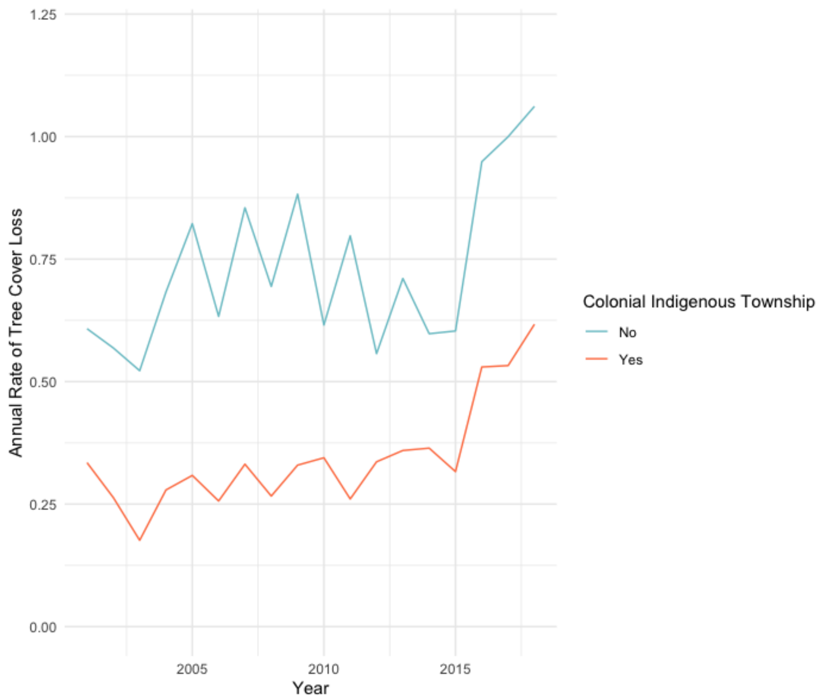


Figure 2.26: **Time series of tree cover loss in communities with indigenous institutions compared to communities without indigenous institutions.** Source: author's own elaboration, with data from (Hansen et al., 2013)

2.9.8.2 Average Density of Wildfires in Forestry Areas

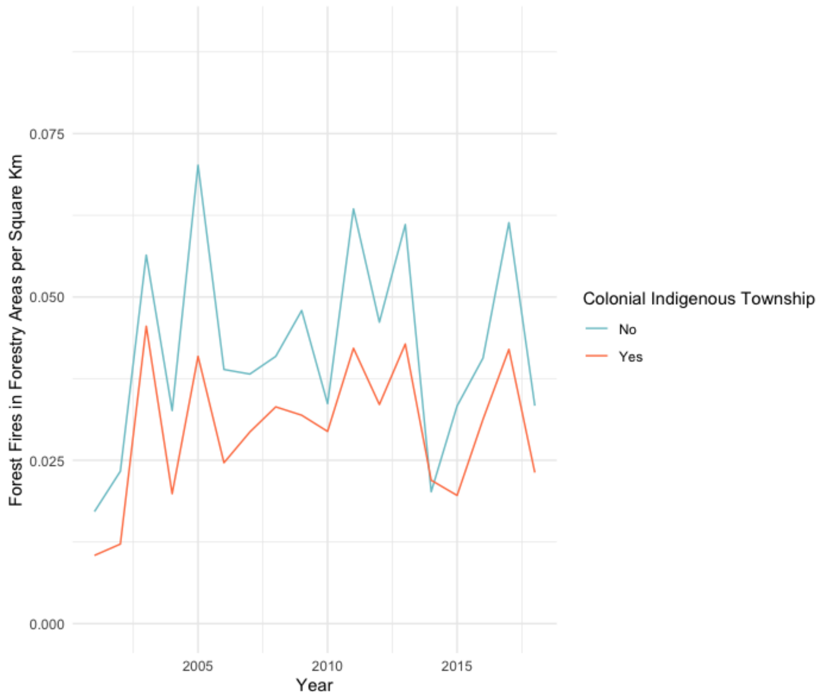


Figure 2.27: **Time series of wildfires per square kilometer of forestry area in communities with indigenous institutions compared to communities without indigenous institutions.** Source: author's own elaboration, with data from (Hansen et al., 2013)

2.9.8.3 Average Density of Wildfires in Conservation Areas

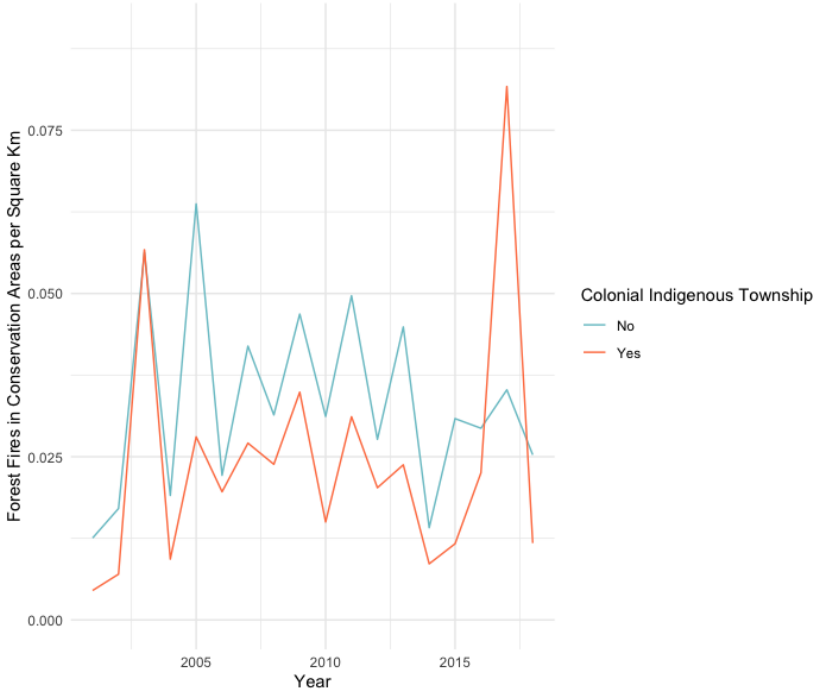


Figure 2.28: **Time series of wildfires per square kilometer of conservation area in communities with indigenous institutions compared to communities without indigenous institutions.** Source: author's own elaboration, with data from (Hansen et al., 2013)

CHAPTER 3

Does Access to Secure Property Rights Promote Forest Conservation? Evidence from a Land Titling Program in Mexico

How do large-scale land tenure interventions affect the ability of rural communities to steward their forests? In this chapter, I analyze the relationship between land titles certification through a large-scale program—the PROCEDE— and deforestation in Mexico. This policy provided both public and private goods among rural communities in the country. In addition, I study how this policy affected other community-level outcomes, including the probability of communal land privatization and the levels of economic activity. I find that *ejidos* and *comunidades agrarias* with agricultural land scarcity and without historical indigenous localities experience an increase in the rates of deforestation in the years leading to the official certification. In contrast, communities without fertile soil scarcity and with long-standing traditional political institutions do not display the same patterns.

Keywords: *Property rights, forest conservation, Mexico, community-based forest management*

3.1 Introduction

Political institutions, including regime type (Bernauer and Koubi, 2009; Kashwan, 2017), electoral cycles (Sanford, 2021; Pailler, 2018; Shen, 2018), and the rule of the law are closely associated with environmental outcomes ranging from greenhouse gas emissions to land use change. Among these, scholars have emphasized the role of secure property rights as key drivers of economic development and sustainability (Milgrom et al., 1990; Tseng et al., 2021). From an economic perspective, the overall consensus in the vast associated literature argues that strong and stable property rights are essential to promote productive investments and efficient allocation of resources.

In addition, the recognition of these institutions is associated with lower levels of environmental degradation, in particular regarding deforestation and other forms of land use change (Robinson et al., 2014). An expanding strand of research shows that the recognition of community-based property rights, in particular among indigenous peoples, affects the ability of these groups to protect their natural resources, hence allowing them to steward key global ecosystems (Garnett et al., 2018; Dawson et al., 2021; Baragwanath and Bayi, 2020).

Nonetheless, despite the vast amount of scholarship on the role of secure property rights on environmental outcomes, there are still several crucial gaps in our understanding of this relationship. First, the number of academic studies evaluating the impact of community-based land tenure interventions on environmental outcomes is still rather small; in contrast, the vast majority of this research focuses on issues such as the effectiveness of natural protected areas, for example (Robinson et al., 2014). Second, the theory behind this relationship is relatively less developed than its empirical tests. Although we have increasing empirical evidence that secure community-level property rights may promote better forest conservation, we know relatively less about why and under what political and economic conditions (Agrawal et al., 2002).

Third, the insights from other areas in political science, including studies on the political economy of land reforms and the role of sub-community power dynamics, is not fully integrated within this scholarship. For example, several authors have argued that property rights play also a crucial political dimension, in terms of redistribution and control of local populations (Albertus, 2015, 2021; Albertus et al., 2016). Moreover, numerous etnographic analyses of these large-scale reforms show that they have profound effects in the relationship among community members, disrupting pre-existing power and inequality structures (Torres-Mazuera, 2014; Cornelius and Myhre, 1998).

Instead, most of the existing research on the role of community-based property rights is apolitical along three dimensions. On the one hand, they frame the large-scale reforms that provide secure property rights as binary outcomes: communities either have them or not. On the other, they view communities as a unitary actor, void from conflicts associated with land tenure. Finally, they apply a somewhat tautological view of these policies: communities, as unified groups, first agree to participate in these programs, and then decide to preserve their forests as a result. This approach rests agency to communities that are either unable or unwilling to preserve all their forest ecosystems, even after receiving full ownership of their lands through secure property rights.

Therefore, the main research question of this paper is, does secure land tenure affect the ability of communities to steward their forest resources? If so, why does this occur? I argue that access to secure property rights not only protects rural communities from either state expropriation of their lands or illegal grabs by private actors; it also sets in motion a process of intra-group negotiation about the allocation of land resources, which starts even before the titles are officially certified. Hence, a large-scale policy, such as the recognition of communal property rights, affects the patterns of cooperation and conflict within communities as much as it impacts their standing versus external actors.

This, in turn, exerts varying pressure levels on forest resources. When the reform promotes individual goods, such as private parcels within the community, its members have strong incentives to appropriate as much common land—including valuable ecosystems—as possible to convert it to a personal holding. I also posit, however, that different types of communities experience heterogeneous effects of these policies. First, communities with less arable land should experience stronger pressures to convert forests in the commons. Second, communities with indigenous political institutions and stronger mechanisms of internal governance should be in a better position to effectively process conflict and, in turn, reduce the levels of deforestation with these institutional incentives.

To test the empirical validity of these arguments, I explore the 1992 agrarian reform of Mexico, which is a particularly suitable case study for two reasons. First, approximately 32,000 agrarian nuclei, known as *ejidos* and *comunidades agrarias* (from now onwards "rural communities"), own the majority of the country's land (51%), including most of its forest resources (Bray et al., 2006, 2005). Second, although these communities had customary rights to use their lands and natural resources during the authoritarian regime years (with several political and economic restrictions), they did not have the legal ownership over them.

In 1992, the government implemented an ambitious overhaul of the countryside, which included the *Programa de Certificación de Núcleos Agrarios y Solares Urbanos* or PROCEDE, a large-scale policy that gave community members three types of goods: the certification of the village boundaries, legal rights over individual parcels, and legal rights to use the commons. Empirically, I leverage the staggered implementation of this program to analyze the relationship between secure land tenure and two outcome variables (Munoz-Pina et al., 2003). First, I explore how deforestation rates changed before and after communities accessed the legal land titles. Second, I study the patterns of parcelization and communal land privatization as a result of the reform.

I show that rural communities with low availability of arable land and without historical indigenous institutions experienced an increased in their rates of deforestation in the period immediately prior to the official access to the secure land titles. Moreover, they showed a strong decrease in their levels of economic activity and a higher propensity to privatize their lands in the years after the implementation of this policy.

In contrast, communities with higher access to fertile land and with historical indigenous institutions did not show the above mentioned pattern regarding deforestation, economic growth, or the probability of privatization. I suggest that the incentive to parcel communal lands and the weakening of community-oriented ties were two of the key mechanisms behind this relationship: the certification program paved the way for underrepresented members in the community to gain access to secure land titles, which usually included forested areas in the main reservoir of the community—the commons.[1]

This paper makes three contributions to the existing literature on the politics of the commons. First, I provide novel insights to explain whether and why access to secure property rights affects the communal stewardship of forest resources; to do so, I depart from the existing work by conceptualizing land tenure reforms as far-reaching and complex processes that affect dynamics internal to the community, instead of binary, apolitical outcomes.

Second, I explore the presence of heterogeneous effects of land security on different types of communities; previous studies tend to focus on only one type of group—indigenous. In this paper, I provide evidence that communities with different natural resources endowments (quality of the soil) and political institutions display distinct trajectories before and after obtaining legal ownership over their land.

Third, in contrast to most of the literature, the Mexican case allows me to study outcomes other than land use change. In general, the lack of available data is one of the main reasons behind the lack of generalizable analyses of the commons. Finally, from a policy perspective, the recognition of secure property rights has become one of the most popular policies to address different societal and environmental goals. Therefore, it is crucial to understand how the content and implementation of these reforms affect different types of outcomes across heterogeneous communities.

However, it is important to clarify two key limitations of the paper. First, in terms of the scope conditions of this study, my insights apply to a specific type of land tenure reforms. It is possible to categorize these policy interventions along two dimensions: (1) the extent to which they recognize communal versus individual landowners and (2) whether

[1] Other authors have explored this issue from a different perspective, including Munoz-Pina et al. (2003)

they recognize existing customary land uses or create new ones. Each of the four resulting categories has different associated political dynamics.

The PROCEDE program lies at the intersection of community-based reforms that legalize pre-existing, use-based land arrangements. Hence, my hypotheses are not particularly suited to explain land tenure policies centered on individual landholders or that endow communities with land for the first time. Nonetheless, despite this limitation, many of the most relevant agrarian reforms in the Global South, particularly in other Latin American countries, fall in the same category as the PROCEDE.

Second, from an empirical perspective, the treatment assignment (land certification) process was not as-if random. Communities chose when to participate in the program and this decision reflected internal characteristics of these groups that could be associated with land use change, for example community conflict. Hence, there are crucial differences between the "early" and the "late" adopters of this program. Although I cannot make strong causal claims with my current research design, the staggered implementation of the PROCEDE gives me some leverage to understand how different types of communities (indigenous versus non-indigenous, for example) reacted to this policy.

This paper proceeds as follows. In the second section I develop my theoretical framework, based on the existing research on the commons, the political economy of land tenure reforms, and indigenous politics. The third section presents the historical and political background of community-based property rights in Mexico, with emphasis on the origins and characteristics of the PROCEDE. The fourth section provides the details of my research design, methods, and data. In the fifth section, I present the main results of my analysis as well as some descriptive statistics of key indicators. The last section concludes with some limitations and contributions of this study.

3.2 Theory and Observable Implications

What is the relationship between land tenure institutions and environmental outcomes? A vast strand of research in the social sciences explores this question from at least three different dimensions. First, some scholars analyze the differences in environmental and other development outcomes among various forms of land tenure, for example community-oriented land management and state-sponsored natural protected areas (Tseng et al., 2021; Robinson et al., 2014; Sze et al., 2022).

There are two subcategories of studies. Some scholars adopt a global perspective to analyze the potential or effectiveness of broad land tenure regimes, for example indigenous territories (Garnett et al., 2018) and natural protected areas (Wolf et al., 2021; Sze et al., 2022). Others, including case studies from Mexico (Ellis and Porter-Bolland, 2008; Barsimantov and Antezana, 2012; Miteva et al., 2019), focus on a smaller region to analyze the patterns of deforestation across different forms of land ownership. Although the findings are quite contingent on the context (Sze et al., 2022), there is a growing consensus that engaging with local populations is essential to sustainable resource use arrangements (Erbaugh et al., 2020; Kashwan, 2017; Dawson et al., 2021).

Scholars in the social sciences have also analyzed the relationship between land tenure and environmental outcomes from a land security perspective (Robinson et al., 2014). Hence, instead of focusing on who owns a particular holding, these authors aim to understand how the provision of secure property rights affects the ability of the owners to protect their natural resources. This literature is closely linked to the vast scholarship on property rights, mostly from economics, which shows that stable property rights are crucial for productive investments and economic growth (North, 1990; Acemoglu et al., 2005).

Although environmental outcomes, particularly at the community level, have attracted less scholar attention compared to other forms of land tenure, there is a growing body of evidence showing that provision of secure property rights is associated with lower levels of environmental degradation—particularly deforestation.

Nonetheless, it is important to mention that the direction of this relationship is not unequivocal, as some scholars, particularly from economics, argue that, since the provision of strong property rights is associated with efficiency gains in land allocation, they could also lead to higher levels of forest cover loss, especially in cases in which landowners can get higher benefits from engaging in other economic activities (Bohn and Deacon, 2000; Busch and Ferretti-Gallon, 2020; Barbier and Burgess, 2001; Robinson et al., 2014).

Recent work has focused on estimating the causal impacts of secure land tenure on deforestation in various settings, including Peru (Blackman et al., 2017; Robinson et al., 2017), Ethiopia (Kahsay and Medhin, 2020; Gebreegziabher et al., 2021), Colombia (Romero and Saavedra, 2021; Vélez et al., 2020), Nepal (Oldekop et al., 2019), and Brazil (Baragwanath and Bayi, 2020; Araujo et al., 2009), employing quantitative approaches and, in some cases, quasi-experimental research designs (before and after the intervention). The overall conclusion of these scholars is that land certification leads to lower levels of land use change among indigenous communities.

Nonetheless, in most cases, there is little explanation about what mechanisms explain this empirical relationship. The main assumption of this scholarship is that providing secure land titles to communities strengthens their ability to protect their territory from external actors, which include not only the state, but also private corporations.

Finally, social scientists have explored the relevance of land tenure on environmental outcomes through the lenses of the commons. The work of Elinor Ostrom and her colleagues showed that certain local groups of common-pool resources (CPR) users are able to use their natural resources sustainably, without the intervention of governmental agencies or markets (Ostrom, 1990, 2000; Ostrom et al., 2002; Cumming et al., 2020; Agrawal, 2003; Agrawal et al., 2002). A key precondition for these communities to do so is the presence of strong mechanisms of internal governance, which allow them to produce and implement effective norms of natural resources use and management.

Based on a series of detailed case studies, Ostrom outlined seven “design principles” that characterize many of the successful examples of sustainable resource systems (Ostrom, 1990). Among these, clearly defined boundaries, which are recognized and respected by actors external to the community, are a crucial dimension for the sustainable management of the commons. Despite the vast number of studies in this area, there are still a few important gaps in this literature. In particular, this strand of research has progressed based on single case studies or small-N analyses (Cumming et al., 2020; Agrawal et al., 2002). Although these have provided quite valuable insights about the stewardship of the commons, this approach has made generalizable theories more elusive for two reasons: the lack of detailed institutional data at the community level and the relatively underdeveloped discussion of the mechanims behind this relationship.

Taken together, these different strands of social science have considerably advanced our understanding of the relationship between land tenure and environmental degradation. The first take-away is that, in contrast to previously held conventional wisdom, no land tenure regime is inherently more suitable for ecosystem conservation. Scholars have found that, for example, community-based arrangements experience lower deforestation rates than natural protected areas in some regions of the world but not in others (Sze et al., 2022).

Second, the mechanisms of internal governance, including, but not limited to secure property rights, are probably more relevant than the specific form of land tenure. Hence, there is a growing body of evidence suggesting that improving land tenure security among rural communities, in particular indigenous peoples, reduces environmental degradation.

Nonetheless, the theory explaining why access to secure property affects group-level decisions about land use is still underdeveloped. That is, we know there is a relationship, but we know relatively less about why is this happening. Scholars in this literature tend to frame the reforms that provide secure property rights in binary, apolitical terms. Hence, they usually treat them as mostly administrative policies, which can be easily separated in periods before and after said change. Nonetheless, a large body of research in political science, particularly in comparative politics, demonstrates that governments employ land tenure regimes as powerful tools to exert political control. Moreover, as numerous descriptions of policy reforms in Latin America show, these are long, complicated, and protracted endeavors of nationwide significance (Albertus, 2015).

Second, numerous qualitative assessments of these reforms emphasize their contentious nature. Instead of being unitary actors that unanimously accept the conditions of the government policy, communities have internal disagreements, long-lasting sub-group differences, and even inter-group territorial conflicts. Hence, secure property rights reforms, by representing a fundamental shift in the patterns of land use and introducing additional legislation and restrictions on how communities could employ their natural resources, also represent a shock to the status quo within communities.

These two elements—the temporal nature of land tenure reforms and their impacts on the governance of communities—are at the core of my theoretical contribution. The central argument I advance in this paper has two components. First, I posit that certification programs like the PROCEDE, based on the provision of private goods to the members of a group, could both undermine the collective action capacity of that community and induce land use change (DiGiano et al., 2013). As the incentives to acquire individual property strengthen, the pressure to convert forests into agricultural parcels increases. Importantly, these effects should occur *before* the official accession to secure titles, as the legal certification "shields" a particular way to allocate land resources.

Second, I argue that the pressures mentioned above do not affect all communities equally. As the proportion of arable land decreases, communities employ less desirable areas in agricultural terms to provide individual parcels; these include forests and other ecosystems. In addition, the presence of strong mechanisms of internal governance, higher levels of collective action, and more effective norms of resource use and appropriation mitigates the influence of these incentives to convert forested lands to agriculture and promotes higher conservation. As mentioned in a previous chapter of this dissertation, a growing scholarship shows that indigenous communities are particularly well-equipped to steward forests and other ecosystems, as they have higher levels of collective action. This means that the internal instability promoted by the provision of individual parcels could be partially offset when this type of institutions are in place.

The observable implications of the theory outlined above are as follows:

1. Land security reforms can result in land use change if they incentivize the acquisition of individual property rights (a private good) in detriment of communal lands. If the above is true, then we should see an increase in deforestation in the years preceding the official certification of property rights.

2. The pattern mentioned above should be particularly pronounced in communities with limited access to fertile soils. As the percent of land suitable for agriculture declines, communities have to parcel forests to provide a higher number of titles.

3. The pattern mentioned above should be either weaker or non-existing in communities with long-standing indigenous political institutions.

4. The provision of private goods (individual titles) should also be associated with a steady decline in the strength of the community, revealed by an increase in the probability of privatization after access to certification.

Hence, my theory departs from existing analyses of the relationship between property rights and land use by focusing on the impacts that land security reforms have on intra-community dynamics. In doing so, I challenge one of the fundamental assumptions of the current empirical literature: that the provision of land titles *per se* leads to lower levels of deforestation. As I show in this paper, this is contingent not only on the actual content of the reform (especially whether it provides some form of private goods), but also on the economics and institutional characteristics of the receiving community.

In terms of the scope conditions of my theoretical framework, the above insights can shed light on a broad set of contexts with the following characteristics. First, my theory could help explain other examples of land use reforms that legally recognize customary uses of land, in particular those with long and complex implementation processes. A handful of policies in Latin America fall into this category. Second, my framework could explain instances of governments providing private public goods in community-based settings; these include, for example, agricultural and other types of subsidies.

3.3 Historical Background

There are three different land tenure regimes in Mexico: state-owned lands, such as natural protected areas; private holdings, which include the largest industrial farms; and community-based ownership, also known as *propiedad social de la tierra*. The last category accounts for approximately 51% of the country's total surface, including the vast majority of its forests, watersheds, and other natural resources, which, together, also constitute the main reservoir of land for the expansion of urban areas.

Ejidos and *comunidades agrarias* represent the basic unit of group-based land ownership in Mexico. Historically, their origins date back to colonial (and even pre-colonial) times (Goyas Mejía, 2020); however, their current form is closely associated with the PRI regime, which emerged after the Mexican Civil War from 1910 to 1920 (Bray et al., 2005).

Land redistribution became one of the main grievances against the government of Porfirio Diaz (1876-1910), who issued vast concessions to national and international extractive companies in the oil, timber, and mining industries (Boyer, 2015; Santiago and Santiago, 2006). Starting in 1915, the postrevolutionary authorities either returned land to indigenous communities that had lost it during the 19th century or dismembered former haciendas to create new agrarian nuclei (Elizalde, 2020). This process lasted until 1992 and resulted in the constitution of more than 32,000 rural communities.

All *ejidos* and *comunidades agrarias* have an identical territorial and basic institutional structure. Each of them has a certain number of individual parcels, mostly for agriculture; a reservoir of land, which includes mountainous terrains, forests, and other natural resources; and, finally, an urban settlement, where most of the population lives (Munoz-Pina et al., 2003). As I will explain later, during most of the 20th century, the conversion of land among these three different uses was more or less fluid (Hernandez Cendejas, 2012; Torres-

Mazuera, 2014; Velasco and Torres, 2019); however, with the 1992 land certification reform, the boundaries within the community became more static—and a lengthy bureaucratic process was necessary to change the allocation of land across different uses, for example from forest to agriculture.

The basic internal governance of these 32,000 rural communities is mostly homogeneous. The main decision-making body is the *asamblea ejidal* or *asamblea comunal*, which includes all inhabitants of the community with legal land titles—but it excludes either the descendants of community members that did not inherit land or migrants from other communities. The *comisariado ejidal* or *comisariado de bienes comunales* is in charge of the day-to-day administration of the community's financial and other assets; their members are elected every three years by the community. Finally, the *consejo de vigilancia* monitors the activities of the executive (de Diputados, 2022).

Although the basic territorial and constitutional structure of these communities has remained more or less invariant since the early 20th century, their ability to effectively own their land has changed importantly (Merino-Pérez, 2004; Merino Pérez, 2014; Boyer, 2015). During most of the PRI years, the ejido system became a cornerstone of the regime's strategy to control the countryside (Albertus et al., 2016).

From a political perspective, the hegemonic party infiltrated the communal decision-making bodies with PRI representatives that had a high-degree of influence over local matters, particularly surrounding land use (Albertus et al., 2016; Boyer, 2015; Cornelius and Myhre, 1998). Moreover, communities did not have legal ownership over their land. Instead, they received use rights from the state, which was the legal owner (De Janvry et al., 2015, 2014). Finally, they had little control over their natural resources, including water and forests. On the one hand, the National Water Commission (or *CONAGUA* in Spanish) prioritized large-scale development projects, such as big dams, over local uses. On the other, the federal government implemented a concession-based forestry policy, which resulted in local communities having little participation in the use of forest resources (Boyer, 2015).

Taken together, these three characteristics of the land tenure regime during the PRI meant that *ejidos* and *comunidades agrarias* were subject to the hegemonic party political control. As Albertus et al. (2016) have argued, this resulted in relatively high levels of poverty, low land productivity, and very weak internal autonomy.

As a consequence of the severe economic crises of the late 1970s and 1980s, the PRI governments implemented far reaching structural reforms, including the privatization of multiple state-owned enterprises and the liberalization of international trade, particularly NAFTA. The economically liberal elites of this period considered the ejido system as a powerful reason behind the low levels of productivity in the Mexican countryside. Although change to the rural sector of the Mexican economy arrived relatively late, it had the same overall objective as the rest of the economic reforms.

In 1992, the government of President Salinas de Gortari undertook a major overhaul of the Mexican countryside with three key reforms. The first and most relevant was the *Programa de Certificación de Núcleos Agrarios y Solares Urbanos*, also known as PROCEDE. The two overarching goals of this program were, on the one hand, certify the external boundaries of the community and, on the other, provide legal land titles to individual parcels within the village (De Janvry et al., 2015, 2014; Aylwin, 2002). Hence, this policy offered the inhabitants of *ejidos* and *comunidades agrarias* a mixture of public and private goods. The government of President Salinas aimed to create a class of small landholders with this reform (Varela and Cruz, 2005).

The second reform consisted in the creation of the *Procuraduría Agraria*, or the Federal Agrarian Attorney's Office, as well as a network of federal agrarian judges, in charge of administering justice both among and within communities (Cornelius and Myhre, 1998). This includes, for example, hearing complaints about issues such as limits between parcels, accession of new members to the community, and succession issues. In addition, the *Procuraduria* has implemented a wide array of programs to improve the internal governance of communities, for example through incentives to enact a community charter and hold regular elections. Before 1992, the president's office was in charge of the administration of justice in the countryside. Finally, the government also reformed the system of financial support to farmers. In particular, the PROCAMPO offered a wide array of subsidies for agricultural production (Magaloni, 2006).

The PROCEDE was a multi-year, large-scale, and ambitious program and one of the highest political priorities of various federal administrations. Although the participation of communities was, on paper, optional, the government employed a wide array of policy tools and political incentives to ensure local support. The certification program operated in various stages (De Janvry et al., 2015). First, representatives from the national statistics agency (INEGI) and the agrarian registry (RAN) visited the *ejido* or *comunidad* to discuss the benefits of the program and the application process.

Then, the local assembly gathered to vote to join the PROCEDE; if the majority of its members agreed, then the official process started. Third, in consultation with the legal members of the community, the technical government agencies prepared the official maps of the community, which showed not only its external boundaries, but also the location and extent of individual parcels (Smith et al., 2009).

Community members had then the opportunity to revise the maps and make the necessary adjustments (Smith et al., 2009). Once the local assembly voted in favor of the maps, these became official. At that point, each *ejidatario* or *comunero* received three types of goods. First, all members of the community benefited from certified external communal boundaries; this, in practice, stabilized the local resource system and provided legal reassurance against land claims from neighboring communities and private landowners. Second, each member of the community obtained legal rights over their individual parcels, also known in Spanish as *certificados de derechos parcelarios.* Finally, they got legal property titles over a percent of the commons area through the *certificado de derechos comunes* (Munoz-Pina et al., 2003).

The most outstanding change introduced by the 1992 land reform was the possibility of privatizing communal land (Bouquet, 2009; Cortés Campos, 2018; Barsimantov et al., 2009;

Torres-Mazuera, 2014; Smith et al., 2009). Before that year, *ejido* and *comunidad* land were completely unalienable. However, the PROCEDE allowed individual parcels to be sold to outside individuals or firms, through the *dominio pleno*, or "full ownership" process. To do so, the local assembly had to approve any individual member's request.

After the vote, land became transferable outside the community. In contrast to individual parcels, it is not possible to privatize communal areas; however, communities can vote to switch land uses from the commons to parcels or other specific uses, which then can transition to *dominio pleno*. A crucial distinction for the purposes of this paper is that, according to article 89 of the National Agrarian Law, communities cannot parcel forested areas (de Diputados, 2022; Torres-Mazuera et al., 2021; Rosales-González et al., 2013; Smith et al., 2009).

The implementation of the program was quite successful from a practical perspective. In ten years, agrarian authorities were able to certify the external and internal boundaries of most rural communities in the country. As I will explain below, however, places that were able to complete the program early are quite different from the laggards. In particular, conflicts within and among communities slowed down the pace of the policy in Mexico's southern states such as Oaxaca, Chiapas, and Guerrero (Smith et al., 2009; Ramos, 2008).

Starting in 2006, the federal government revamped its efforts to finalize certification with the FANAR program—an extension of the PROCEDE—which has reached the vast majority of the remaining *ejidos* and *comunidades* that had not certified previously. In political terms, however, the program failed to realize one of its main goals, as only a small fraction of the participant communities has initiated the process of privatization (Torres-Mazuera, 2015b). Hence, the *ejido* system has been quite resilient to economic crises, political changes, and policy reforms (Barnes, 2009).

The implementation of the PROCEDE program shows that land tenure interventions could be much more intricate than what the current literature assumes. First, in contrast to other smaller-scale reforms, the PROCEDE offered three types of benefits to community members. Two of them are public goods. These include the certification of the community's boundaries and the delimitation of the commons within the village, which include most of the forests and mountains (Smith et al., 2009).

As mentioned by Ostrom (1990), clear resource system boundaries are a key design principle that allows local users of common-pool resources to effectively manage their ecosystems. In addition, legal certification of the community allowed them to participate in other federal conservation programs, such as the payment for ecosystem services and commercial forestry certification. The other one, the legal titles over individual parcels, is, however, a private good. This paved the way for any member of the community to not only fully privatize their land, but also sell it to outsiders, diminishing the ability of the community to engage in collective action (Smith et al., 2009).

As mentioned in the theory section, this mix of public and private goods affected the incentives of communities to protect their forests. Directly, local inhabitants had to decide how to split their land between the commons and individual parcels; in some cases, the entirety of the community was divided in plots, while in others all the land stayed as group-based property. Depending on the demographic pressures and availability of arable land, the lure of individual property rights could incentivize some communities to reduce the share of the commons. Indirectly, the introduction of private property could undermine the ability of the community members to cooperate with each other and engage in meaningful forms of collective action, including the creation of forestry firms and participation in large scale federal environmental programs (Barsimantov et al., 2009).

Finally, it is important to mention that these incentives started affecting behavior even before the program was completed and community members accessed their parcel and common titles. More generally, the community effects of the PROCEDE are diffuse in geographic and temporal terms, which entails that all communities were more or less exposed even before they officially joined the program.

Geographically, the timing of treatment was not homogenous across or within states, which means that neighboring communities were exposed to different treatment status. Temporally, the federal government implemented an ambitious communications strategy to ensure that as many communities as possible knew about the program, which means that their members knew about the potential effects of the program even before applying.

In contrast, the legal security effects of land titling (the mechanism usually studied in the literature) should occur only after the certification is complete. A wide array of qualitative studies confirms that the negotiation process leading to the different assembly votes involved internal conflicts and instability (Cortés Campos, 2018; Rosales-González et al., 2013; Torres-Mazuera, 2014, 2015a).

3.4 Research Design

The main objective of this paper is to analyze the relationship between land tenure interventions and environmental and societal outcomes. My hypotheses suggest that the provision of private goods in communal settings could raise the rates of deforestation, particularly in communities with low availability of productive land and without institutional frameworks to process conflict. The unit of analysis is the rural community.

Given that my theory is centered on the dynamics effects of land certifications, I will employ an event studies analysis, in which the key independent variables are the lags and leads around the date of the PROCEDE program. Hence, I leverage the staggered implementation of the program, which provides me with a source of variation in the time of access to secure land titles. Since I am agnostic with respect to the time frame to observe an impact of the policy, I include eight lags and eight leads. The models are estimated using ordinary least squares with unit (village) and time (year) fixed effects to account for unobservable cross-sectional confounders and trends affecting all units. The standard errors are clustered at the community level.

It is important to mention that my research design does not allow me to estimate the causal impact of the PROCEDE for various reasons. First, treatment assignment is not random. As mentioned above, initial enrollment into the program was voluntary; numerous qualitative analyses show that the decision to participate is closely related to the number and intensity of intra-community conflict and other societal and political characteristics. Hence, states in southern Mexico, for example Oaxaca, Guerrero, and Chiapas (where communities have relatively high levels of conflict) experienced significant delays compared to states in central and northern Mexico, for example.

Given the time frame of the land use change data, I am able to estimate the relationship between access to secure land tenure and deforestation only for the latter cohorts in the program. As I will show in the next sections, these "late-adopters" are quite different from the early ones in key variables that could be associated with the outcomes.

The specific model I estimate in this paper comes from (Cunningham, 2021):

$$Y_{its} = \gamma_s + \lambda_\tau + \sum_{\tau=-q}^{-1} \gamma_\tau D_{s\tau} + \sum_{\tau=0}^{m} \delta_\tau D_{s\tau} + X_{is\tau} + \epsilon_{is\tau} \tag{3.1}$$

3.5 Data Sources

The unit of analysis of this paper is the rural community. There are 32,000 *ejidos* and *comunidades agrarias* in Mexico, distributed across all the 32 federal entities of the country. As mentioned before, I will focus on those communities that implemented the PROCEDE program from 2000 onwards—9,435 or 29% of the total. The geospatial data on the villages' boundaries comes from the National Agrarian Registry (RAN), the agency in charge of administering agrarian information. The effective sample does not include a subset of communities which were unable to certify their boundaries due to conflicts among members and with other rural villages (Ramos, 2008).

In this paper, I analyze two main outcomes, one of them measuring the extent of environmental degradation and the other approximating the strength of community-oriented behaviors. There are a number of ways to measure the presence of sustainable management of common-pool resources, including the prevalence of wildfires in specific areas, the levels of erosion, and the quality of the soil.

For the purposes of this study, I focus on the rate of forested land use change at the yearly level. The data comes from Hansen et al. (2013), who employed a machine learning algorithm to process thousands of satellite images and mapped the location of forests around the Earth. I specifically used two datasets. The first one determines whether a particular pixel was covered by trees in the year 2000 on a scale from 0 (no forest) to 100 (full coverage). I aggregate all the pixels within a community to determine the baseline tree cover. The second one shows whether a pixel with tree coverage in 2000 was still present by 2018 and, if not, in what year deforestation occurred. This allows me to construct a time series of tree cover loss from 2001 to 2018 for all communities.

A central component in my argument is that access to secure property rights, by providing a private good in a communal setting, undermines the ability of the group to engage in collective action. To study this, I employ two additional variables that measure the extent to which members decided to privatize parts of their community. As mentioned above, the most consequential change brought by the PROCEDE was the possibility to transition to full individual ownership and, subsequently, sell the land to outsiders. Hence, the first one of these variables takes the value of 1 when any member of a given community successfully adopted "dominio pleno" and 0 otherwise.

This legal option was only available to individual parcels, as communities could not privatize their common areas. However, villages can vote to switch the final use of specific parts of the commons from group-based to individual parcels, which could then transition to private property; this is known as *cambio de uso*. According to numerous accounts, this route has allowed the privatization of a vast number of hectares of communal lands across Mexico (Torres-Mazuera and BENET, 2021).

The specific variable I employ in the analysis take the value of 1 when the communal assembly approved a request to convert some of the commons to individual parcels and 0 otherwise. Another version of this variable measures the specific number of hectares affected by this conversion as a percent of the total community surface. The data for all of these variables comes from the National Agrarian Registry (RAN).

The main independent variables are the lags and leads around the time of official certification by the PROCEDE program. The dates of the community assemblies come from the National Agrarian Registry. I employed the official date of the vote as the starting point to create the timing variables—the main regressors.

Another key element in my theoretical framework is that the impacts of land certification should be heterogeneous across different types of communities, depending on the characteristics of their land and their institutional structure. First, I measure the availability of productive soils as a percent of the community's total surface to group communities into two categories (low and high agricultural productivity potential). The data comes from Mexico's National Institute of Statistics and Geography.

Second, I explore whether indigenous communities display different behaviors before and after getting access to secure property rights. There are various approaches to measure this variable. One of them is by the percent of the community's population who speaks an indigenous language. Another one is by the share of the population who self-identifies as indigenous. Although the latter is a more appropriate definition, I am constrained by the lack of available data at the community level.

Instead, I adopt a historical approach to define indigenous communities that focuses on the presence of long-standing traditional institutions. As mentioned above, despite centuries of land grabs, dispossession, and large-scale violence, some indigenous peoples in Mexico were able to survive up to the present time. Numerous ethnographic studies show how long-standing attachment to a particular territory is closely associated with ethnic identification and religious affiliation (Caballero, 2017). Moreover, as explained by Ostrom (1990), these repeated interactions among community members are essential to develop stronger norms of resource use and appropriation. I measure the presence of historical indigenous localities with the location of indigenous settlements in the year 1800, by the end of the Spanish colonial period.

These *pueblos* were indigenous settlements recognized by the Spanish crown as polities. By the end of the colonial rule, only a fraction of the pre-colombian indigenous communities were able to survive, most of them located in remote areas of the country, closer to mountain ranges and forests—as the vast majority of the best agricultural lands were taken by the Spanish colonizers (Elizalde, 2020).

In a separate chapter of the dissertation, I show that rural communities with one of these historical indigenous localities within their current geographic borders show higher levels of collective action potential, including a higher proportion of their lands held communally, a higher number of community forestry enterprises, and a higher likelihood to join federal conservation programs. For the purposes of this paper, I test the effects of access to secure property rights in historical indigenous communities compared to rural communities without these long-standing political institutions.

Finally, I test whether the certification of land titles affects economic activity. I employ nighttime lights (from satellite imagery) to approximate the levels of economic output. The data comes from the NASA, which released composite images of the Earth that measure the luminosity of a particular pixel. As with the previous satellite imagery data, I aggregate the values at the community level. Although several scholars have raised some caution against using this data for such purpose, given that the last *ejido* census occurred in 2010, satellite imagery is the only available source of information to track changes in the economic output of rural communities in Mexico.

3.6 Statistical Analysis

3.6.1 Descriptive Statistics

The average annual rate of deforestation for all communities from 2001 to 2018 in the country was 0.74% per year. As **Figure 3.15** in the Online Appendix shows, there was a substantial decrease in land use change from 2001 to 2016 and then a rapid rise afterwards. There is a large geographic variation in the extent to which *ejidos* and *comunidades agrarias* were able to effectively steward their natural resources. The states with the highest accumulated levels of community-level deforestation in this period were Campeche, Yucatan, Chiapas, Veracruz, Quintana Roo, Tabasco, and Baja California. With the exception of the last one, these are located in the south and southeast of the country, regions with higher rates of poverty. **Figure 3.16** in the Online Appendix show the trajectories of deforestation at the state level for different regions of Mexico.

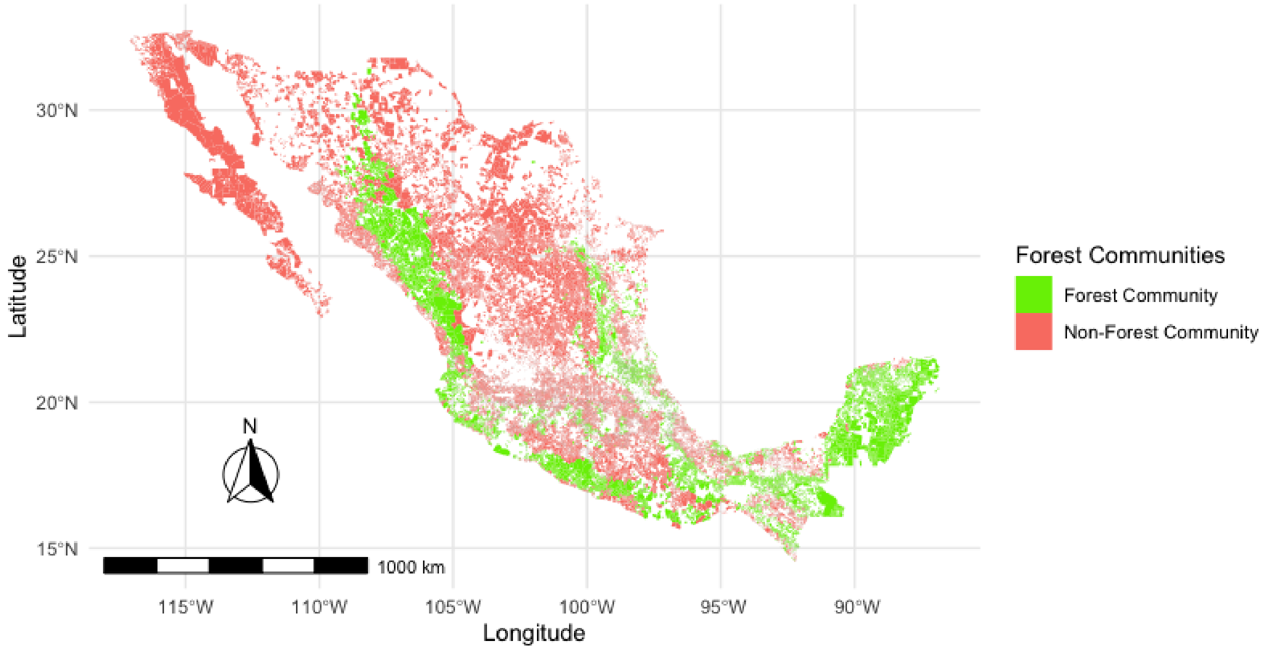


Figure 3.1: **Geographic distribution of forest communities (*ejidos* and *comunidades agrarias* with more than 10 percent of their surface covered by primary vegetation in 2000**

Regarding the outcomes measuring the strength of communal institutions, despite the expectation that *ejidos* and *comunidades* would engage in extensive privatization of communal lands, the number of assemblies to transition to "full ownership" remained quite small. Between 2001 and 2018, there were only 2,025 of these events across the country; nonetheless, the number has increased substantially over time: from only 3 in 2001 to 233 in 2017 and 177 in 2018 (see **Figure 3.17** in the Supporting Information). Moreover, there is no clear geographic pattern in terms of the privatization assemblies; the states with the largest number of them are Michoacan (277), Jalisco (244), Veracruz (239), and Guanajuato (238).

A similar situation occurred with the assemblies to convert communal lands into other forms of property (a step before privatization). There are two different ways to conceptualize this variable. A restrictive definition includes only changes from communal lands to individual parcels. A broader one also accounts for other forms of property.

The number of communal assemblies that approved such transition—narrowly defined—increased from 0 in 2001 to 28 in 2016 and then to 22 in 2018. The states with the highest absolute number are Yucatan, San Luis Potosi, Michoacan, and Guanajuato. In terms of area, between 2001 and 2018, 408,483 hectares of the commons became individual parcels. Baja California, Sonora, Chihuahua, Oaxaca, and Yucatan concentrate the majority of these lands. The total surface including other forms of property is 838,615 hectares (approximately 3,237 square miles). Campeche, Baja California, Michoacan, and Chiapas are the states with the largest number of communal lands converted to any other use. See **Figures 3.19, 3.20** in the Supporting Information.

As mentioned above, the PROCEDE was a successful public policy in terms of its implementation. By the end of the 90s, the majority of the rural communities in Mexico had finalized the long process to get their boundaries certified. In this paper, I analyze the remaining 7,338 that received their certified land titles between 2001 and 2018. The states with the highest number of "laggards" were Chiapas, Veracruz, Oaxaca, Michoacan, Jalisco, and Guerrero. In relative terms, Chiapas, Oaxaca, Guerrero, and Jalisco had the lowest rates of participation by 2001, with 72%, 53%, 43%, and 40% of their communities certified respectively. Figure 3.2 shows the distribution of these villages.

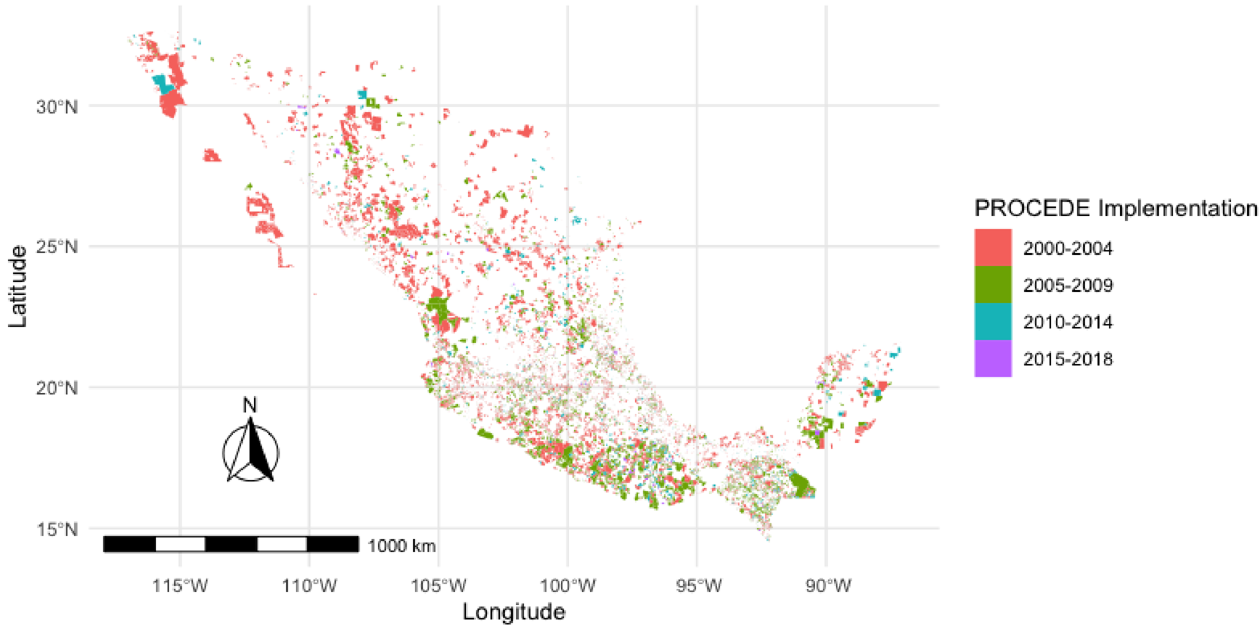


Figure 3.2: ***Ejidos* and *comunidades agrarias* that joined the PROCEDE program after 2001 (the "late adopters")**

There are some crucial differences between the early-adopters and the laggards in the PROCEDE program. Communities that received their titles after 2000 had a much higher percent of their territory covered by forests than the early adopters. In addition, these *ejidos* and *comunidades* have a larger share of their surface covered by areas of high ecological diversity [2] and had a higher potential to exploit their forest commercially. Both of these variables are defined by Mexico's National Forest Commission (CONAFOR). However, despite having more natural resources, the PROCEDE laggards suffered from less availability of arable land as a percent of the total community's surface.

[2]These include, for example, high-cloud mountain forests, mangroves, and other areas of exceptional biodiversity

Hence, from an ecological perspective, forests play a much more relevant role for the the late-adopters of the program than for the early ones, in both commercial and conservation terms. The two groups also differ substantially in terms of the proportion of historical indigenous localities and the percent of the community's surface devoted to the commons. Nonetheless, there are no statistically significant differences in their average elevation and their distance to medium and large urban centers. **Figure 3.30**, **Figure 3.31**, and **Figure 3.32** in the Supporting Information show kernel density plots for this variables.

Finally, it is important to mention that there are some key differences across cohorts in the sample (communities that received their land titles from 2001 to 2018) for variables associated with land use change and community ownership. These include the remaining tree cover in 2000 (the first year of the sample), the number of historical indigenous localities, the distance to medium and large cities, and the percent of arable land, total population, and total community area.

3.6.2 Event Studies Models

In this section, I present the main findings of the paper on the relationship between access to certified property rights through the PROCEDE, deforestation, community resilience, and land use. The first cut of the analysis explores the effects of secure land titles on deforestation. Figure 3.3 presents the results for all forest communities in the sample, as well as two subgroups (*ejidos* and *comunidades agrarias*).

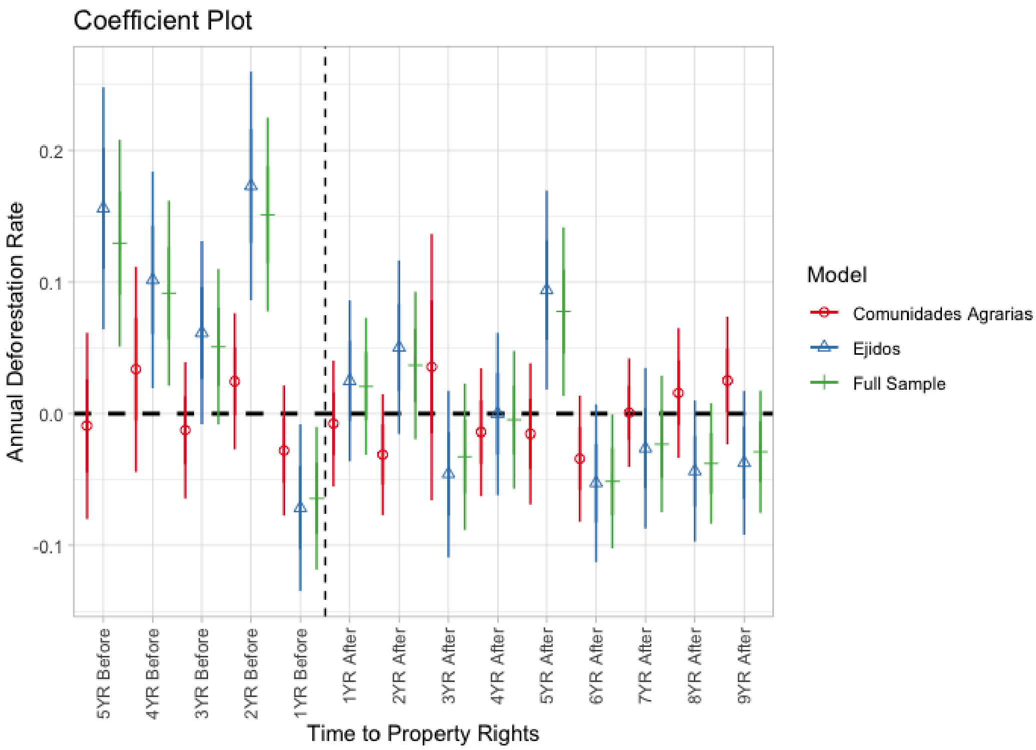


Figure 3.3: **Baseline model for forest communities (villages with more than 10% of their surface covered by primary vegetation).** The outcome variable is the annual deforestation rate. The main regressors are the lags and leads around the PROCEDE adoption year.

There are three main take-aways from this figure. First, the annual rate of deforestation for the entire sample increased during the years leading to the formal certification assembly and then remained stable for the period afterwards. Second, the magnitudes of the coefficients for the year dummies before the PROCEDE are statistically significant at the conventional levels (95%) and substantively relevant, as they approximately one fifth of the mean value on the main outcome variable. Third, most of the association is driven by *ejidos*, as *comunidades agrarias* remained stable in the period around the PROCEDE.

Figure 3.4 presents the same models for non-forest rural communities (villages with less than 10% of their surface covered by primary vegetation). In contrast to the previous analysis, we do not observe any statistically significant association or pattern between timing to access to secure property rights and the annual rate of deforestation.

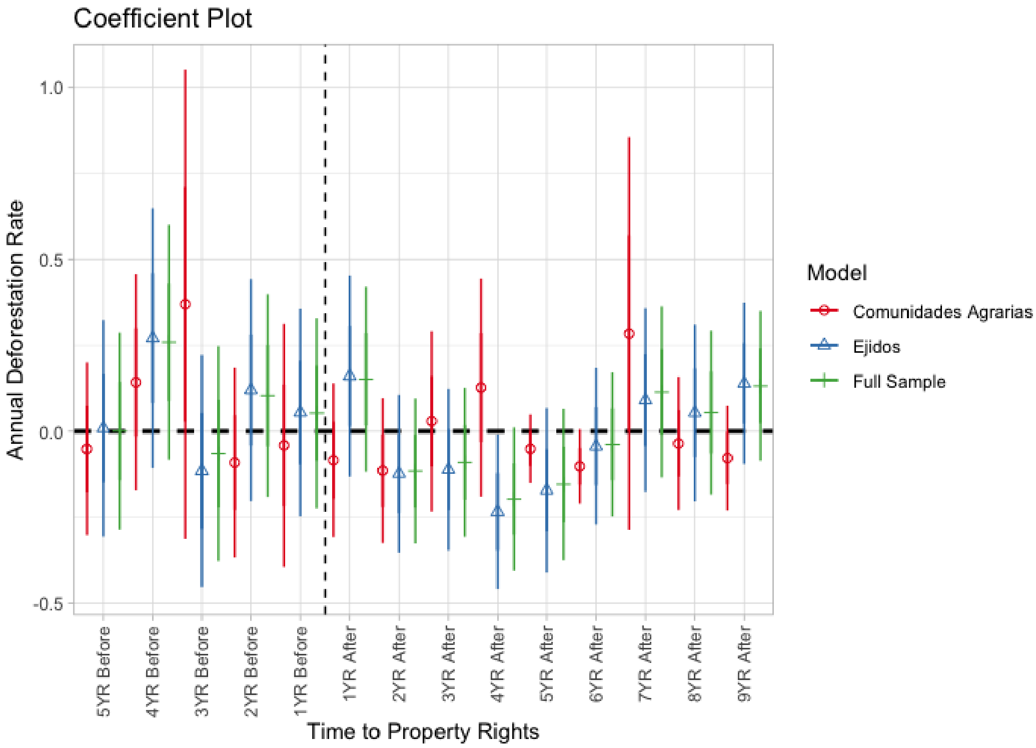


Figure 3.4: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation).** The outcome variable is the annual deforestation rate. The main regressors are the lags and leads around the PROCEDE adoption.

As mentioned in the theory section, I expect different types of communities to react differently to the incentives offered by the PROCEDE program, depending on two key intervening variables: the availability of fertile soils and the presence of long-standing political institutions to process cooperation and conflict. To test these hypotheses, I run the same models in different subsets of rural communities in the country.

First, I investigate how the provision of private and public goods through the PROCEDE affected rural communities with low availability of fertile agricultural land. Two broad patterns emerge from Figure 3.5. First, as in the baseline models, there is an increase in the annual rates of deforestation in the years leading to the certification program, particularly among *ejidos*. Second, moreover, the magnitude of the coefficients is remarkably higher, as it is close to 27% of the mean value of the outcome variable. Third, as shown in the Supporting Information, these results are robust to the cutoff to define communities with arable land scarcity. In **Figure 3.33**, **Figure 3.34**, and **Figure 3.35** I present the results for the same specification, but using 10%, 30%, and 40% to subset this group.

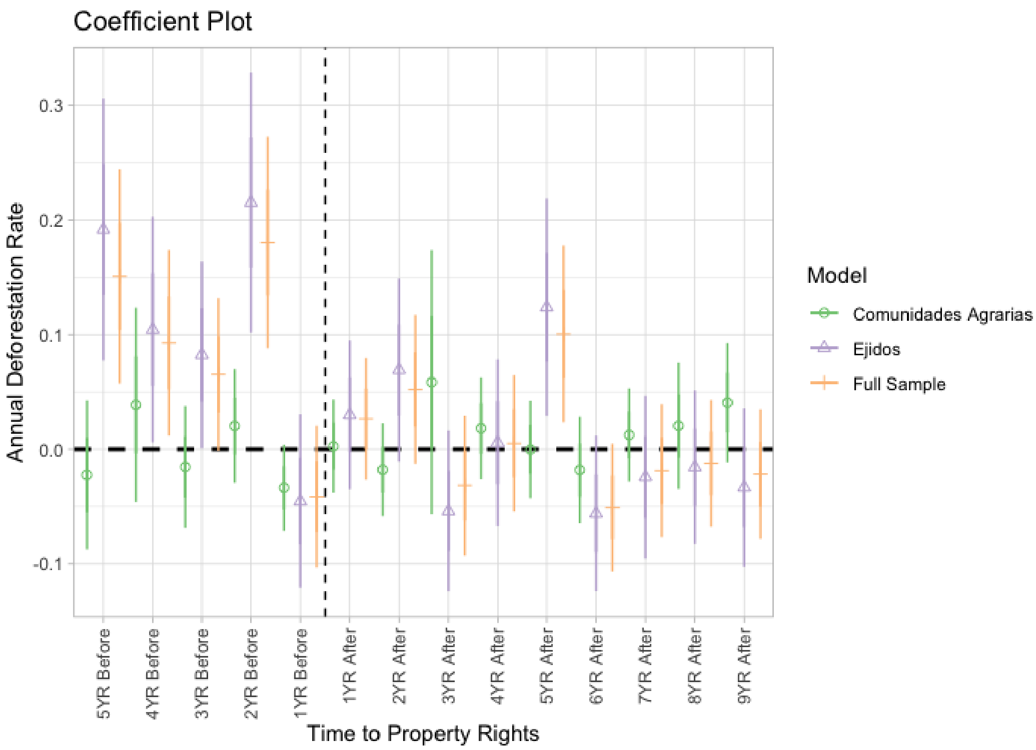


Figure 3.5: **Baseline model for forest communities (villages with more than 10% of their surface covered by primary vegetation and with low availability of arable land (less than 20% of their territory covered by fertile soils).** The outcome variable is the annual deforestation rate. The main regressors are the lags and leads around the PROCEDE adoption.

The findings look remarkably different for rural communities with abundance of fertile land (See Figure 3.6). In contrast to the previous group, the expectation of accessing secure land titles does not affect the rates of deforestation for these villages, either before or after the

PROCEDE certification. This applies to both *ejidos* and *comunidades agrarias*. Moreover, the results are robust to different cutoffs to subset this group. See **Figures 3.36, 3.37** in the Supporting Information.

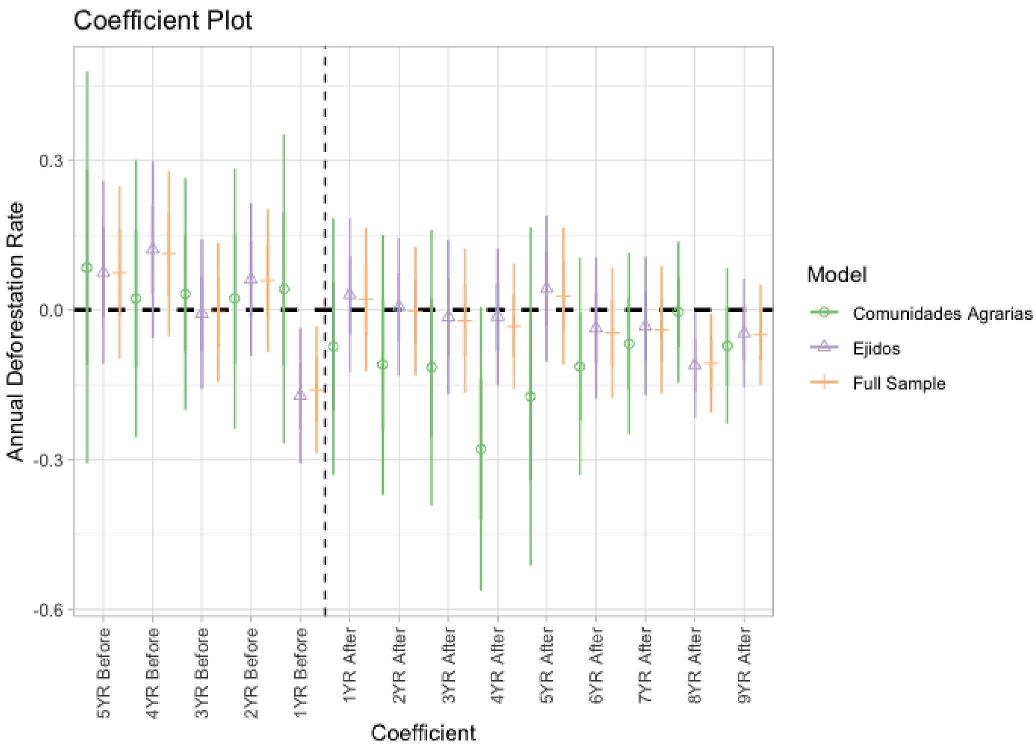


Figure 3.6: **Baseline model for non-forest communities (villages with more than 10% of their surface covered by primary vegetation and with high availability of arable land (more than 50% of their territory covered by fertile soils).** The outcome variable is the annual deforestation rate. The main regressors are the lags and leads around the PROCEDE adoption.

Second, I analyze how the bundled treatment of the PROCEDE affects indigenous versus non-indigenous communities. To do so, I separate the sample into two categories. One includes forest villages with at least one historical indigenous locality (*pueblo*) within its current borders and the other does not. There are three broad patterns from Figure 3.7. First, rural communities without one of such historical polities experienced higher rates of deforestation in the period leading to the official certification by the PROCEDE. These coefficients are statistically significant at the conventional levels and substantial in magnitude. In contrast, communities with long-standing traditional political institutions did not experience any change in the rate of deforestation either before or after.

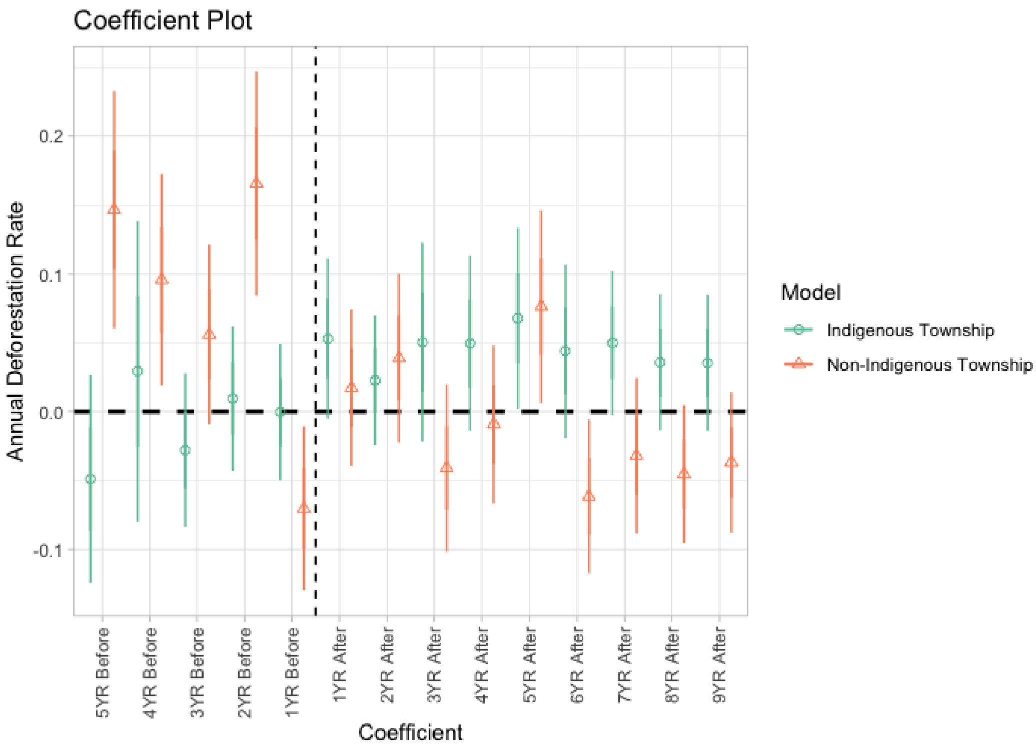


Figure 3.7: **Baseline model for forest (villages with more than 10% of their surface covered by primary vegetation) with and without historical indigenous localities.** The outcome variable is the annual deforestation rate. The main regressors are the lags and leads around the PROCEDE adoption.

Figure 3.38 to **Figure 3.39** in the Supporting Information show some additional robustness checks that strengthen the findings mentioned above. Whereas in the previous specification I employ the entire sample of forest communities in the country, for these figures I adjust the threshold to define a village as a forest community. Specifically, I increase the cutoff from 10% of their surface covered by primary vegetation to 20%, 30%, 40%, and 50%. The results remain the same, as rural communities with long-standing indigenous institutions did not experience any statistically significant change in their rates of deforestation; in contrast, the rest of them had more forested land use change in the period leading to the official certification, for various levels of forest cover.

The second half of the analysis aims to disentangle some potential mechanisms that may explain the patterns above. First, I explore how the provision of private and public goods associated with the PROCEDE changed the probability of land privatization in rural communities; this would reflect a weakening in the collective action capacity of the group, which is a precondition for the successful stewardship of the commons.

The model specification remains unchanged, with a different outcome. Figure 3.8 shows, on the X axis, the lags and leads around the official certification date whereas the Y axis presents the linear probability of holding a privatization meeting. The sample includes, as in the previous models, all rural communities with at least 10% of their surface covered by forests. There are two main patterns that emerge from this figure. First, there is an overall increase in the probability to privatize part of the community in the years after the PROCEDE, particularly in the medium-term. Second, as in the initial baseline model on deforestation, most of the effects come from *ejidos* as opposed to *comunidades*.

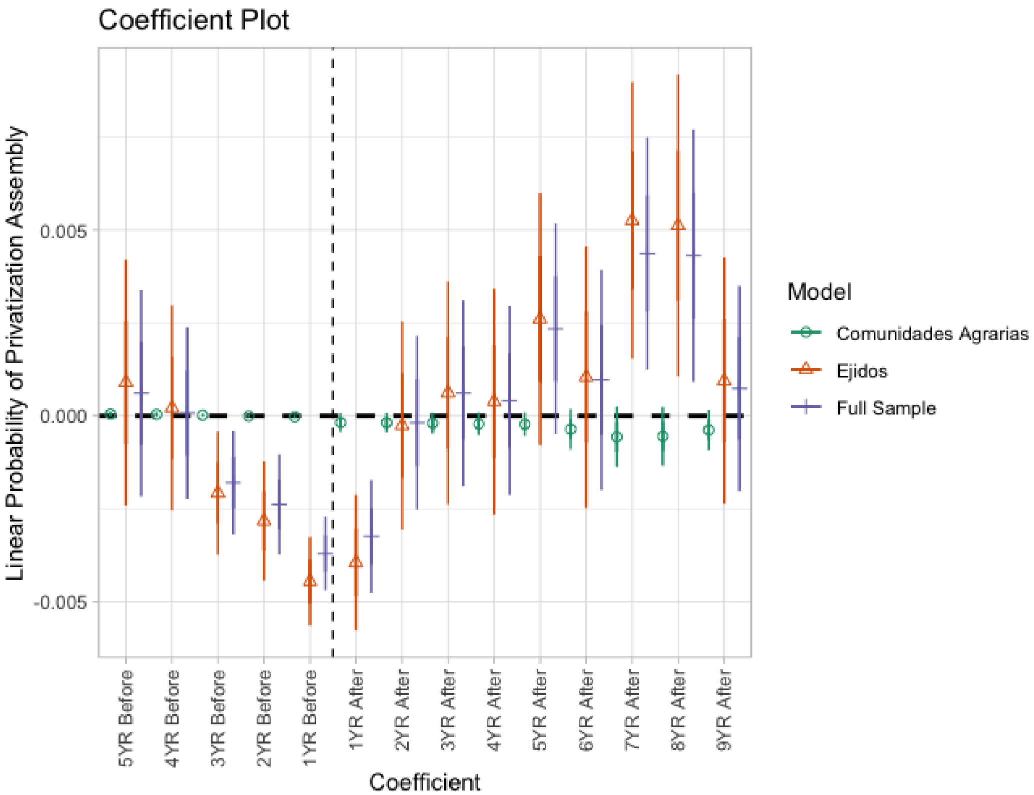


Figure 3.8: **Baseline model for forest communities (villages with more than 10% of their surface covered by primary vegetation.)** The outcome variable is the linear probability of privatization. The main regressors are the lags and leads around the PROCEDE adoption.

It is important to mention that this pattern is not exclusive from forest communities. Figure 3.9 shows the same specification for villages with less than 10% of their territory covered by forests. The overall trend is the same, but the spikes in the privatization probability occurred much faster (almost immediately after the program implementation).

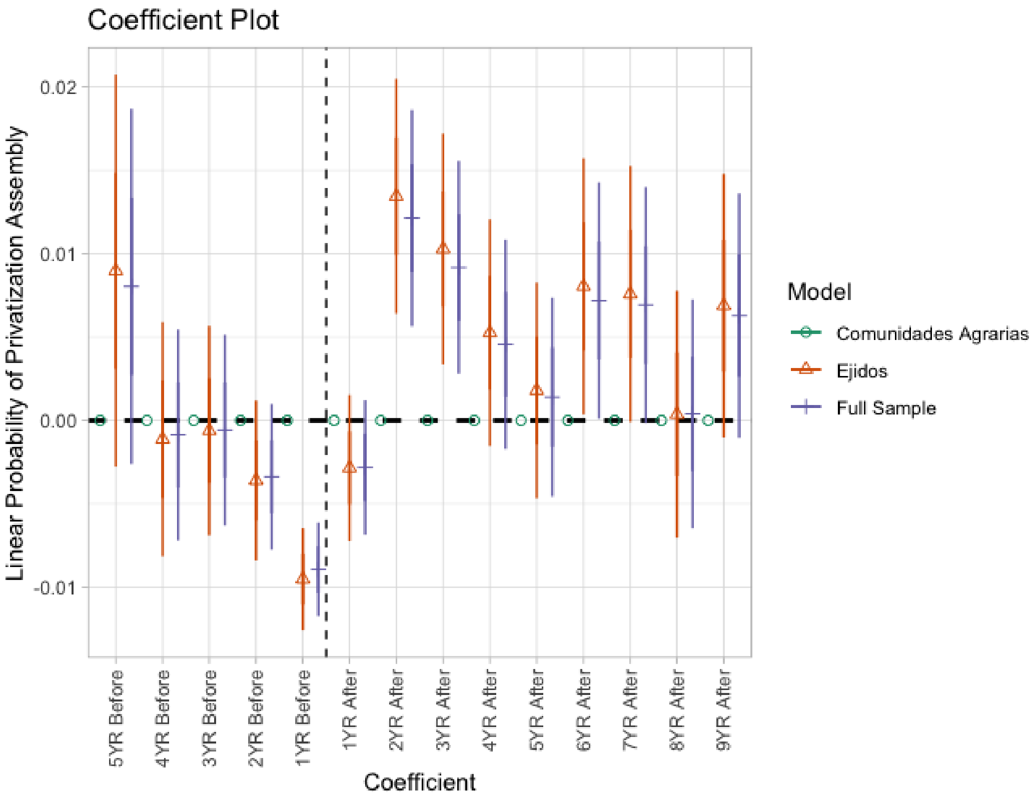


Figure 3.9: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation).** The outcome variable is the linear probability of privatization. The main regressors are the lags and leads around the PROCEDE adoption.

As in the first part of the analysis, I investigate how the probability of privatization changes before and after the land titles certification for different subgroups of communities. For villages with acute scarcity of agricultural soils, the results are practically identical to the models using the entire sample, as shown in Figure 3.10. That is, there is an increase in the likelihood of privatization in the medium-term after the PROCEDE. In contrast, communities where the availability of land fertile for agriculture is not an issue, I do not observe the same pattern (see Figure 3.11).

Figure 3.40 to **Figure 3.44** in the Supporting Information present some additional robustness checks, in particular different thresholds to define communities as land-scarce and land-abundant (from 10 to 30 and 50 to 70 respectively).

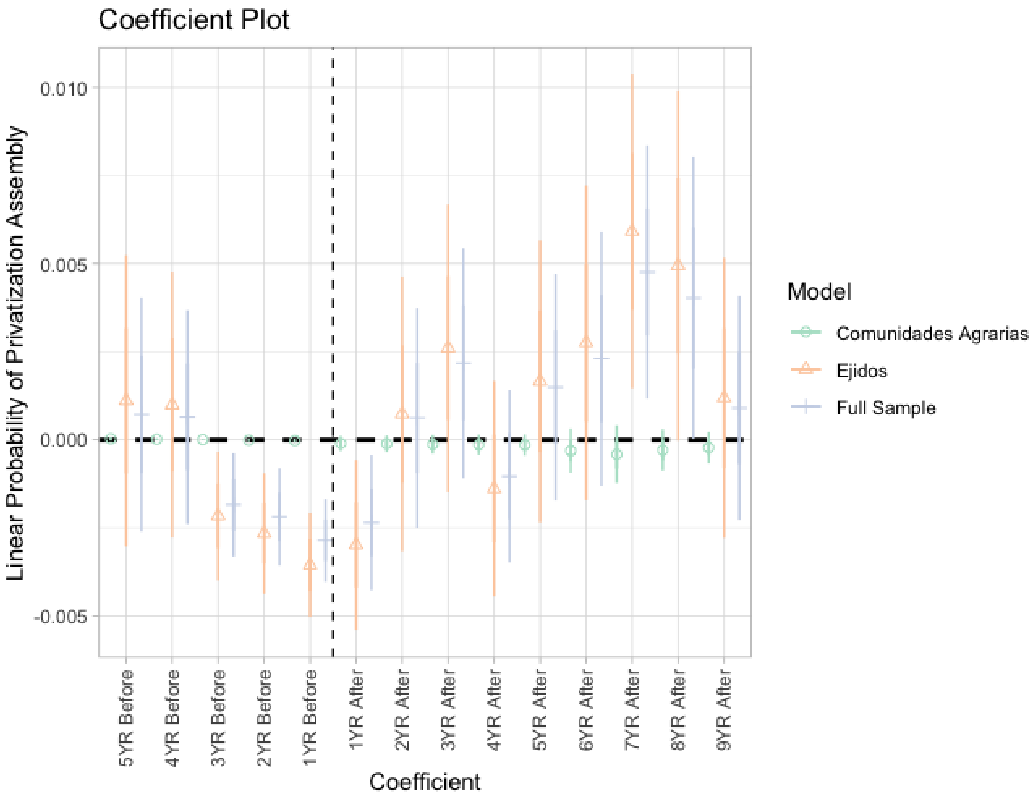


Figure 3.10: **Baseline model for forest (villages with less than 10% of their surface covered by primary vegetation) with agricultural land scarcity.** The outcome variable is the linear probability of privatization. The main regressors are the lags and leads around the PROCEDE adoption.

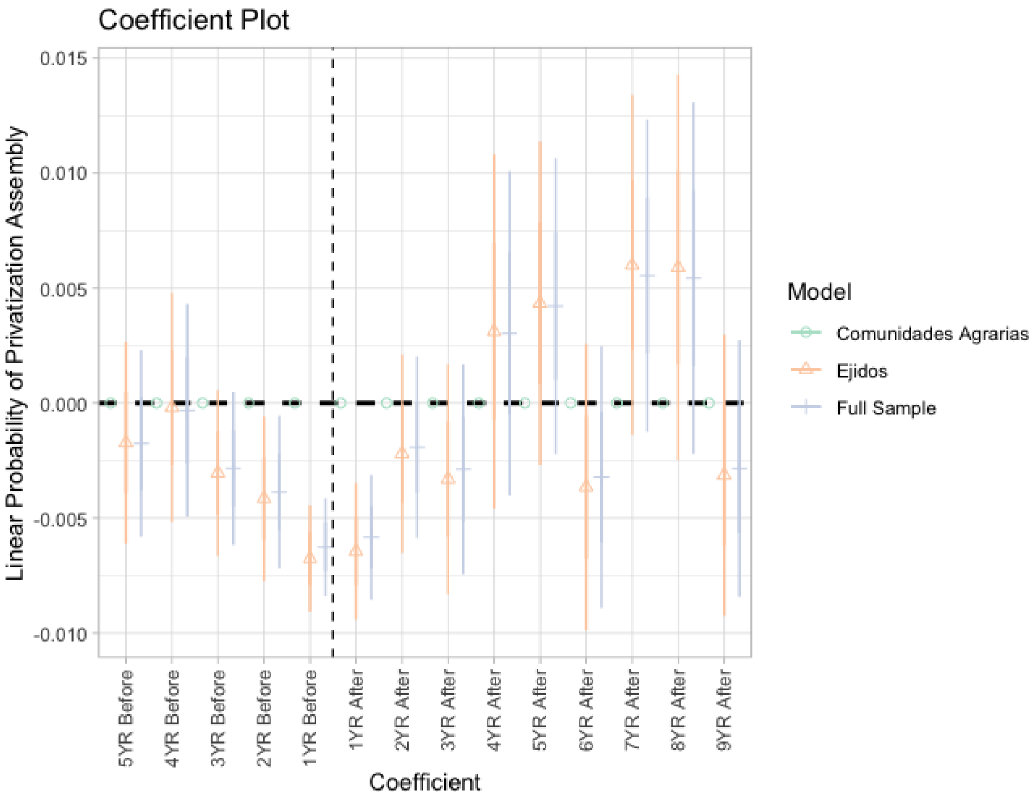


Figure 3.11: **Baseline model for forest communities (villages with less than 10% of their surface covered by primary vegetation) without agricultural land scarcity.** The outcome variable is the linear probability of privatization. The main regressors are the lags and leads around the PROCEDE adoption.

Lastly, I study how the probability of privatization changed before and after the PROCEDE for indigenous and non-indigenous forest communities. Figure 3.12 presents the results of these models. As in the previous cases, the X axis includes the lags and leads around the date of certification and the Y axis the probability of privatization.

Forest communities without long-standing indigenous political experienced a much higher chance of holding a privatization assembly after the PROCEDE, as compared to forest villages with historical indigenous localities. For the former group, the probability was the highest 6-7 years after the official certification. These results are robust to the definition of forest community (I employ a cutoff of 20%, 30%, 40%, and 50% instead of the

10% baseline).

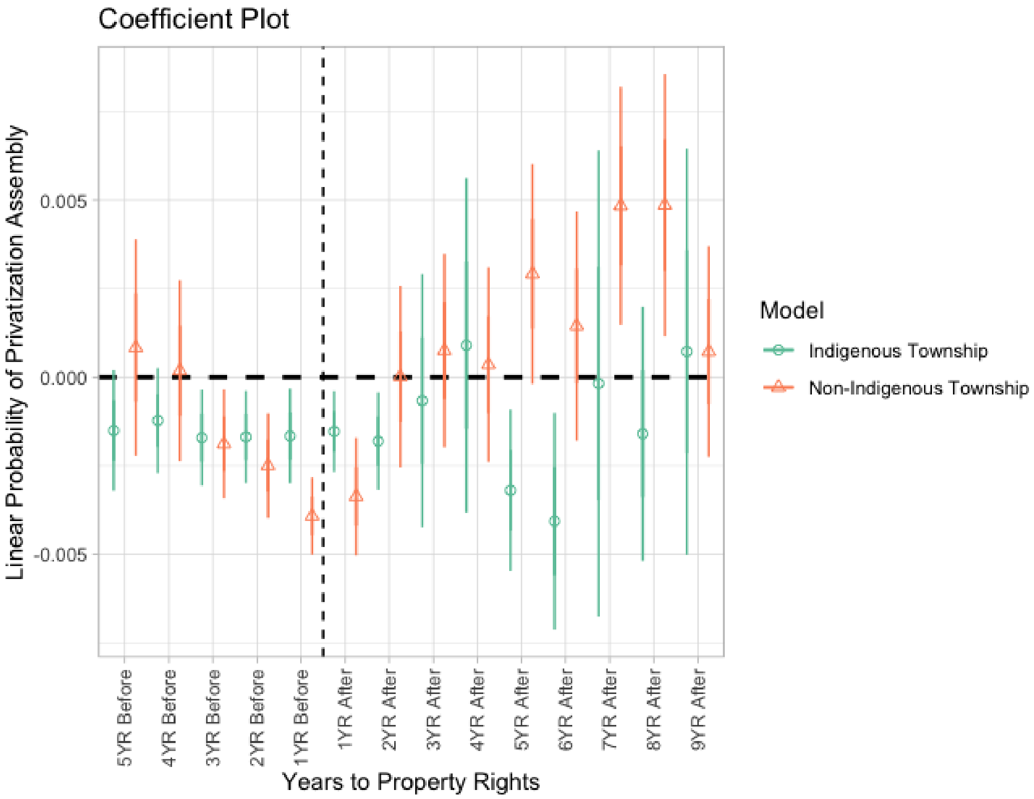


Figure 3.12: **Baseline model for forest communities (villages with less than 10% of their surface covered by primary vegetation) with and without historical indigenous localities.** The outcome variable is the linear probability of privatization. The main regressors are the lags and leads around the PROCEDE.

Finally, the last component of the statistical analysis explores some additional outcomes affected by the certification process: economic activity and access to agricultural subsidies. First, Figure 3.13 shows the event studies model using the nighttime luminosity data as the outcome. The main take-away from this analysis is that communities experienced a decrease in their economic output immediately after the certification occurred. This is particularly pronounced among non-indigenous communities and villages with relatively high levels of arable land. These findings may seem puzzling at first, but they are consistent with other research on this program. Specifically, De Janvry et al. (2015). show that accessing secure property rights induced a different allocation of labor within communities, incentivizing migration to the United States. My findings show that this relationship is not statistically significant among indigenous communities.

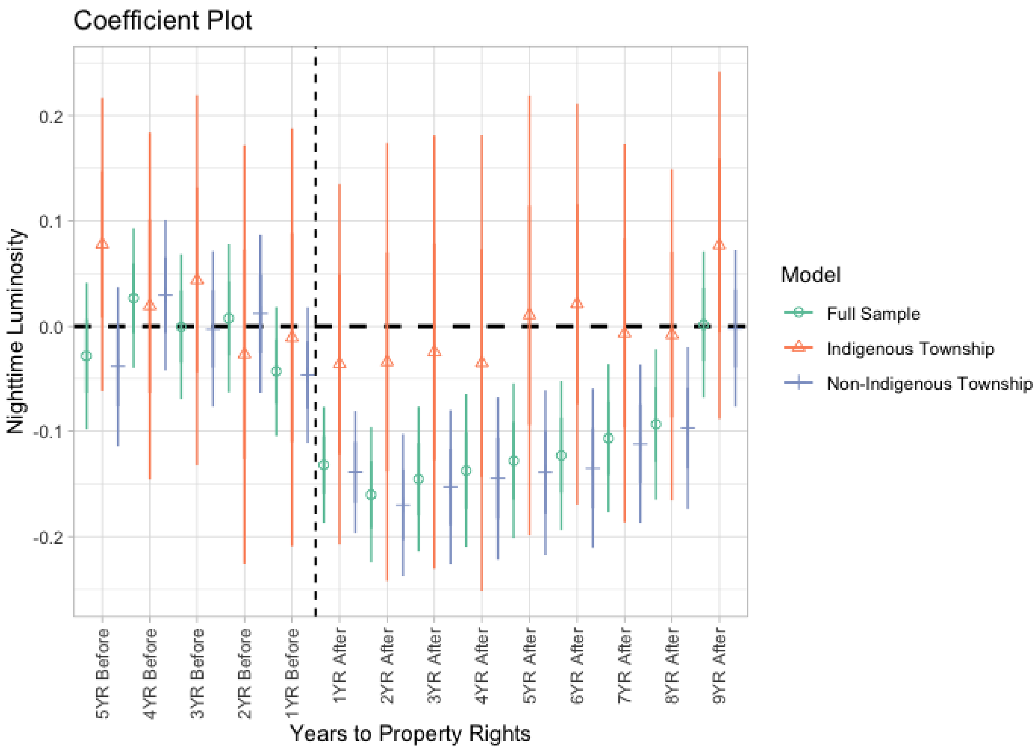


Figure 3.13: **Baseline model for forest communities (villages with less than 10% of their surface covered by primary vegetation) with and without historical indigenous localities.** The outcome variable is the nighttime luminosity. The main regressors are the lags and leads around the PROCEDE.

The last cut of the analysis investigates how the certification program affected villages' access to agricultural subsidies, one of the main drivers of deforestation in the country. Figure 3.14 presents the results of the event studies model. Although both indigenous and non-indigenous communities received more funds from the PROCAMPO program after the certification, the former did so at higher levels than the latter.

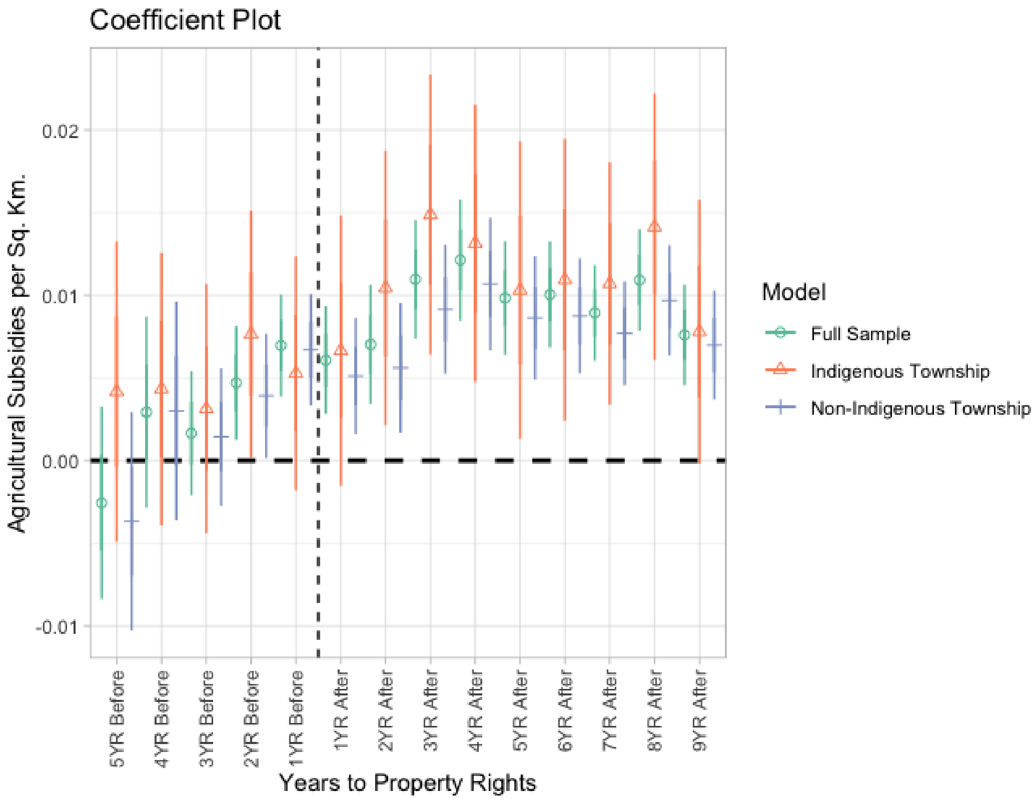


Figure 3.14: **Baseline model for forest communities (villages with less than 10% of their surface covered by primary vegetation) with and without historical indigenous localities.** The outcome variable is the amount of agricultural subsidies from the PROCAMPO program per hectare of land. The main regressors are the lags and leads around the PROCEDE.

3.7 Discussion and Conclusions

The main objective of this chapter is to understand how one of the most ambitious land tenure reforms in the Global South affected the ability of thousands of rural communities in Mexico to steward their ecosystems. The first take-away from my analysis is that this type of reforms is more complex than what is sometimes assumed in the existing literature. The PROCEDE bundled two types of treatments that, from a theoretical perspective, have opposite effects on the ability of communities to protect their forests. One of them, the certification of the village's external boundaries, is a common good, which according to the existing research promotes conservation outcomes. The second one, the provision of titles to individual parcels, is a private good that promotes agricultural production and, therefore, it may undermine the collective action potential of the community.

My findings suggest that there is an increase in the annual deforestation rates in the years prior to the official adoption of the PROCEDE among villages with low availability of arable land and without long-standing indigenous political institutions. Why do we observe this counter-intuitive relationship between titles and deforestation? Why does it happen before the official implementation of the program?

Access to secure land tenure has profound consequences for the economic stability of a household, as it allows its members to invest in capital, use the land as collateral, and even sell it to outsiders. Hence, the individual titles component of the program represented a powerful incentive for community members. However, not everyone agreed on whether to participate in the PROCEDE and how to allocate the different parts of the community to various users and members. This, naturally, introduced a certain degree of political instability and power dynamic changes within communities.

Moreover, numerous accounts describe how authorities displayed a wide array of positive and negative incentives to accelerate the process, which, in turn, exacerbated the political instability within communities. Hence, the PROCEDE provided powerful incentives to prioritize individual land for agriculture over communal lands for forests; indirectly, the long and contentious implementation process resulted in a diminished potential for collective action among certain communities. Both of these characteristics, I argue, affected the ability of communities to steward their natural resources.

In addition, as many other land tenure reforms in Latin America, the PROCEDE was a highly publicized policy that created expectations and concerns from the very beginning, even before communities officially joined the program. Therefore, we should expect that the incentives and the political instability mentioned above affected communities' ability to protect their forests in the period leading to the official certification of land titles.

Given the incentives to provide titles to community members and the indirect instability generated by the program, I also posit that there are two variables that mediate the impacts of the PROCEDE. The first one is the availability of arable land. When the community lacks enough fertile soils to provide good quality parcels, they resort to lands which are less suitable for agriculture, including forested areas and other ecosystems.

The second variable is the political framework within communities, in particular the presence of long-standing indigenous political institutions. As I explain in another chapter of my dissertation, there is strong empirical evidence that communities with historical traditional institutions have higher levels of collective action potential as well as strong institutional mechanisms to promote intra-group cooperation and negotiate conflict.

My findings suggest that indigenous communities did not experience higher deforestation rates either before or after the official certification of their land titles via PROCEDE. In contrast, non-indigenous villages showed higher rates of land use conversion before the titling. Moreover, I show evidence that the former group requested fewer individual titles per square kilometer in the PROCEDE year as compared to the latter group.

Finally, in this paper I also present evidence of the medium and long-term effects of the certification program on the resilience of communities. As shown in the empirical analysis, non-indigenous communities were much more likely to privatize part of their territory in the years following the PROCEDE, which is consistent with the idea that these villages requested more land titles per square kilometer and engage in higher rates of deforestation. In contrast, indigenous communities remained practically unchanged.

My work has three main contributions to the existing literature on land tenure reforms. The first one is about the mechanisms that link secure titles with land use change; whereas the basic assumption of most of the existing research is that strong property rights protect communities against external actors, in this paper, I present evidence that such type of interventions also affects the internal dynamics of communities, in particular those facing land scarcity pressures and lacking institutional mechanisms to process conflict. Rural communities are not monolithic actors and policies as far-reaching and consequential as land tenure reforms result in important political changes within the group.

Second, this chapter introduces important nuances on the specific "treatments" associated with a land tenure reform. Most of the existing literature has focused on policies that recognize the external boundaries of the group; however, many other rural interventions include the provision of different forms of private goods—in this case, individual parcels titles. Hence, in my work I show the relevance of taking these into account when analyzing community-level dynamics associated with land use change.

Third, in my research, I challenge one of the main assumptions about land tenure interventions. The PROCEDE, as many other similar land tenure interventions across Latin America, was large-scale and ambitious. This meant that eligible communities knew about the benefits and costs of the program even before they officially voted to participate in it. Given that the incentives to clear the forests mentioned above are not tied to the actual reception of the titles, the effects of the PROCEDE did not start when communities issued the final vote. Quite the contrary: this is the last stage of a long and contentious process that affects intra-group dynamics.

Finally, the last contribution of this study is to go beyond land use change outcomes and explore how access to land titles affects other aspects of the community. These include variables such as the probability of privatization, participation in other federal programs (such as agricultural subsidies), and the levels of economic activity. In contrast, most of the existing research on the topic has focused mostly on deforestation.

3.8 Supporting Information

3.8.1 Descriptive Figures

3.8.1.1 Time-Series of Selected Outcomes (National Level)

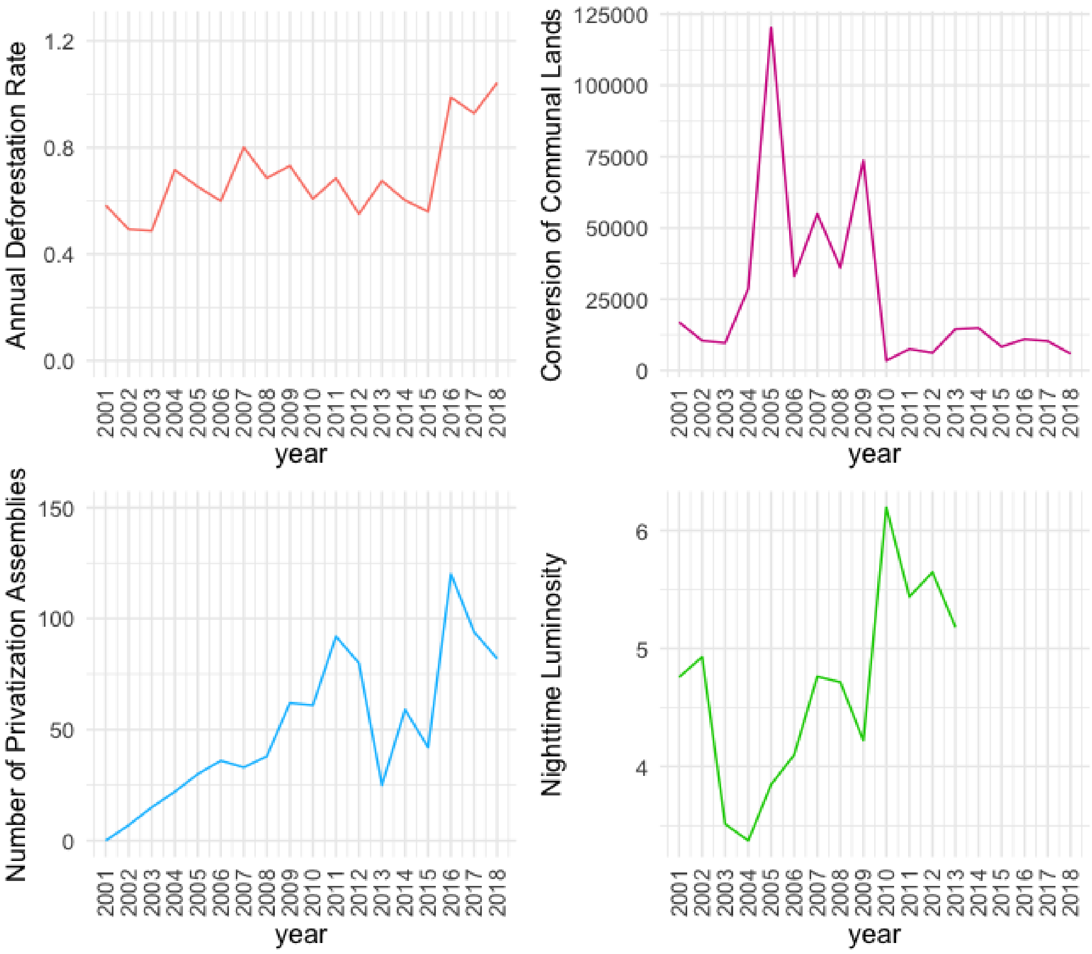


Figure 3.15: **Time-series of selected outcomes**. Top left: average annual deforestation rate across all forest communities in Mexico from 2001 to 2018. Top right: total number of hectares of communal lands converted to any other land use across all forest communities in Mexico from 2001 to 2018. Bottom left: total number of privatization assemblies across all forest communities in Mexico from 2001 to 2018. Bottom right: average nighttime luminosity across all forest communities in Mexico from 2001 to 2012.

3.8.1.2 Deforestation by State-Year

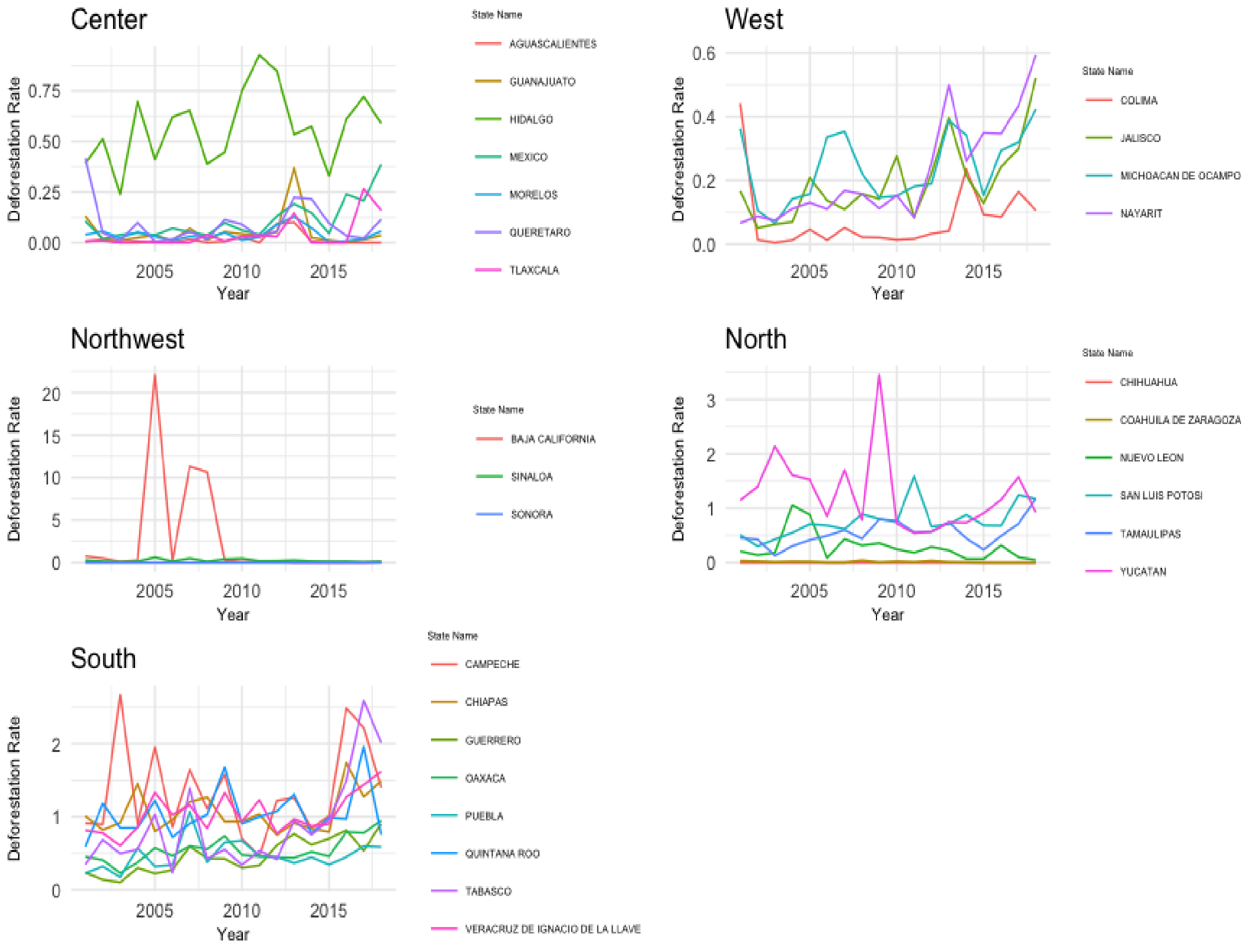


Figure 3.16: **Deforestation rates in different regions of Mexico.** Each one of the lines in these plots show the average rate of tree cover loss for all forest communities in a given state-year. The sample includes villages with more than 10% of their surface covered by primary vegetation in the year 2000; the data comes from Hansen et al.

3.8.1.3 Privatization Assemblies by State-Year

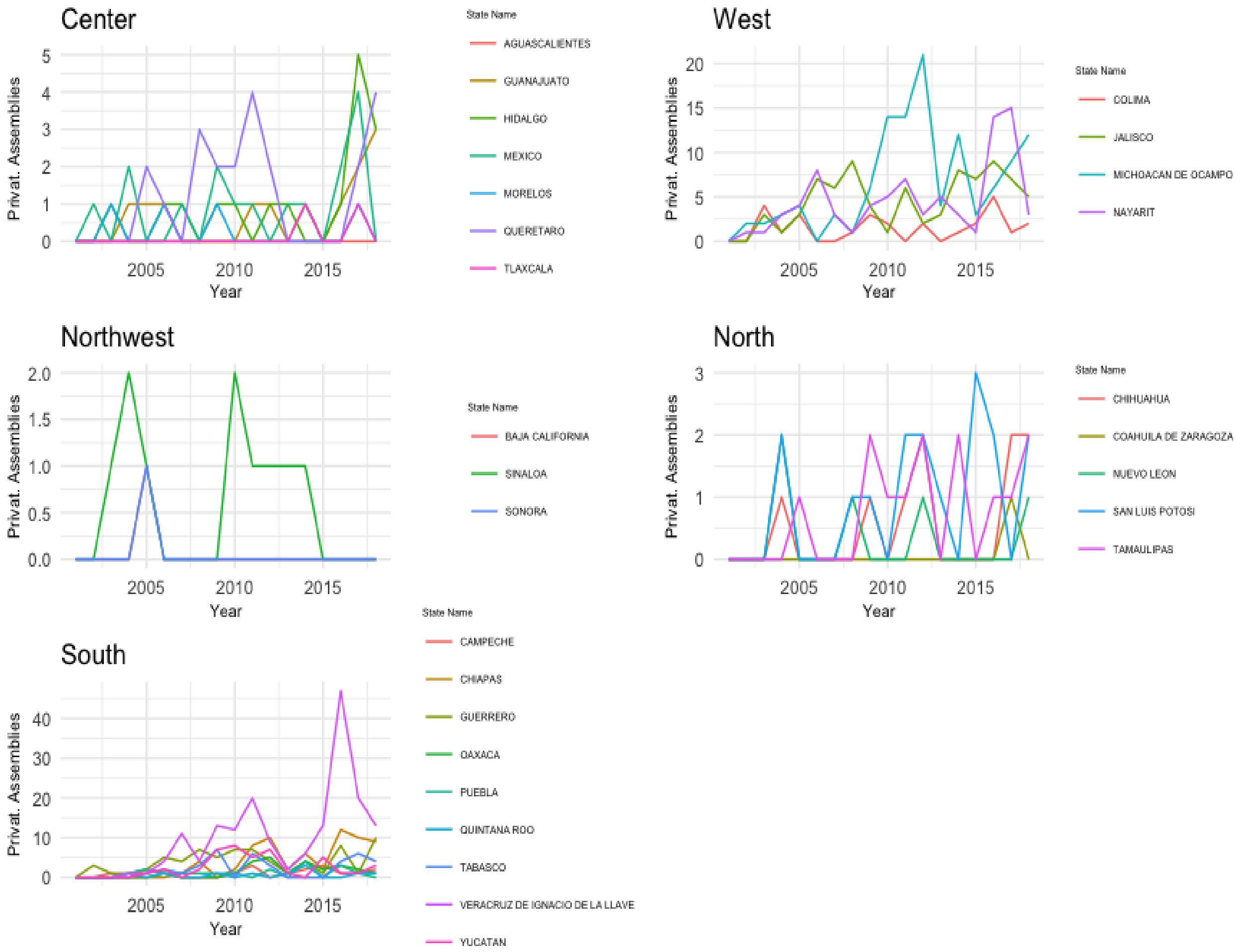


Figure 3.17: **Privatization assemblies among forest communities (*asambleas de dominio pleno*) in different regions of Mexico.** Each one of the lines in these plots show the average number of privatization assemblies per community in a given state-year. The sample includes forest villages, defined as those having more than 10% of their surface covered by primary vegetation in 2000. The data comes from the National Agrarian Registry.

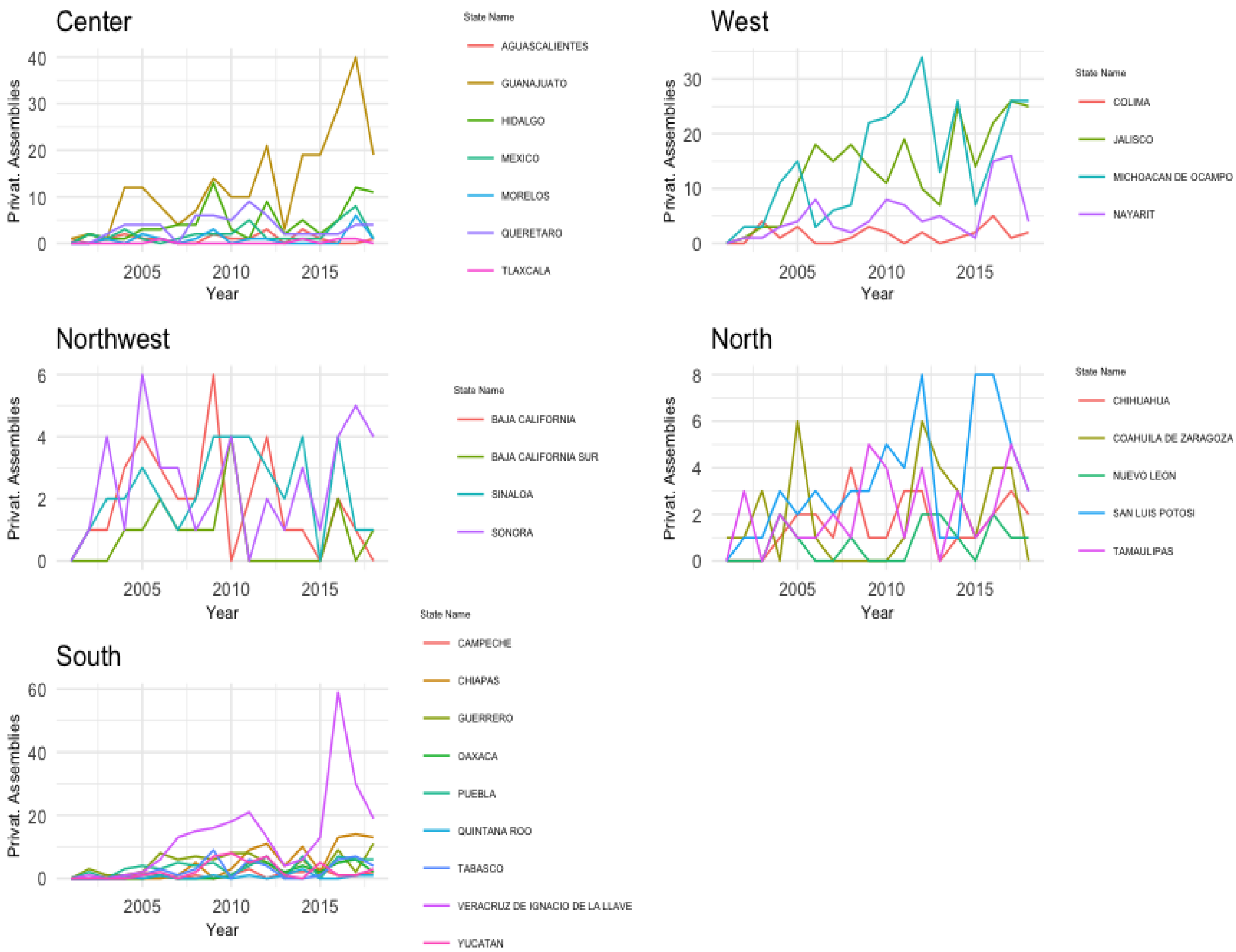


Figure 3.18: **Privatization assemblies (*asambleas de dominio pleno*) among all villages in different regions of Mexico.** Each one of the lines in these plots show the average number of privatization assemblies per community in a given state-year. The sample includes all rural villages in Mexico, regardless of their initial share of forest cover. The data comes from the National Agrarian Registry.

3.8.1.4 Commons Conversion by State-Year

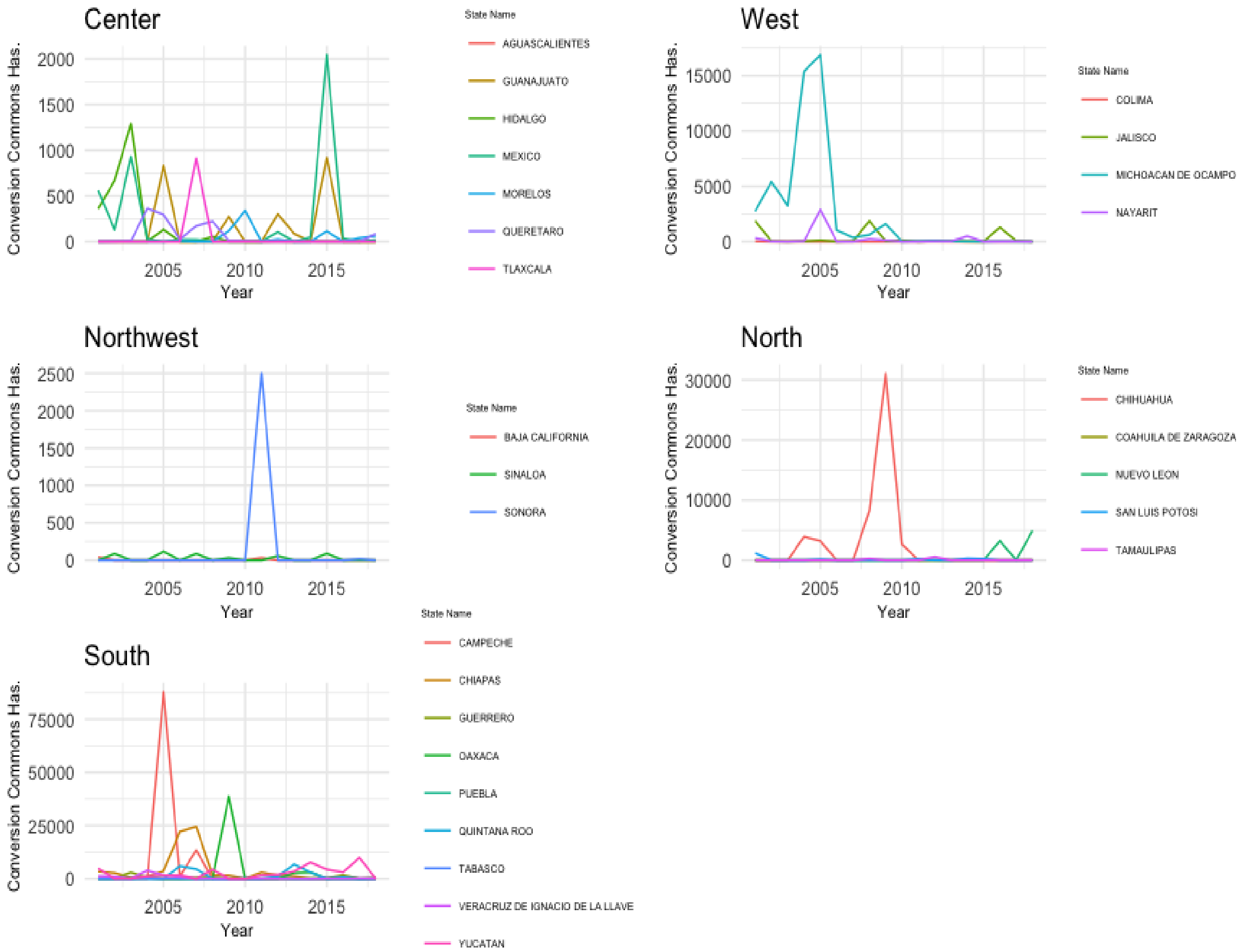


Figure 3.19: **Conversion of communal lands among forest communities in different regions of Mexico.** Each one of the lines in these plots show the average number hectares of communal areas that switched to any other land use, including individual parcels, in a given state-year. The sample includes forest villages, defined as those having more than 10% of their surface covered by primary vegetation in 2000. The data comes from the National Agrarian Registry.

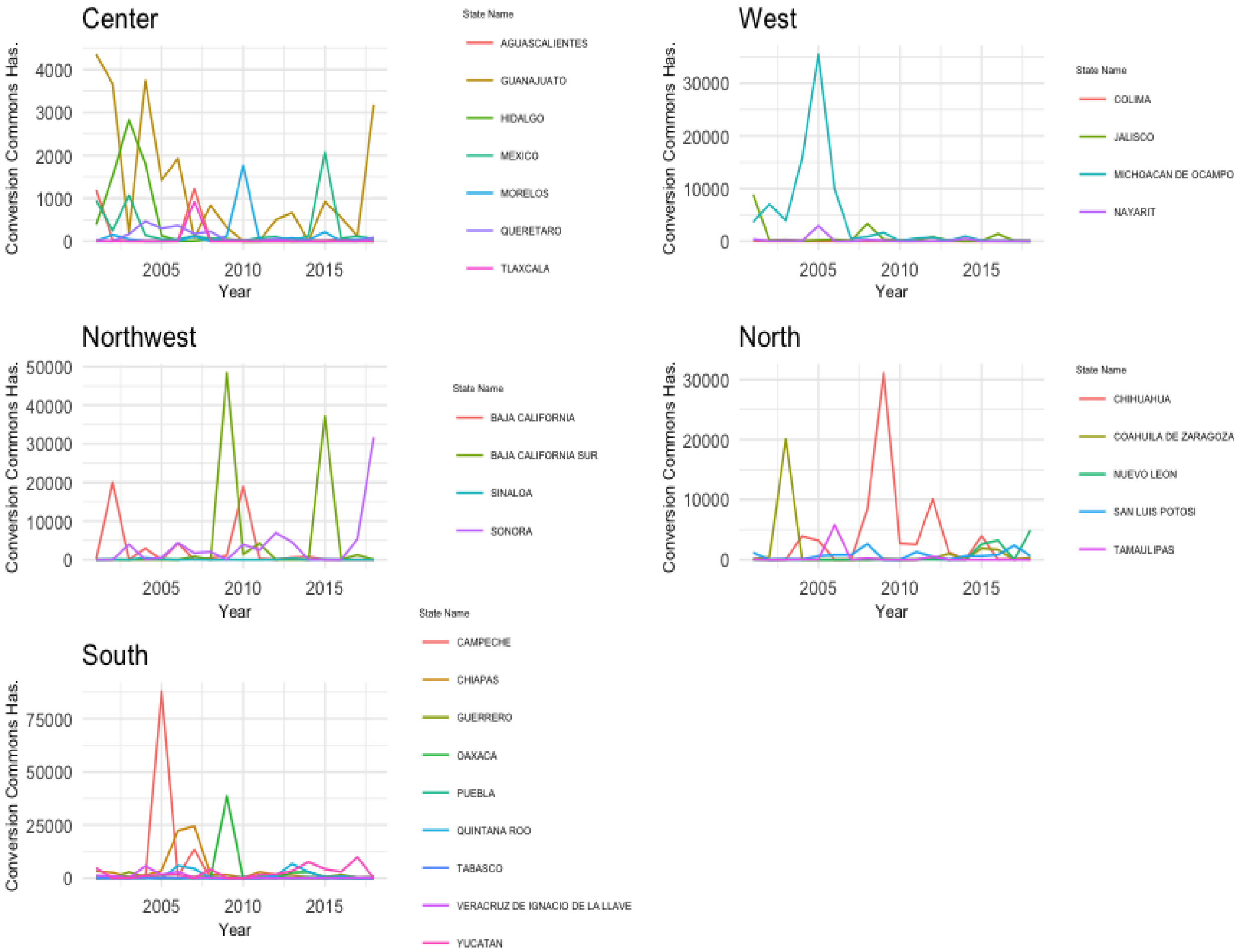


Figure 3.20: **Conversion of communal lands among all communities in different regions of Mexico.** Each one of the lines in these plots show the average number hectares of communal areas that switched to any other land use, including individual parcels, in a given state-year. The sample includes all rural villages in Mexico, regardless of their initial share of forest cover. The data comes from the National Agrarian Registry.

3.8.1.5 Nighttime Luminosity by State-Year

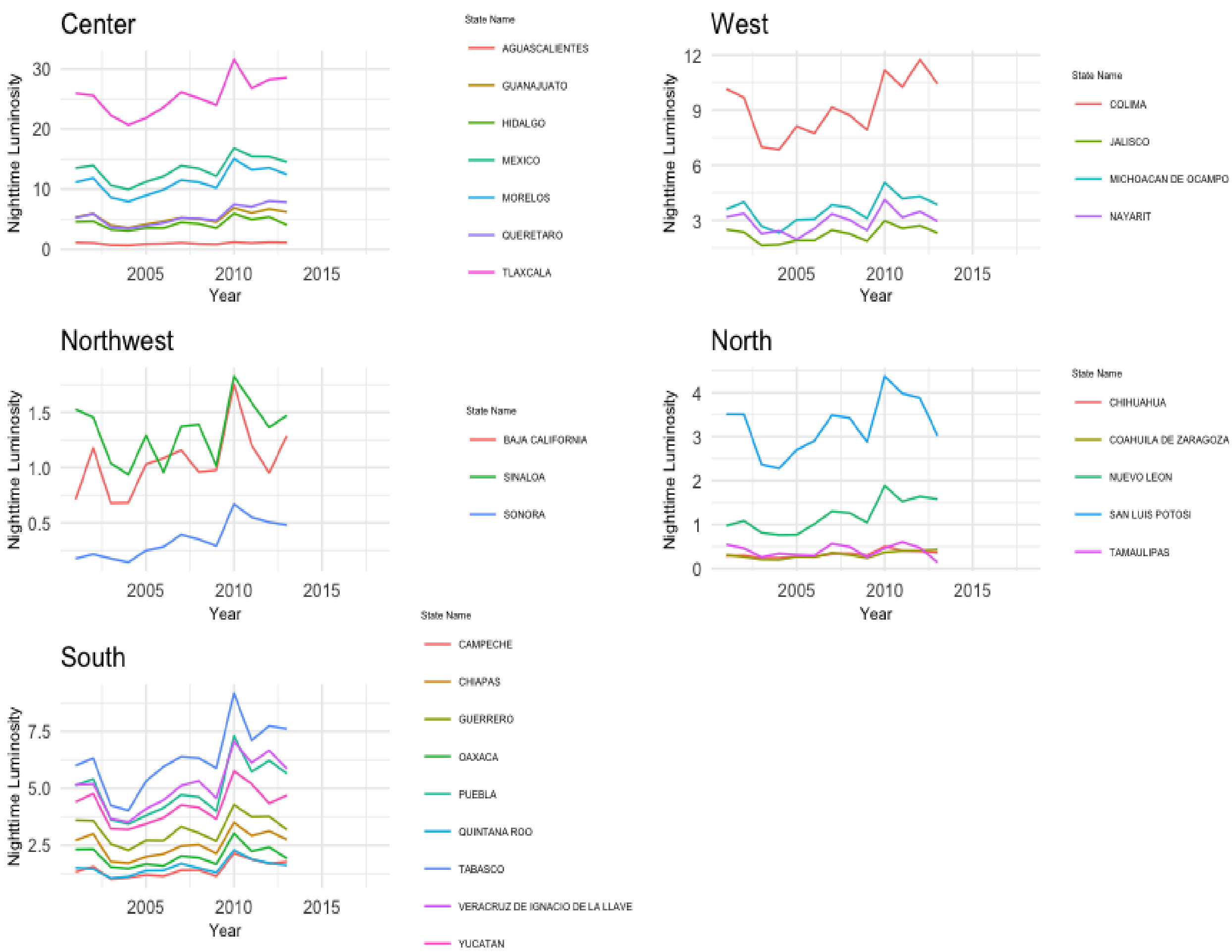


Figure 3.21: **Nighttime luminosity among forest communities in different regions of Mexico.** Each one of the lines in these plots represents the average nighttime luminosity of the communities of a given state-year. The sample includes forest communities, defined as those having more than 10% of their surface covered by primary vegetation in 2000. The data comes from NASA

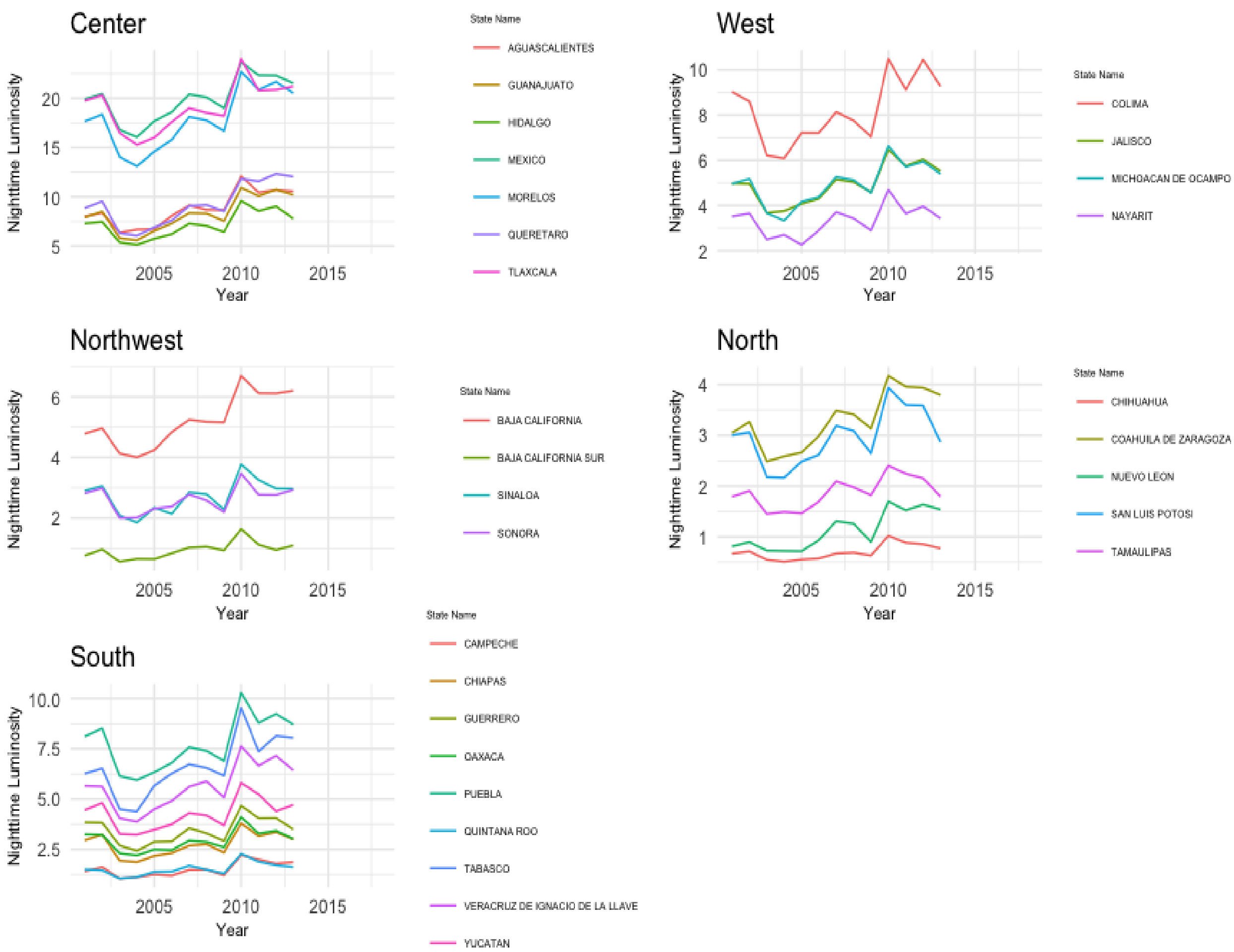


Figure 3.22: **Nighttime luminosity among all communities in different regions of Mexico.** Each one of the lines in these plots represents the average nighttime luminosity of the communities of a given state-year. The sample includes all communities, regardless of their initial share of forest cover. The data comes from NASA.

3.8.1.6 Maps

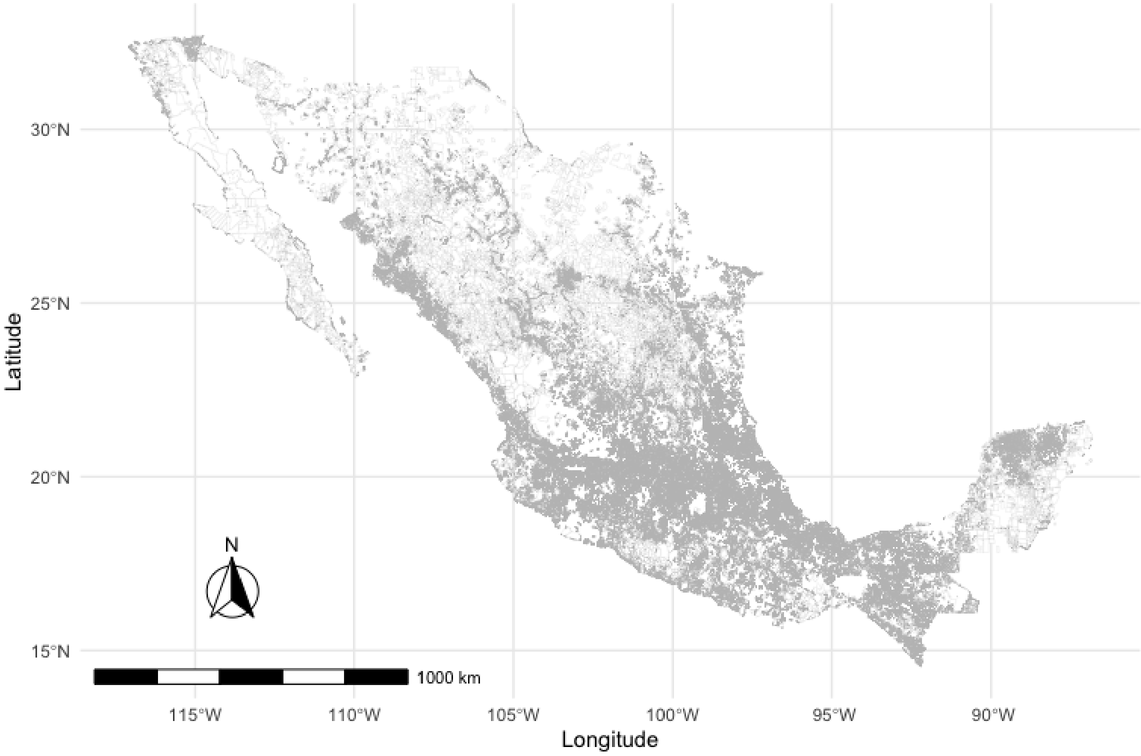


Figure 3.23: **Geographic location of all *ejidos* and *comunidades agrarias* in Mexico**

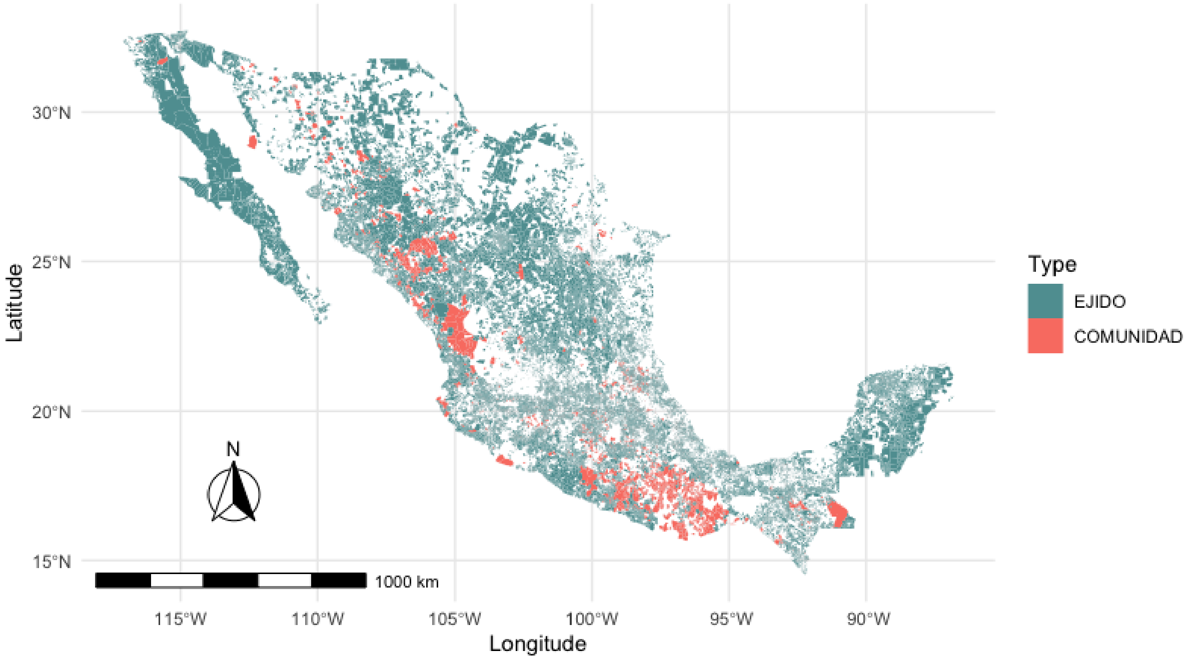


Figure 3.24: **Geographic location of rural communities by type.**

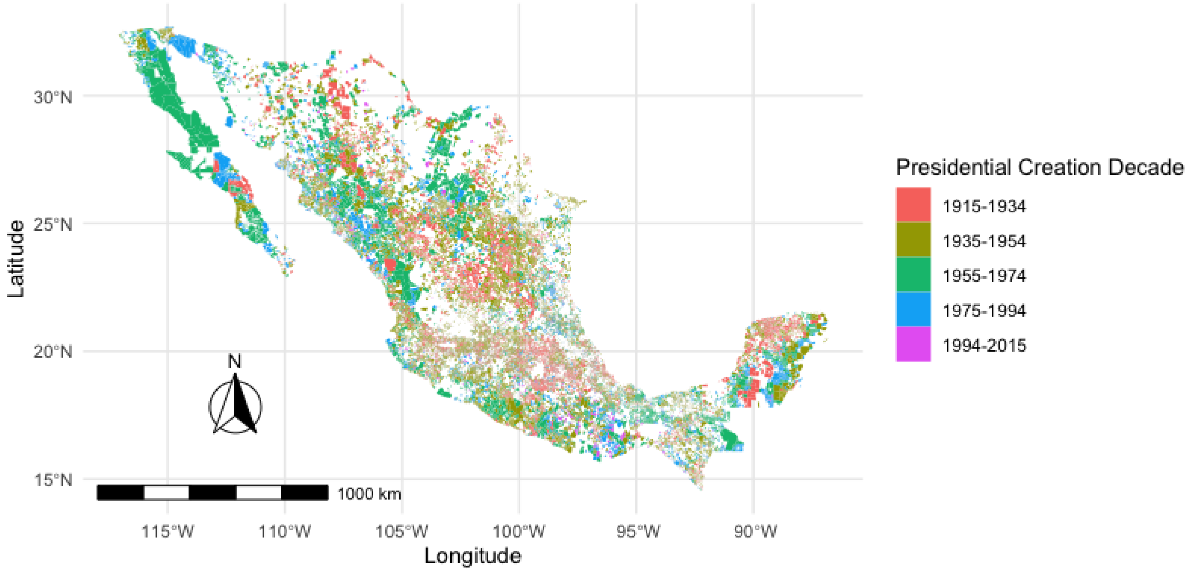


Figure 3.25: **Geographic distribution of all *ejidos* and *comunidades agrarias* by year of creation from a presidential decree.**

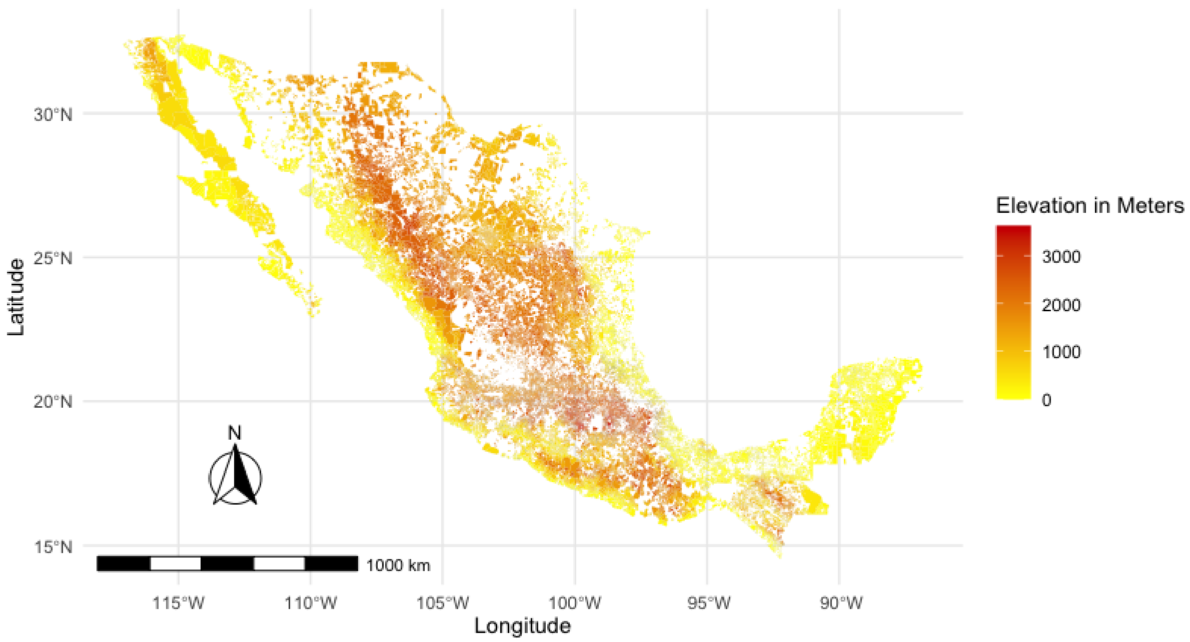


Figure 3.26: **Average elevation in meters above the sea level.**

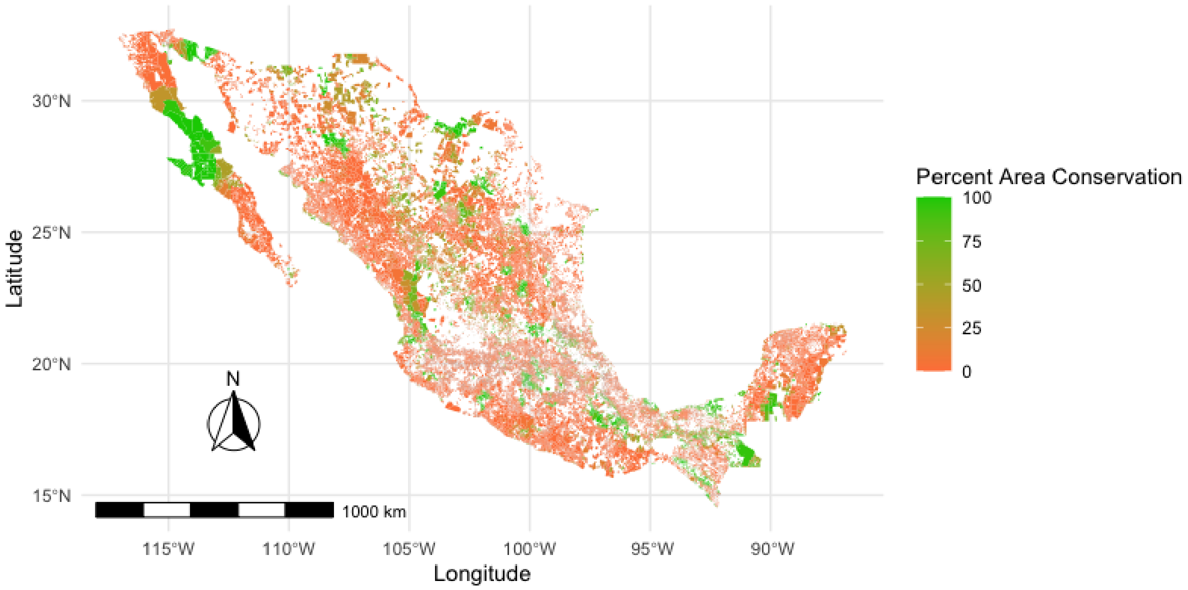


Figure 3.27: **Percent of the community's total surface corresponding to areas of ecological priority; these include, for example, high cloud forests and mangroves, among other ecosystems.**

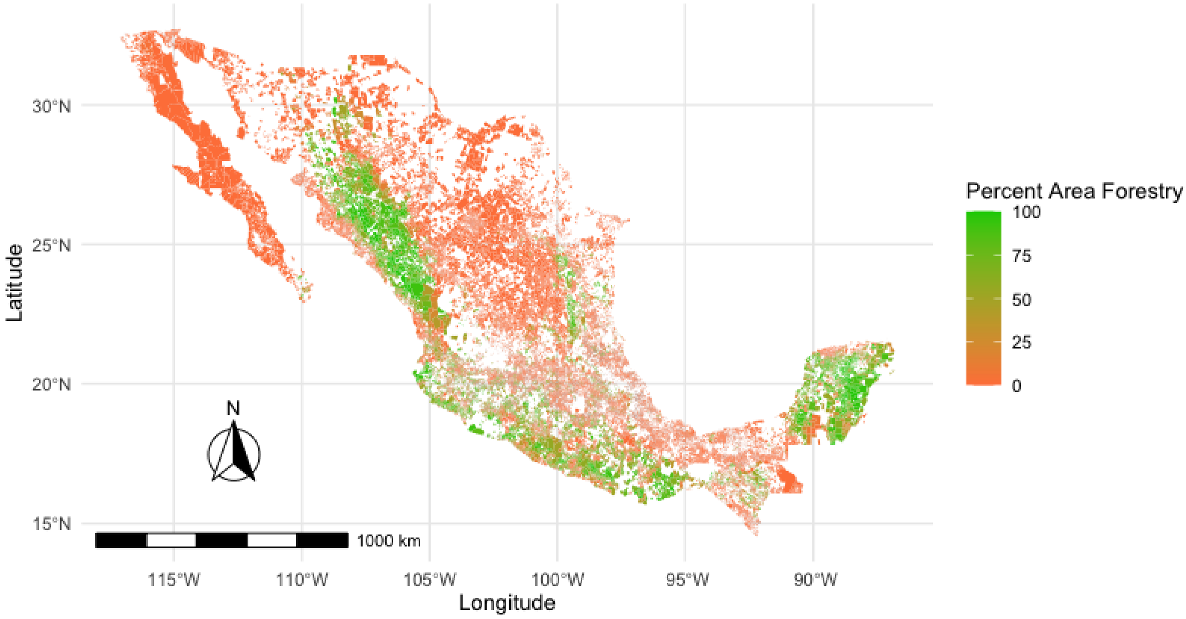


Figure 3.28: **Percent of the community's total surface corresponding to areas suitable for commercial forestry.**

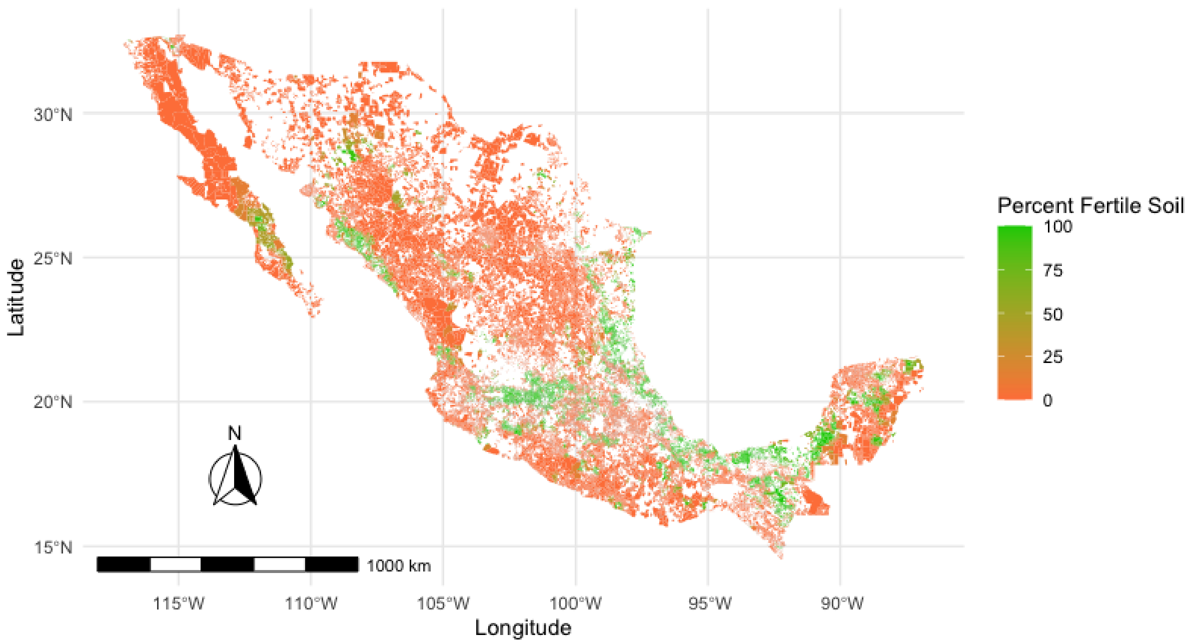


Figure 3.29: **Percent of the community's total surface corresponding to areas of high agricultural potential.**

3.8.2 Balance Between Early and Late PROCEDE Adopters

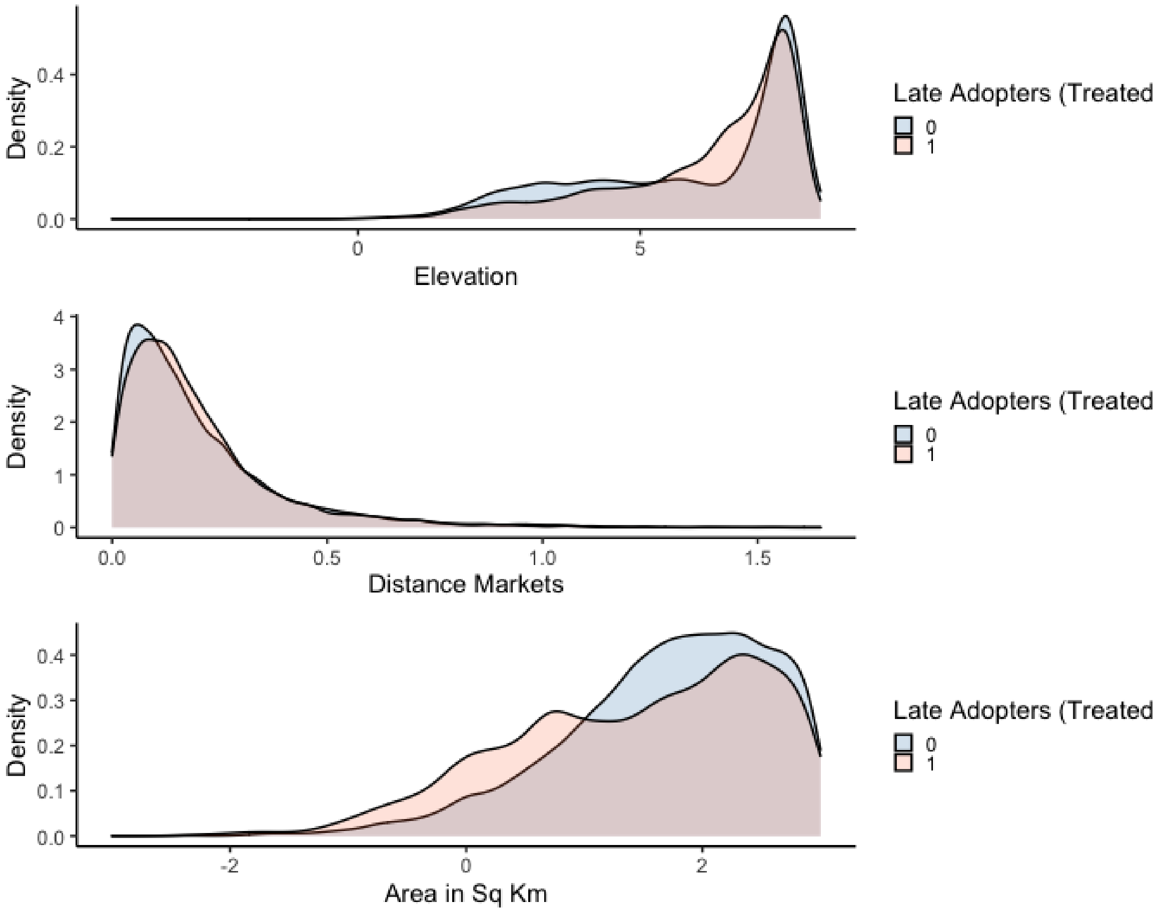


Figure 3.30: **Kernel density plots for two categories of communities (early adopters of PROCEDE (1994-1999) and late adopters of PROCEDE (1999-2018)) for selected variables.**

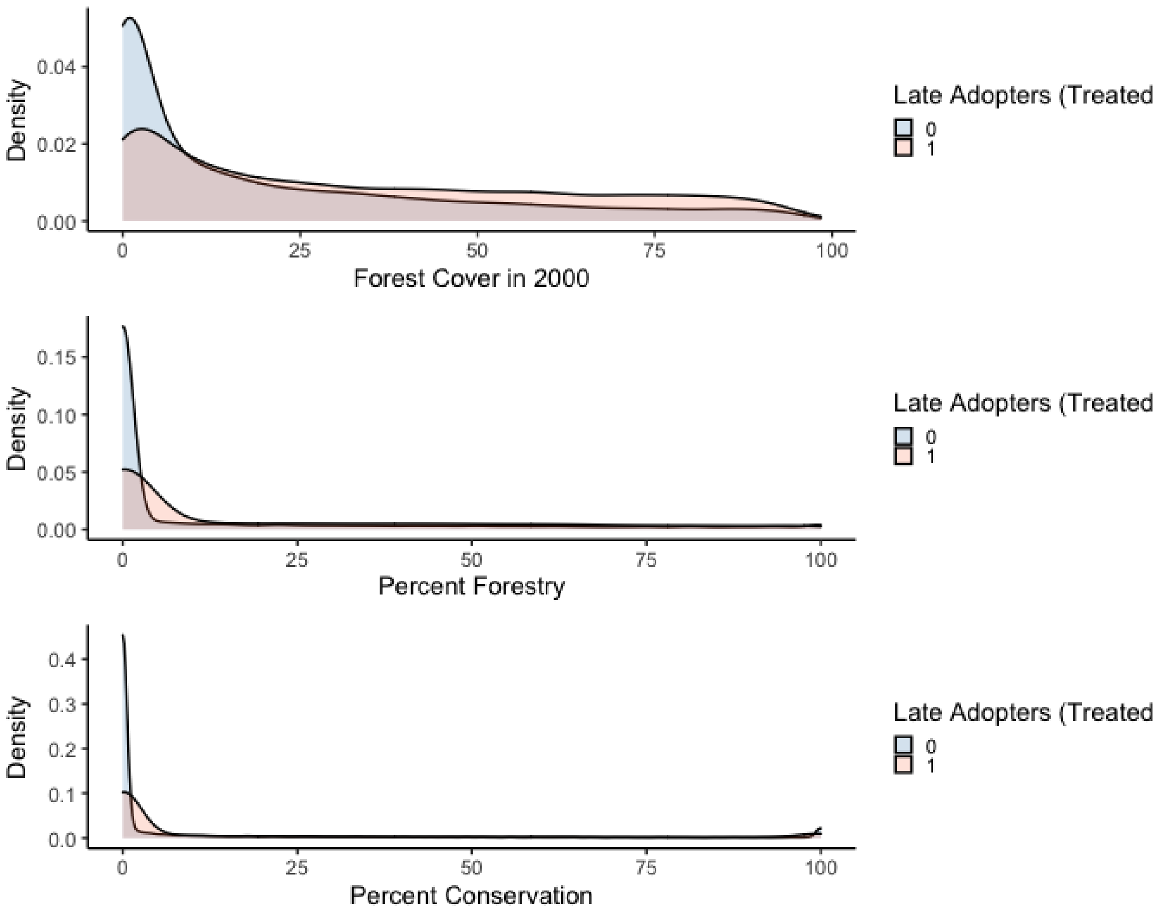


Figure 3.31: **Kernel density plots for two categories of communities (early adopters of PROCEDE (1994-1999) and late adopters of PROCEDE (1999-2018)) for selected variables.**

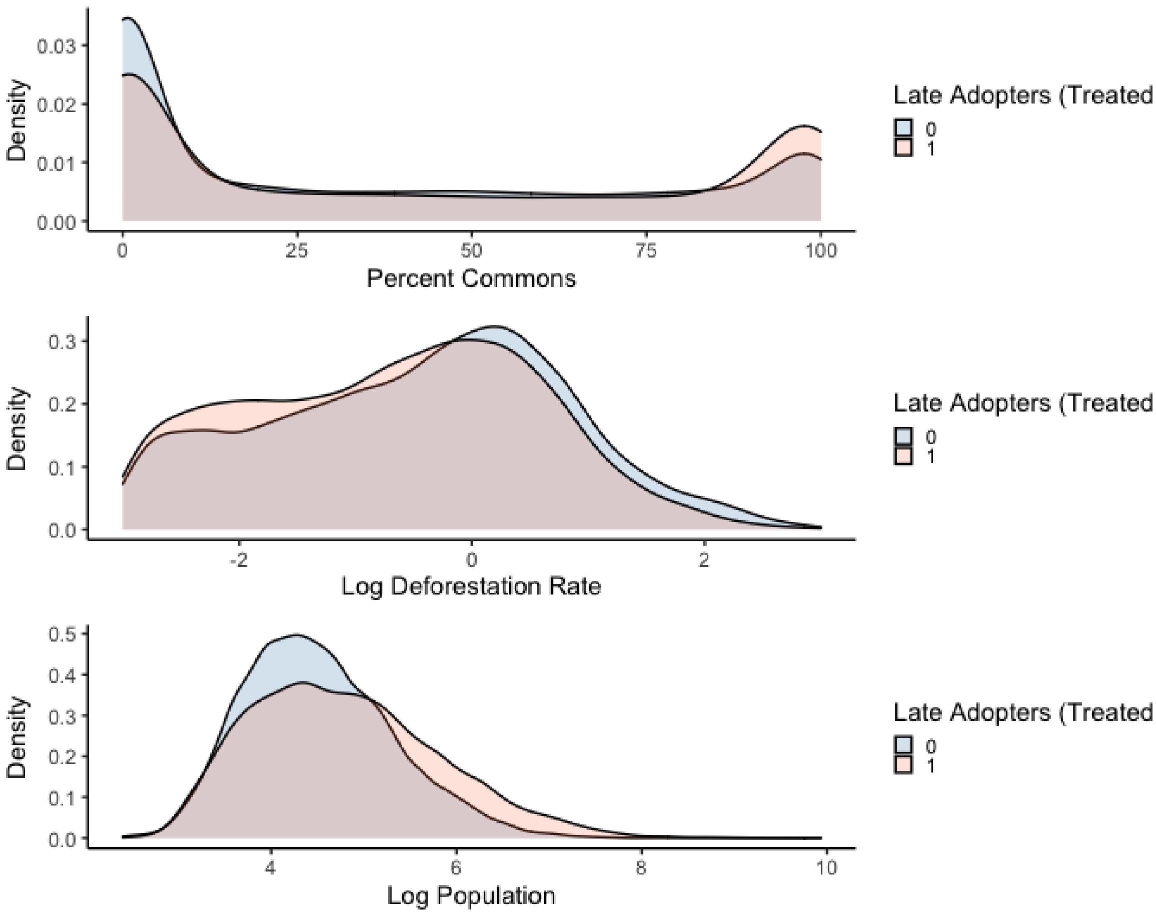


Figure 3.32: **Kernel density plots for two categories of communities (early adopters of PROCEDE (1994-1999) and late adopters of PROCEDE (1999-2018)) for selected variables.**

3.8.3 Robustness Checks

3.8.3.1 Robustness Checks to Figure 3 (Low Agricultural Productivity)

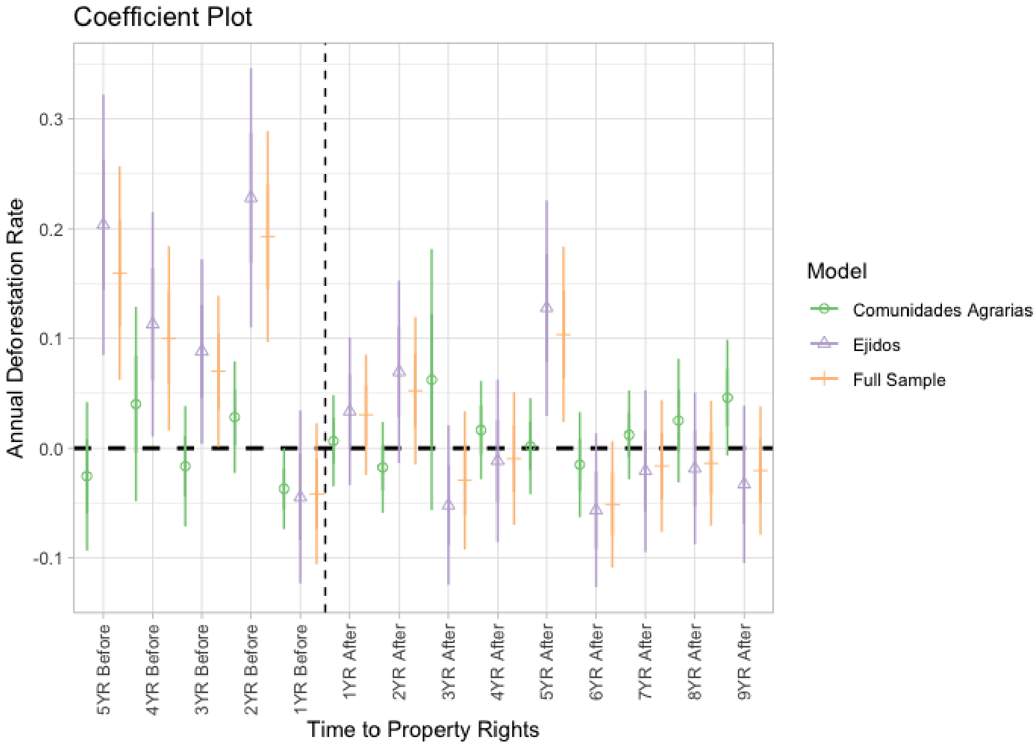


Figure 3.33: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation and with low availability of arable land (less than 10% of their territory covered by fertile soils)**

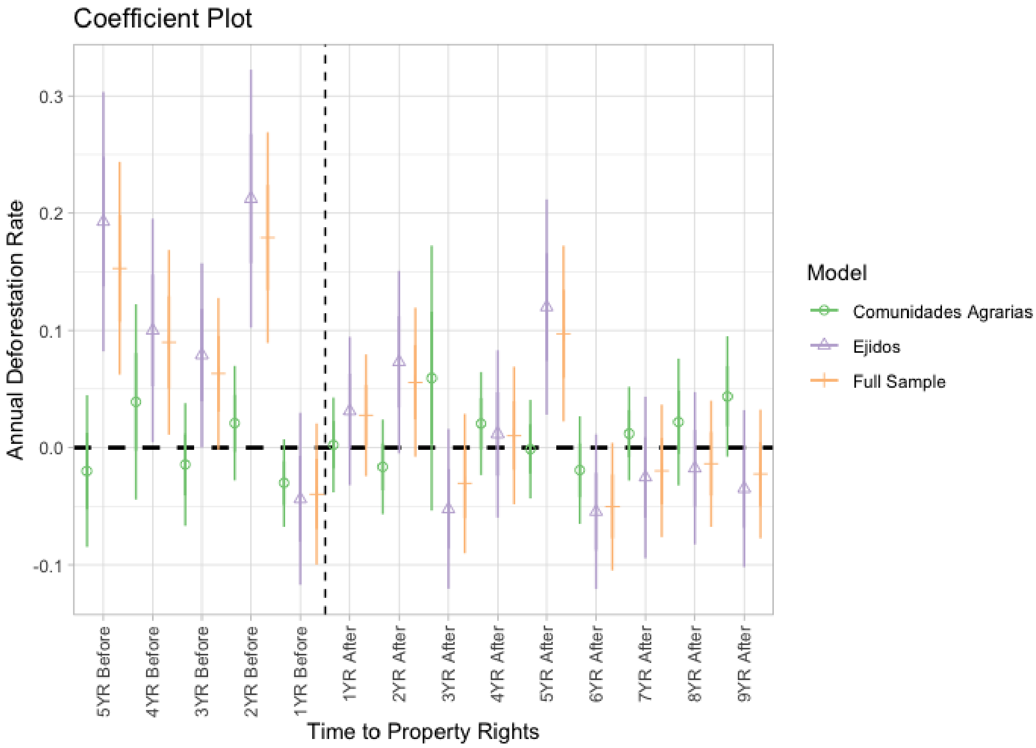


Figure 3.34: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation and with low availability of arable land (less than 30% of their territory covered by fertile soils)**

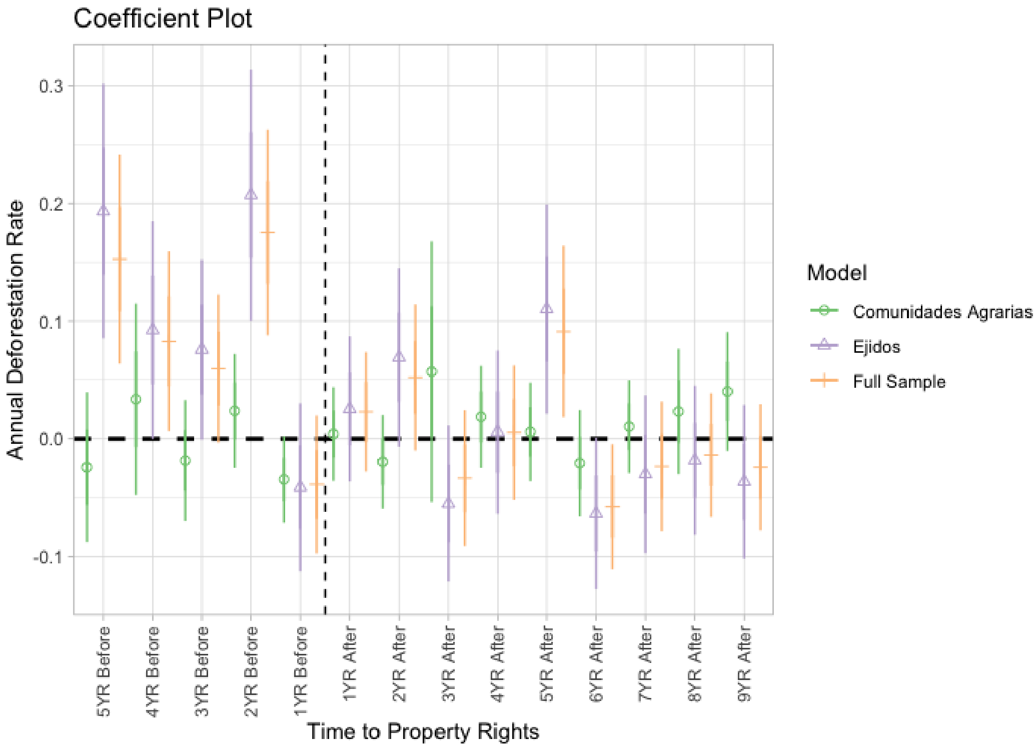


Figure 3.35: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation and with low availability of arable land (less than 40% of their territory covered by fertile soils)**

3.8.3.2 Robustness Checks to Figure 4 (High Agricultural Productivity)

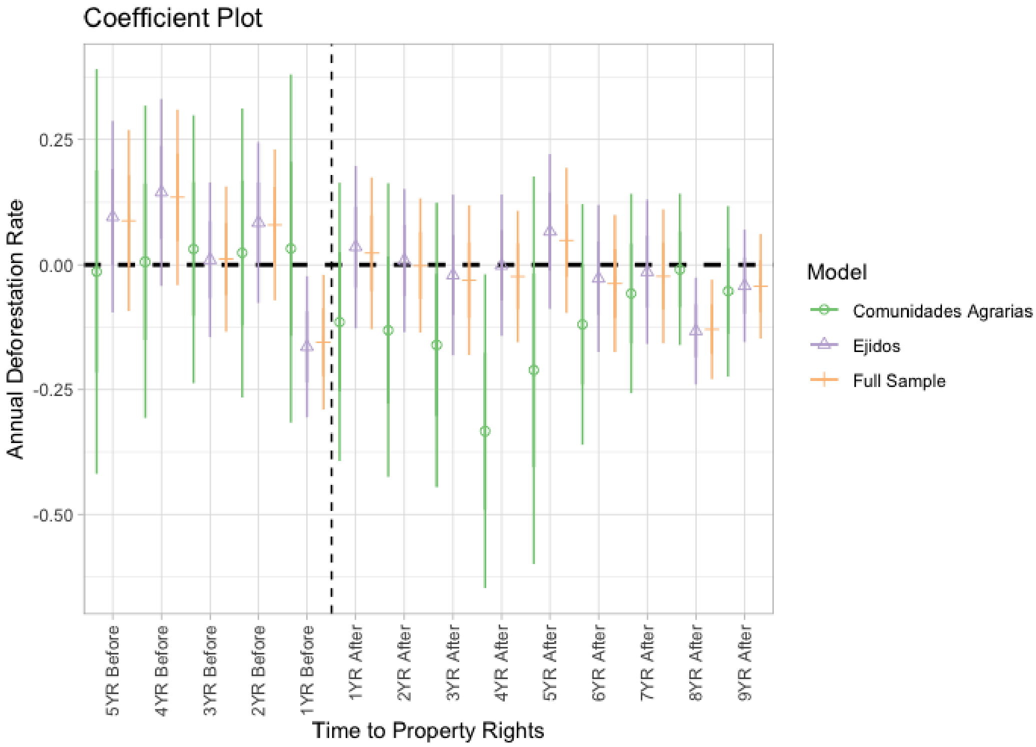


Figure 3.36: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation and with high availability of arable land (more than 60% of their territory covered by fertile soils)**

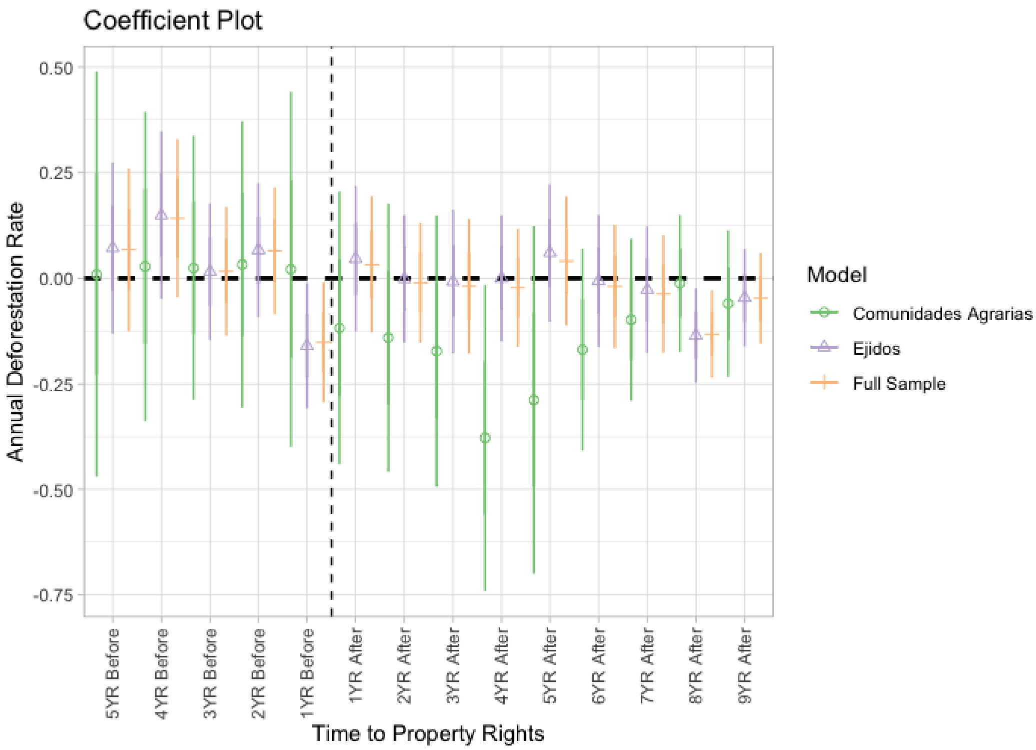


Figure 3.37: **Baseline model for non-forest communities (villages with less than 10% of their surface covered by primary vegetation and with high availability of arable land (more than 70% of their territory covered by fertile soils)**

3.8.3.3 Robustness Checks to Figure 5 (Indigenous versus Non-Indigenous Communities)

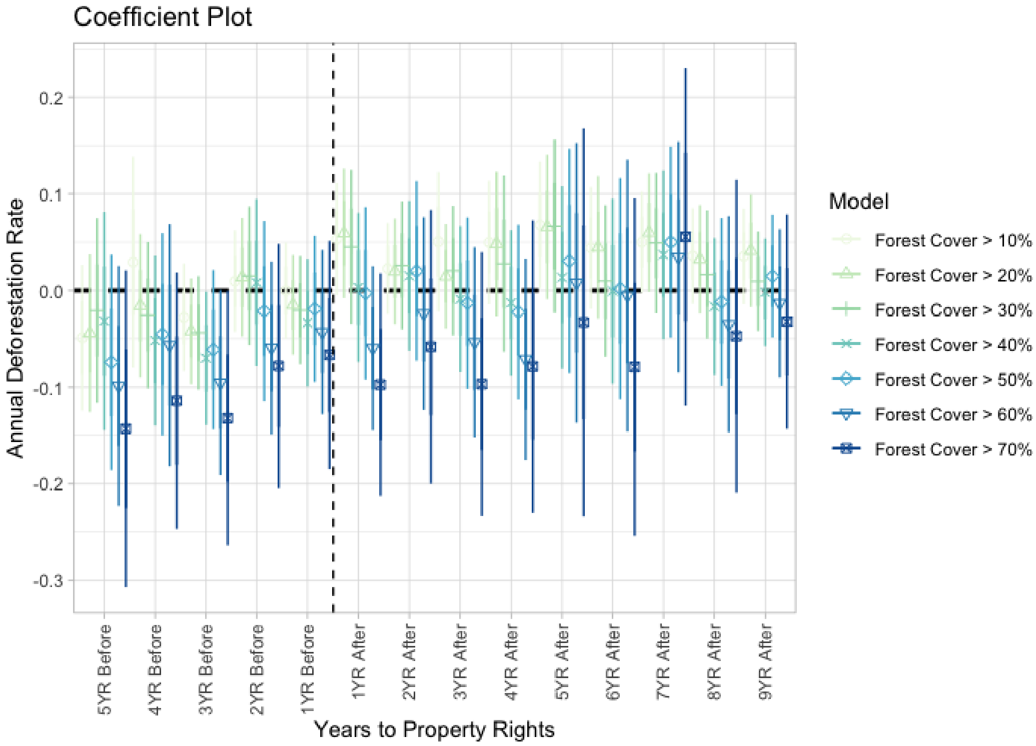


Figure 3.38: **Baseline model for rural communities with historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

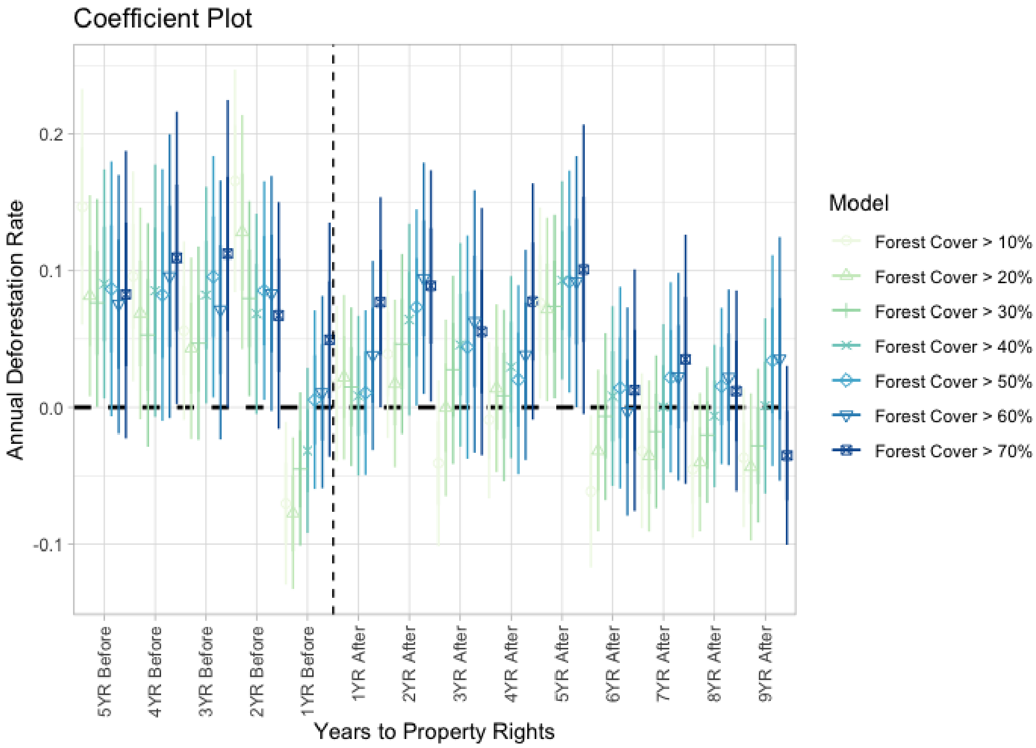


Figure 3.39: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

3.8.3.4 Robustness Checks to Figure 8 (Low Agricultural Productivity)

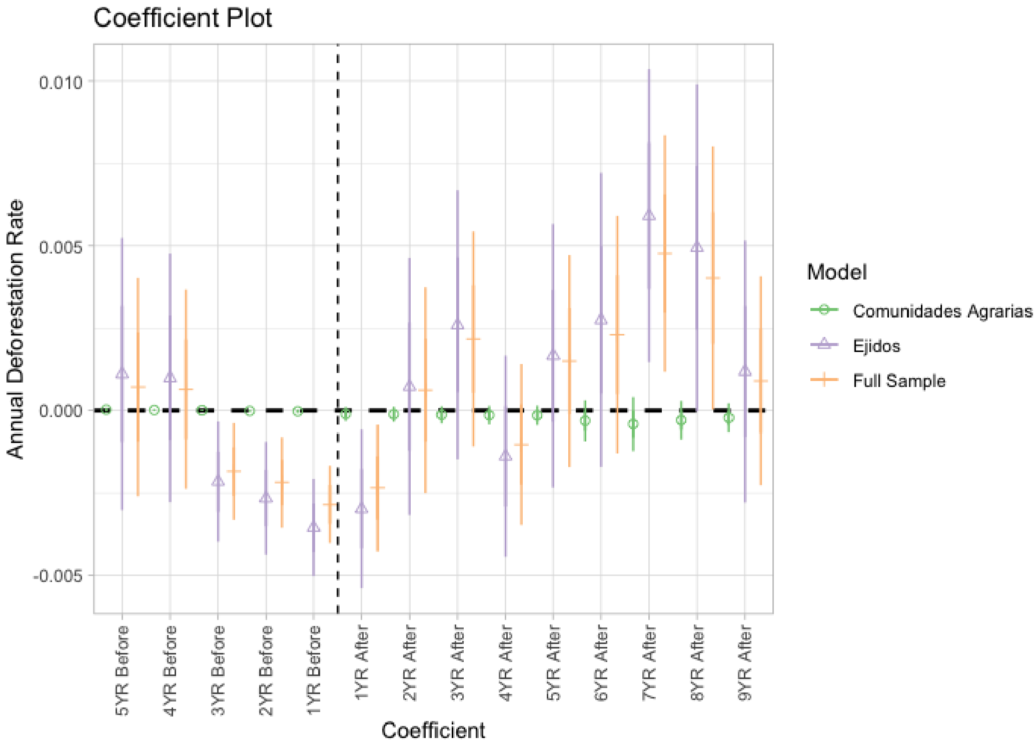


Figure 3.40: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

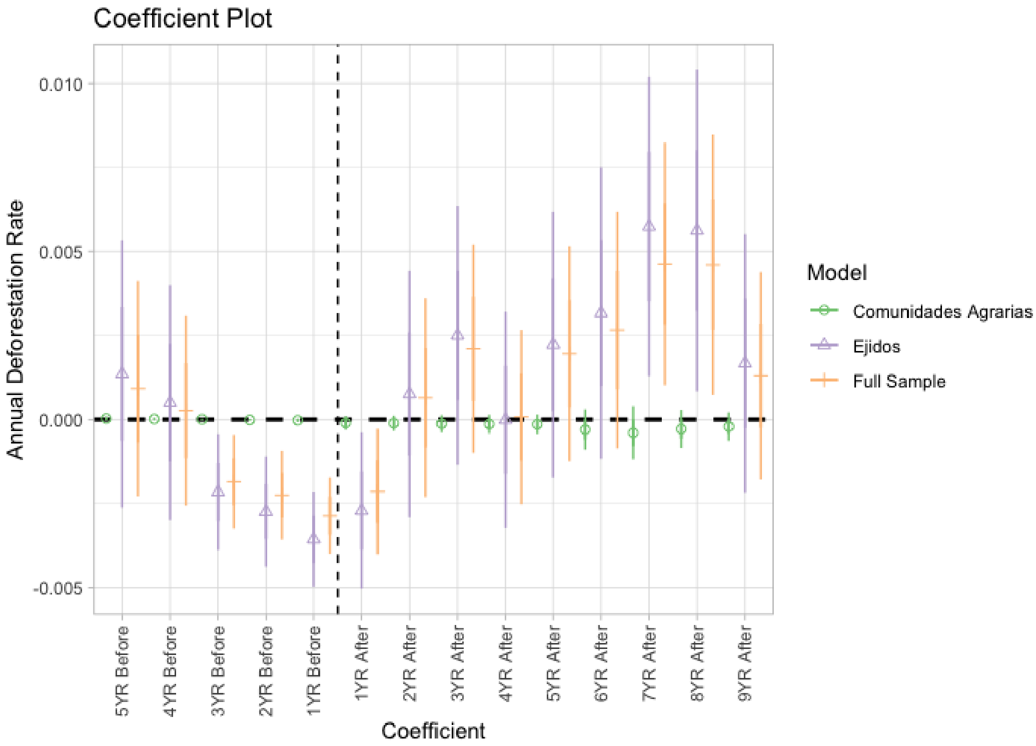


Figure 3.41: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

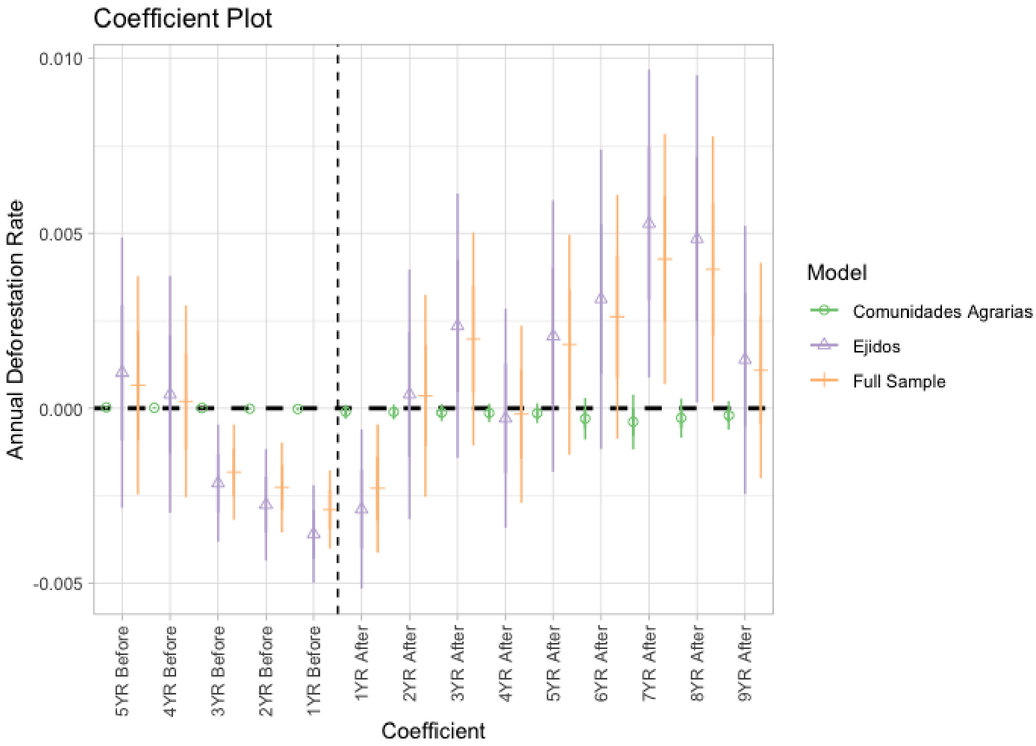


Figure 3.42: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

3.8.3.5 Robustness Checks to Figure 9 (High Agricultural Productivity)

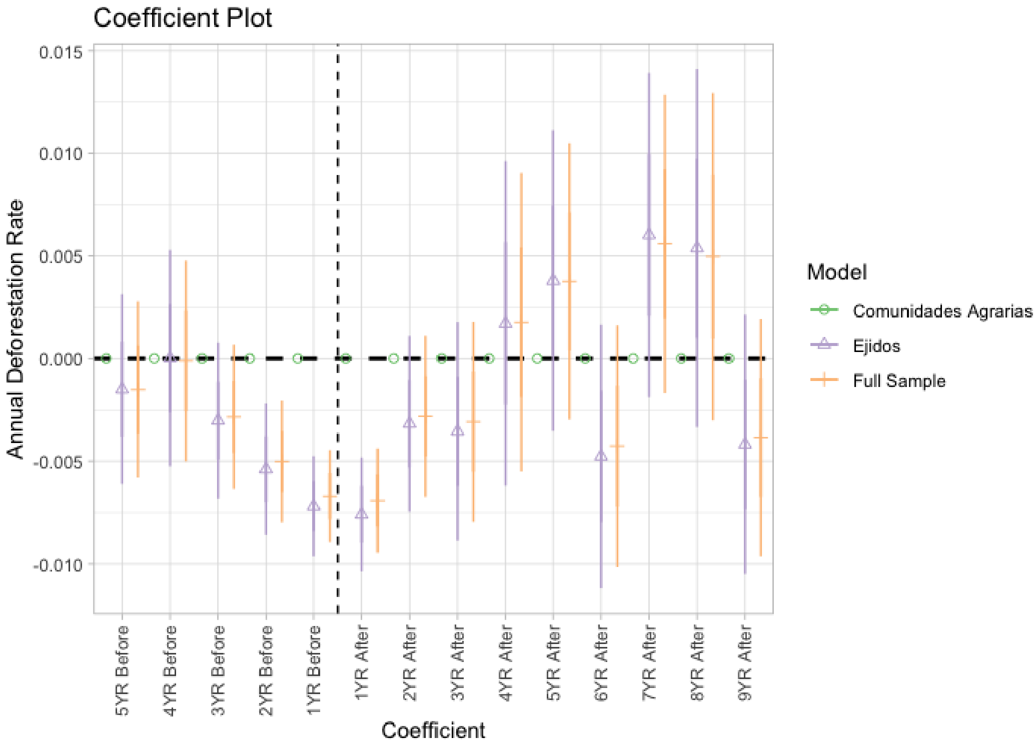


Figure 3.43: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

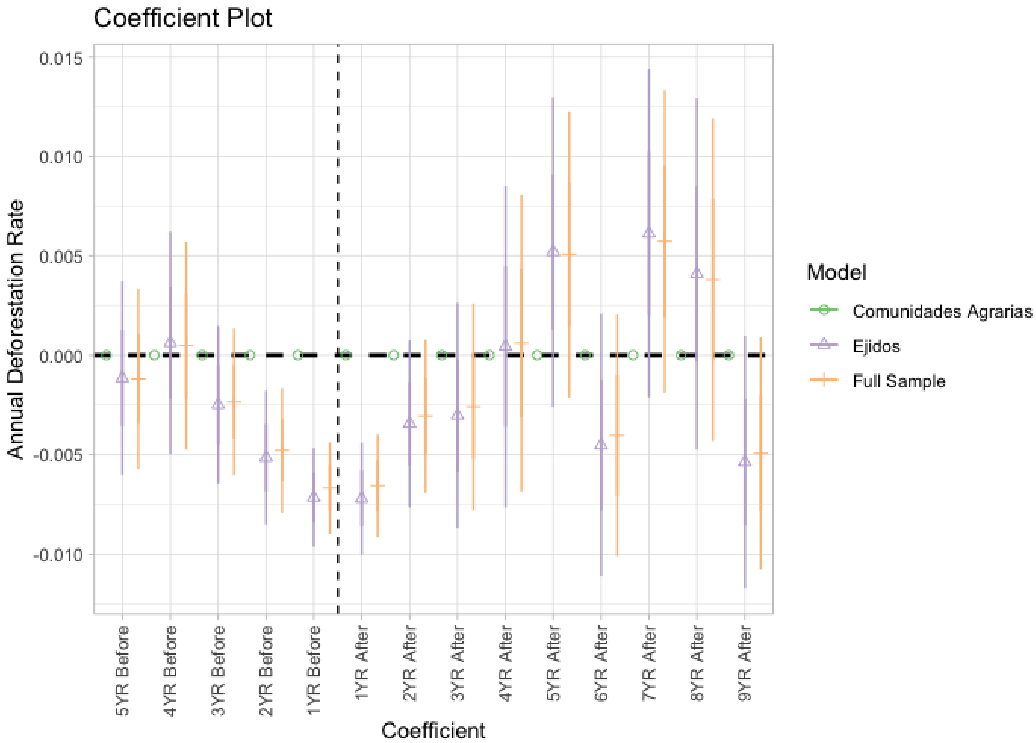


Figure 3.44: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

3.8.3.6 Robustness Checks to Figure 10 (Indigenous versus Non-Indigenous Communities)

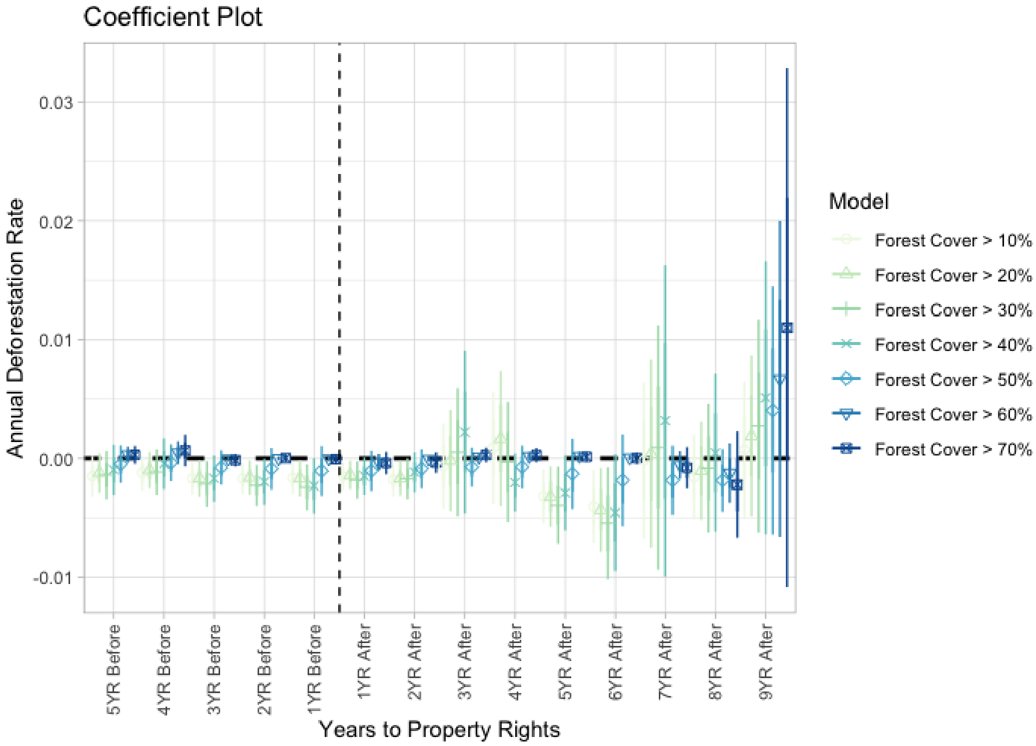


Figure 3.45: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

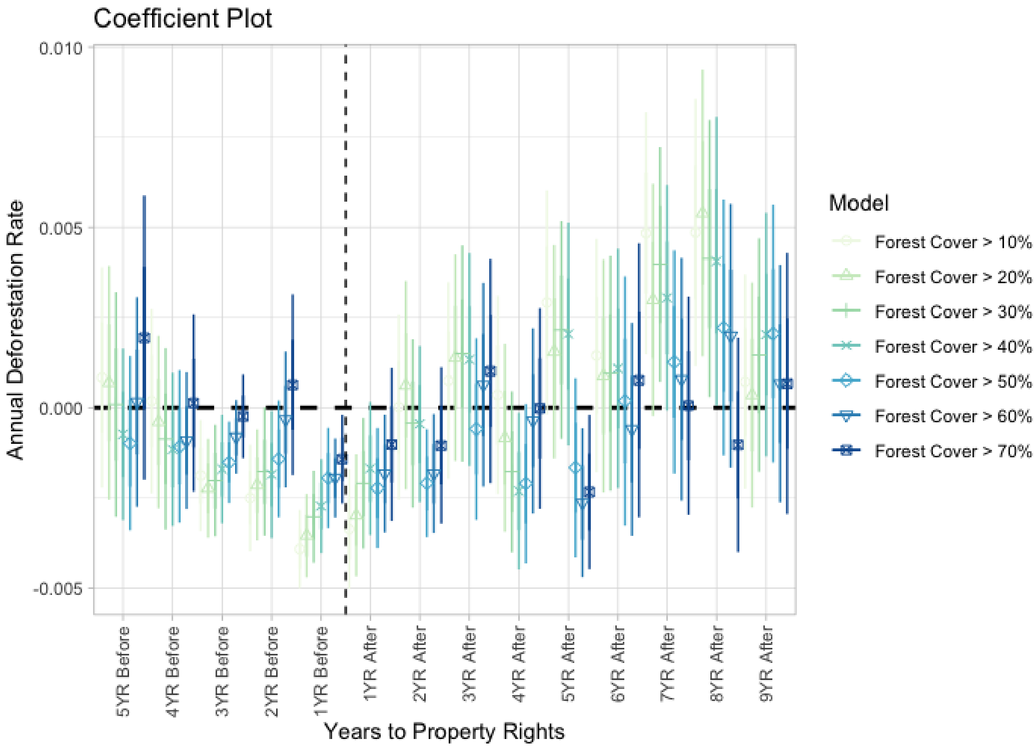


Figure 3.46: **Baseline model for rural communities without historical indigenous localities with different levels of forest coverage (more than 10% of their surface covered by primary vegetation to more than 70% of their surface covered by primary vegetation**

CHAPTER 4

The Societal and Environmental Impacts of the Super-Commodity Boom on Rural Communities: Evidence from Mexico

Communal lands, including indigenous territories, hold an enormous potential to preserve global biodiversity, capture carbon dioxide, and provide sustainable livelihoods for millions across the world. Extractive industries, including mining, represent a major challenge for the realization of these goals. Despite the relevance of this issue, we have relatively little systematic evidence of how such investments impact the environments and livelihoods of the communities where they operate. In this chapter, I study the effects of the mining boom of the 2000s on Mexican rural communities. My research design employs a staggered differences-in-differences estimator, using fine-grained administrative data and satellite imagery. I find that rural communities exposed to a mining concession experience a sharp deterioration in their productive activities in the short-term after the project's approval. In the long-run, they show a higher propensity to privatize communal lands. By depressing some of the crucial drivers of land use change, however, mining concessions are also associated in the long-run with a small decrease in tree cover loss.

Keywords: *extractive industries, super-commodity boom, Mexico, community-based forest management, rural livelihoods*

4.1 Introduction

According to the Intergovernmental Panel on Climate Change, land use, land use change, and agriculture are some of the most relevant sources of carbon emissions worldwide, accounting for approximately 23% of all greenhouse gas from 2007 to 2016 (Shukla et al., 2019). Hence, reductions in deforestation, reforestation of affected areas, and improvements in land restoration are crucial components in the global strategy to address this major environmental challenge (IPCC, 2022). Moreover, forests and other ecosystems provide other types of benefits, in addition to their carbon capture potential. They are responsible for a wide array of ecosystem services, ranging from hosting the majority of the world's biodiversity to the regulation of watershed functions, essential to the supply of clean water in many parts of the world. They also represent the foundation for the livelihoods of hundreds of millions of citizens (Shukla et al., 2019).

A large strand of research shows that land tenure forms and governance are critical to realizing these goals. According to the work of Elinor Ostrom and her colleagues, some groups of common-pool users are able to effectively steward their forests and other ecosystems even without the intervention of states and markets (Ostrom, 1990; Ostrom et al., 2002; Agrawal et al., 2002; Cumming et al., 2020). The presence of effective norms of resource use and appropriation is one of the necessary conditions to do so. These include, for example, rules that determine what members of the community are entitled to use water, timber, or mineral resources and under what conditions; the mechanisms to monitor community members; and the sanctions against defective behavior.

Scholars across different disciplines and methodological approaches have provided ample evidence of this phenomenon. There is a vast number of individual case studies that show the importance of internal governance arrangements within communities (Barsimantov et al., 2011; Barsimantov and Antezana, 2012); one of the common denominators across them is their emphasis on the formal and informal rules that their members use to govern their resources. From a quantitative standpoint, there is a growing body of research showing that both the form of land tenure and their official recognition by the state are crucial variables to explain complex phenomena such as deforestation. Some studies employ a global perspective to show that community-based lands are sometimes more effective at reducing deforestation than other types or to estimate the potential to host biodiversity spots (Sze et al., 2022; Garnett et al., 2018).

Other scholars adopt a causal inference approach that allows them to make stronger claims about the effect that communal tenure has on land use change (Oldekop et al., 2019). For example, Baragwanath and Bayi (2020) show that the certification of indigenous lands in Brazil is associated with a sharp decrease in deforestation. Vélez et al. (2020) and Romero and Saavedra (2021) find that legalization of land titles for Afro-Colombian communities has a similar impact on the rates of deforestation.

Recently, other studies have analyzed the relevance of additional governance variables in Ethiopia (Kahsay and Medhin, 2020; Gebreegziabher et al., 2021), Peru (Blackman et al., 2017), India (Kashwan, 2017), Kenya (Kashwan, 2017; Okumu and Muchapondwa, 2020), Tanzania, and other countries in the Global South. The emerging consensus in the literature strengthens the idea that internal arrangements among community members, political structures, and the recognition of legal property rights are important elements in the ability of common-pool resources groups to steward their forests and other ecosystems.

There are, however, important gaps in our understanding of the political economy of the commons. In other parts of my dissertation I explain how property rights affect the internal politics of communities, which are not monolithic entities in terms of their preferences, but rather complex polities with multiple interests and political dynamics.

For the purposes of this chapter, I focus on another missing piece of the puzzle: the role that external political and economic actors play in rural communities. According to the design principles of Elinor Ostrom, autonomy in the local decision-making is a cornerstone of communal stewardship of natural resources (Ostrom, 1990). However, despite the vast literature in the topic, the relevance of broader political and economic systems for the functioning of groups of common-pool resources users remains relatively underdeveloped, both theoretically and empirically.

External actors can be governmental, at both the national and subnational levels. Their relevance ranges from constitutional matters (recognition of land rights and indigenous political institutions) to very practical concerns, such as the ability of rural communities to exploit their forests (Merino-Pérez, 2004; Bray et al., 2005, 2006) and the capacity to regulate land for other uses (Pailler, 2018). They can also be economic, such as private landowners and businesses and corporations. In general, the latter type of actors operate in the territory of communities with the explicit or implicit acquiescence of the former category.

Communities across the world have historically faced a wide array of challenges from both political and economic external actors. For example, rural villages in England and other European countries suffered from encroachment processes during the 18th and 19th centuries, which led to extreme inequalities in land ownership. Later on, developmental states also impacted rural communities through the construction of highways, dams, and other large-scale projects (Kirchherr et al., 2016; Scott, 2008). More recently, the expansion of extractive industries—the so-called "super-commodity boom"—represented the latest chapter in a long history of violence against local communities (Nixon, 2011; Erten and Ocampo, 2013; Alvarez-Berríos and Aide, 2015).

Extractive industries encompass a wide array of economic activities, including, among others, mining concessions, energy infrastructure (oil and gas), and large-scale industrial agriculture. A large number academic studies has documented the impacts of these external actors on communities and ecosystems (Bebbington et al., 2018). Specifically on mining, the literature on the resource curse has extensively investigated the effects of revenues from non-renewable natural resources, mostly oil and minerals, on societal and political outcomes (Ross, 2015; Blair et al., 2021).

We know, for example, that mining concessions are associated with high levels of disagreement among community members (Hill et al., 2020) and generate protests (Christensen, 2019). In addition, as several scholars point out (Perez et al., 2021; Hill et al., 2020), mining activities limit other productive activities, in particular agriculture. Finally, other studies have analyzed the relationship between violence and mining activities cross-nationally and in case studies of Colombia (Dube and Vargas, 2013) and Mexico (Herrera and Martinez-Alvarez, 2022). A recent meta-analysis by Blair et al. (2021) showed that access to revenues from minerals is consistently correlated with the levels of violence across a wide array of studies. Hence, there is substantial evidence demonstrating that extractive industries, such as mining, can have deleterious social consequences in the communities where they operate.

There is also a growing literature showing that mining concessions and projects affect the functioning of ecosystems, particularly deforestation patterns (Sonter et al., 2017; González-González et al., 2021; Swenson et al., 2011; Schueler et al., 2011; Caballero Espejo et al., 2018; Alvarez-Berríos and Aide, 2015; Asner et al., 2013; Diringer et al., 2019; Abood et al., 2015). These studies share four main characteristics. First, from a methodological standpoint, they employ high-resolution satellite imagery, usually from a specific region, to measure both the presence of (mostly) illegal mining activities and the associated land use change patterns.

With the exception of Sonter et al. (2017), in most cases scholars employ basic statistical tools to determine the relationship between mining and deforestation. For example, González-González et al. (2021) compare the rates of tree cover loss within and outside mining concessions in Colombia. Other scholars measure this variable along the location of illegal mines, while others only study the overlap between concessions and communal forests (Perez et al., 2021), without analyzing how the uses of land change over time and across space.

Second, a large number of these quantitative studies of land use change and mining are concentrated in a small number of Latin American countries (including Peru, Colombia, and Brazil), and even a few specific regions—most notably the *Madre de Dios* department in Peru. Outside Latin America, there are some statistical analyses of the cross-section time-series relationship between mining and deforestation in Indian states (Ranjan, 2019).

Third, with very few exceptions (Perez et al., 2021), the vast majority of the existing literature ignores variables of land tenure in their analyses. Hence, most of these studies are apolitical. As explained before, the research on the political economy of the commons suggests that group-based owners of common-pool resources behave quite differently from individual owners or the state when dealing with many drivers of environmental degradation. This should not be different for the effects of extractives.

Communities have legal rights (recognized by both national constitutions and international treaties) to be informed and grant their consent to economic development projects, formal and informal rules to manage their natural resources, provisions to allow the participation of external actors in their communities, and resistance strategies. Scholars across different subfields have found that all of these factors are correlated with their ability to steward their natural resources. Hence, we should expect that the impacts of mining concessions and projects differ in territories governed by communities.

Finally, the last characteristic of the literature measuring the effects of extractive industries on deforestation is their relative lack of theorization. In most cases, the main goal of these studies is to demonstrate the presence of such relationship, with less attention to tease out the potential mechanisms that could explain it. Although in most cases the explanation is quite mechanical (mines require space to operate, including forested areas), some authors expand their explanation to other factors, for example the need to produce agricultural goods for an expanded population (Rorato et al., 2020). Given the lack of attention to issues of land tenure, it is not surprising that other community-level outcomes have not been widely studied in the literature.

Hence, although there is a vast scholarship analyzing the political economy of common-pool resources management and another, equally substantial, strand of research studying the impacts of extractive industries on diverse societal and environmental outcomes, the intersection between these two is much smaller. Given the enormous potential of communal lands to realize climate and conservation goals and the growing threats they are facing from a wide array of actors, addressing this gap in the literature is critical.

To shed light on these issues, I explore how the super-commodity boom of the early 2000s impacted the rural livelihoods of 32,000 communities in Mexico, known as *ejidos* and *comunidades agrarias*. Mexico represents an ideal case study to analyze this question for two reasons. First, the majority of the country's lands, including most of its forests and other ecosystems, is administered by these rural communities (Bray et al., 2003, 2006; Boyer, 2015).

Despite their constitutional similarities, these polities have enormous differences in terms of their institutions, norms, and abilities to steward their natural resources, which entails a large variation in the dependent variables under analysis (Merino Pérez, 2014). Second, rural populations in Mexico have historically faced the impacts of extractive development, ranging from the Spanish colonial-era exploitation regime to the present-day super-commodity boom.

For the purposes of this paper, I study how the presence of large-scale extractive projects, in particular mining concessions, affected the livelihoods of rural communities in Mexico along three dimensions. First, from an economic perspective, I analyze how such projects impacted the general levels of economic activity within rural villages. Second, numerous studies suggest that extractives, for example mining activities, induce intra-community conflict and disagreement among members of the polity. I explore how exposure to such projects affects the propensity of members to prioritize private over public goods, using the issuing of individual land titles as an approximate measurement of this concept. Finally, I also analyze the impacts of mining concessions on the rate of land use change.

Methodologically, I leverage the timing of the mining concessions, which, I argue, is exogenous to the outcome variables. This allows me to estimate the group-time average treatment effect of exposure to a mining project on the economic, political, and environmental outcomes mentioned above using a staggered differences-in-differences estimator.

My findings point out to a paradoxical overall impact of mining concessions on communal livelihoods. In the short term, exposure to a mining concession is associated with a sharp decrease in the overall levels of economic activity—measured by nighttime satellite imagery. In the long-term, communities that experienced an overlap with mining concessions experienced a higher number of individual property titles issued per square kilometer, which denotes a weakening of community-level institutions. Paradoxically, treated villages also experienced a moderate decrease in their rates of tree cover loss.

The rest of the paper proceeds as follows. In the second section, I present the historical background on community ownership of land in Mexico and the recent expansion of mining concessions in the country. In the third section, I explain my identification strategy, based on a staggered differences-in-differences estimator that uses time of exposure to a mining concession as the treatment variable. In the fourth section, I describe my data sources and methods. The fifth section shows the main findings of the study. Finally, the sixth section concludes with areas for further research.

4.2 Historical Background

Mexico has a long history of community-based management of land, including forests and other ecosystems. However, the country has also experienced the effects of resource-based boom and busts for centuries, which have severely affected local communities. For those two reasons, it represents an ideal case study to understand the impacts of extractive industries on communal livelihoods. Currently, 32000 rural communities, known in Spanish as *ejidos* and *comunidades agrarias* have legal ownership over 51% of the country's surface. This includes, moreover, the majority of Mexico's forests and other key ecosystems. From an institutional perspective, these rural villages have identical constitutional standing, legal rights and obligations, mechanisms to accept new members, attributions to govern their communal resources, and administrative structure.[1]

[1] The main decision-making body in the community is the *asamblea ejidal* or *asamblea comunal*, which includes all formal members of the village. The *comisariado de bienes comunales* or *comisariado ejidal* represents the executive authority; members of the community elect them every three years. Finally, the *consejo de vigilancia* is in charge of monitoring the activities of the executive authorities.

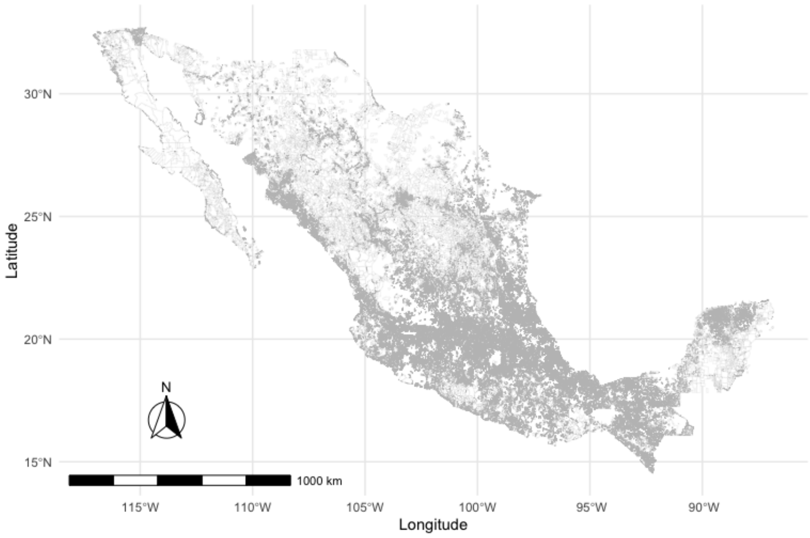


Figure 4.1: **Geographic location of *ejidos* and *comunidades agrarias*.** This map shows the spatial distribution of the 32000 rural communities under analysis.

Despite these similarities, each one of these communities has had particular historical processes that have affected their institutional structure. Although the legal origins of these villages goes back to 1915, when the revolutionary government started a massive land redistribution program (*reforma agraria*) (Boyer, 2015), hundreds of them were founded during colonial (and even pre-colonial) times, whereas others had no prior history of community. As a result, they differ substantially in terms of their specific rules of resource use and appropriation, the complexity of their political institutions, their relationship with state authorities and other external actors, and the relevance they assign to forest conservation (Merino Pérez, 2014).

Methodologically, these unique features of the Mexican case allow me to analyze the economic, environmental, and political trajectories of thousands of common-pool resource systems, controlling for factors that vary considerably in other settings, including the basic administrative structure and legal rights to steward forests. In addition, in contrast to other Latin American countries where governments decentralize land management to mostly indigenous communities, in Mexico not all *ejidos* and *comunidades* have indigenous political institutions and not all indigenous peoples own land as a group.

Another feature of these rural communities is their long history of resistance to external economic and political actors. Many indigenous communities were able to survive despite the pandemics of the 16th century and the ensuing colonial regime (Diaz-Cayeros et al., 2021), which was based on the extraction of metals and the exploitation of indigenous labor. During the 19th century, successive political reforms weakened the political standing of indigenous communities. This process culminated in the dramatic expansion of international businesses in the logging, mining, and oil Mexican industries under President Diaz, which entailed vast land grabs that affected indigenous peoples in particular (Boyer, 2015; Santiago and Santiago, 2006).

The extreme concentration of land and violence against local populations were among the leading grievances that led to the Mexican Revolution. However, despite the regime change and the massive redistribution of land, rural communities continued experiencing the influence of external actors, in this case the developmental state. The PRI employed at least three different strategies to ensure political domination in the countryside: (1) the infiltration of the *ejido* system with members of the party, (2) the control of all productive subsidies for agriculture (Albertus et al., 2016; Diaz-Cayeros et al., 2016), and (3) the creation of massive logging concessions, in particular during the 1960s and 1970s (Boyer, 2015; Bray et al., 2005).

Taken together, these policies helped mobilized the economic resources of the countryside to support the hegemonic party's strategy of industrialization via import substitution. In doing so, however, the PRI created new forms of economic dominance of rural communities, this time in benefit of the regime's broader economic goals.

The severe economic crises of the 1980s and 1990s led to a massive overhaul of the Mexican countryside, which resulted in some opportunities and challenges to rural communities. On the one hand, the federal government implemented some reforms in the agrarian system, including a large program to certify individual and communal property rights and a reform of the agrarian justice institutions, which nominally increased the autonomy of rural communities to administer their resources (De Janvry et al., 2015; Cornelius and Myhre, 1998). In addition, the official end of the logging concessions program and the creation of new environmental policy instruments to promote ecosystem conservation paved the way for certain communities to regain control over their forests (Bray et al., 2005) and invest in sustainability.

Nonetheless, on the other hand, rural areas of Mexico have been exposed a wide array of new threats. These include, for example, the stiff foreign competition in agricultural markets resulting from NAFTA and the high levels of migration to the United States during the 1990s and early 2000s. Another crucial challenge has been the expansion of extractive industries and megaprojects; these include, for example, large-scale dams (La Parota), highly-polluting power plants, industrial agribusiness, and predatory touristic complexes, among others. Together with the ever-rising levels of criminal presence in the countryside, these economic activities have been associated with repression and violence against local communities, in particular leaders who organized against these actors.

Among the extractive industries mentioned above, mining has been particularly damaging to the livelihoods of rural communities. Mexico has been a leading exporter of precious metals like gold and silver since the early colonial times, with a few periods of rapid expansion, including the late 19th century. Rapid growth in the international demand for a large number of metals and minerals in the early 2000s pushed the price upwards, causing the so-called “super-commodity boom”, thus transforming the mining industry of Mexico in the process.

The Mexican mining industry has three main characteristics: it is highly deregulated, it has little connection with local populations, and it is particularly predatory. As mentioned above, the economic approach of the late-PRI governments aimed to attract foreign direct investment in a large number of sectors. Mining was a priority among them. As mentioned by Perez et al. (2021), with the reform of the Mining Law in the early 1990s, this activity took precedence over other productive uses of land, which paved the way for the dramatic expansion in the number of mining concessions starting in the early 2000s (De la Fuente et al., 2017).

Numerous policy analysis and scholars have pointed out to the straightforward process to extract minerals from Mexico, along the life-cycle of a mine. In addition to the relatively simple procedure to get a license from the Ministry of the Economy, authorities rarely enforce the consultation regulations required to open a project. Moreover, numerous accounts have shown that mining companies do not internalize the costs of the environmental degradation they cause, including water and air pollution, health impacts to the local populations, and destruction of the environment (Tetreault, 2015, 2019; Orozco, 2010; Rojas, 2013; Martínez Salvador and Martínez Salvador, 2021). Hence, although the country has a complex institutional and legal framework to monitor these extractive activities, corporations operate in a grey area of low levels of enforcement.

A second characteristic of the mining industry in Mexico is their concentration and isolation from the communities where they operate in economic terms. In contrast to other Latin American countries, for example Brazil, Colombia or Peru, illegal and small-scale artisanal mining is not a major issue in Mexico. Instead, the vast majority of participants in the industry are massive corporations, many of them international.

Moreover, these companies have very little engagement with the local populations affected by their activities. On the one hand, their effective tax rate is quite small, meaning they pay in royalties to the federal government a negligible share of their profits (De la Fuente et al., 2017). On the other, unlike other parts of Latin America, these companies do not contribute with local development in meaningful ways. A few years ago, the federal government created the *Fondo Minero* to benefit producing municipalities. However, the funds for this program were rather small and there was not enough monitoring of their activities. Finally, the mining industry is a minuscule employer in the country, especially compared to other primary activities.

The third defining feature of the Mexican mining sector is its particularly predatory nature. The early 2000s not only experienced a dramatic increase in foreign investment in this industry; this was also the time of the onset and expansion of the War on Drugs. Numerous accounts and academic studies have pointed out to the close association between criminal violence and extractive activities (Herrera and Martinez-Alvarez, 2022). Journalists and non-governmental organizations have documented a series of human rights abuses against communities (and their leaders) opposing mining projects for environmental, security, and public health reasons (De la Fuente et al., 2017; Lemus, 2018). According to some sources, mining companies ally with criminal networks to repress dissent among the local populations and ensure the continuing operations of these industries.

In summary, communal tenure of land in Mexico offers an enormous opportunity to fully realize the climate, biodiversity conservation, and poverty alleviation goals of the country. However, despite some recent improvements in their legal standing, these groups have historically faced the impacts of external political and economic actors that threaten their ecosystems and livelihoods. The mining industry has become one of the most pernicious among these since the super-commodity boom of the early 2000s.

The procedure to establish a mining project is relatively straightforward and easy for these companies (in terms of leasing lands and paying taxes); in addition, these corporations have little to none contributions to both the federal budget or the local communities where they operate. Finally, they are known for their violent tactics to repress dissent and punish local leaders who oppose to their activities.

4.3 Research Design

The main goal of this paper is to identify the causal effect of exposure to extractive industries, in this case mining concessions, on key community livelihoods, including economic activity, demand for private goods (individual land titles), and deforestation. To do so, I focus on the so-called super-commodity boom of the early 2000s, which led to a massive overlap of concessions and community-owned lands in Mexico from 2000 to 2013. Analyzing this natural experiment presents, however, two types of empirical challenges. The first one is about estimation of the average treatment effect and the second one about measurement.

First, this setting is suitable to estimate a differences-in-differences analysis that retrieves the average treatment effect of exposure to a mining concession on the variables of interest. Nonetheless, the causal claims of this design depend, crucially, on the treatment assignment process. A vast strand of research in political science shows that places with non-renewable natural resources tend to be quite different from those with them.

Although the location of mineral and metal deposits responds mostly to geological reasons (Cassidy, 2019) unlikely to be related to economic and political outcomes, the process through which some of them become productive may be associated with my outcomes of interest. As I shown in the Supporting Information Figures **4.19** and **4.20**, rural communities with and without exposure to mining concessions (the treated and control groups under analysis) differ substantially on variables clearly associated with the outcomes of interest.

These include, for example, the percent of the community's surface overlapping with priority ecosystems and areas suitable for commercial forestry, the share corresponding to soils fertile for agricultural production, the average elevation, the distance to small and medium-sized cities, and the total population in the village.

Although it is possible to visually inspect the presence of pre-treatment trends, the differences between rural communities exposed to mining concessions and those not exposed diminish the strength of the design's causal claims. Instead, I rely on the quasi-exogenous nature of the *time to treatment* within the treated group. That is, while I do not assume that places with and without an extractive project are comparable, *when* they get a concession should not be related to the potential outcomes of interest. Hence, the main assumption of my design is that communities that are exposed to a concession on year t should not be different from those exposed at $t+1$, $t+2$, $t+3$ and so on.

Recently, scholars have pointed out to the flaws and limitations of using a two-fixed effects estimator. For example, Callaway and Sant'Anna (2021) show that this choice introduces important sources of bias, in particular in settings that entail multiple treatment periods and groups—including many substantively relevant applications of this method. A reason for this is the comparison among different sub-groups of units based on treatment status, including early adopters of the treatment, late adopters, and never-treated units. Hence, I estimate a group-time average treatment effect of exposure to a concession on the outcomes of interest (Callaway and Sant'Anna, 2021). To aggregate the different group-time ATEs, I employ both event studies plots and cohort-based estimators.

4.4 Data Sources

The unit of analysis of this paper is the rural community, of which there are two (almost identical) types: *ejidos* and *comunidades agrarias*. I obtained the corresponding shapefiles for most of them from the National Agrarian Registry (or RAN by its Spanish acronym), the agency in charge of updating, keeping, and administering all the information related to these communities.[2] There are approximately 32,000 rural villages.

The main phenomenon I aim to explain as a function of exposure to extractive industries (mining concessions) is communal livelihoods, including its economic, political, and environmental dimensions. From an economic perspective, I argue that mining concessions decrease the ability of communities to engage in other productive activities. Although agriculture is a key source of income for these groups, data on crop production is unavailable at the community-year level. Instead, I employ an indirect approximations to the overall levels of economic activity: the average nighttime luminosity in the village, which I calculate with satellite imagery from NASA. The raster data ranges from 0, when no lights are detected to 62, the maximum value of this variable.

Regarding the political dimension, I posit that extractive industries weaken the ability of rural communities to engage in effective collective action. As explained before, there are a handful of observable implications of this argument; for the purposes of this paper,

[2]The data for some communities is missing because they have still not completed the PROCEDE program, which provides them with certified external boundaries, managed by the RAN

I focus on two of them. First, I analyze how community members engage in individually-oriented behaviors, specifically the number of private property titles (*certificados de derechos parcelarios*) per square kilometer. As mentioned above, a higher value of this variable denotes a stronger demand for individual goods within the community. Second, I also explore the extent to which the mining concession increases the probability of a community engaging in a privatization assembly, which would denote weaker communal institutions. The data for both variables at the community-year level comes from a freedom of information request to the National Agrarian Registry.

Finally, the third dimension that I analyze is environmental. I investigate how exposure to mining concessions affect the annual rate of tree cover loss. The data comes from (Hansen et al., 2013) who processed thousands of satellite images using machine-learning algorithms to produce two specific outputs. The first one is a raster that measures whether a pixel was covered in forest in the year 2000. This allows me to measure a baseline level of tree cover. Then, the second raster determines whether a pixel identified as forested in 2000 still had primary vegetation in 2018; if not, it shows the year when the original forest was lost. Using this data, I construct a time-series of tree cover loss from 2001 to 2018 at the community-year level for all communities.

The independent variable of the analysis is exposure to extractive industries. As mentioned above, most of the existing research either employs satellite imagery to determine the location of illegal mining or uses data on concessions. Given that the former is not a prevalent issue in Mexico, I will focus on the latter. Using the location of concessions to approximate exposure to extractive industries implies two closely-related, but different phenomena. First, in itself, a concession without proper consultation violates the territorial autonomy of communities (Perez et al., 2021) as it allows external actors to make decisions about how to use land. Second, given that not all concessions lead to extraction, they represent a precursor of a different, but related treatment.

To address these issues and tease out these two different treatments, I employ three measurement strategies. The first version of the exposure variable takes the value of 1 when more than 10% of a community's area overlaps with *any* mining concession and 0 otherwise. This can occur either at once (when a company acquires, in a year, a concession with more than 10% of overlap) or cumulative (when a company acquires, in a year, less than 10% of a community's land, but, cumulatively, the total area under the concession surpasses this threshold). The second version subsets to only mining concessions corresponding to gold and silver, the two most valuable mineral exports.

Finally, to tease out the impact of extraction versus land grabs, I use two strategies. On the one hand, I use administrative data from the Ministry of the Economy to subset all the concessions to only those with some level of resource extraction. On the other, I follow Caballero Espejo et al. (2018) and include only the gold and silver concessions in municipalities that reported some level of mineral production. Finally given that the 10% threshold is arbitrary, as robustness checks I re-calculate all of these variables using different overlap percentages. The data comes from the Ministry of the Economy and includes information about all mining concessions approved in Mexico from 1943 to 2017. These last set of robustness checks will be added in the next iteration of the project.

4.5 Statistical Analysis

4.5.1 Descriptive Statistics

From 1990 to 2018, the communal livelihoods of *ejidos* and *comunidades agrarias* went through considerable change. First, although in general the Mexican countryside remained relatively stagnant, certain regions experienced accelerated economic growth (measured with the change in nighttime luminosity), in particular around the urban areas of Valley of Mexico and Puebla-Tlaxcala. In contrast, more isolated communities in the mountainous and coastal areas (for example Sonora, Guerrero, Nayarit, and Quintana Roo) had the lowest rates of economic growth. Indeed, almost one quarter of all rural villages had negative rates of economic growth. Figures **4.21** in the Supporting Information shows the trajectory of satellite-measured luminosity for different regions of Mexico, as well as the distribution of state growth averages for the 1990-2010 period.

Politically, the two main phenomena I analyze are the demand for individual groups in communal settings (the number of *titulos de derechos parcelarios*) and the privatization of community lands. Regarding the former, from 2000 to 2005 there was an important increase in the number of titles and titles per square kilometer across different regions of Mexico, followed by a plateau and another small spike around 2010. In contrast to the number of titles, there is no apparent temporal trend in the propensity of communities to privatize their land (a behavior that has remained quite rare). In general, there is a very strong negative statistical association between these two behaviors and the share of the community corresponding to communal lands.[3] Figure **4.21** in the Supporting Information shows the temporal distribution of these two variables for different regions of Mexico.

Finally, during the period of analysis there was an important increase in the rate of deforestation at the community-level, in particular from 2001 to 2010. Moreover, there are substantive differences across Mexican states; in particular, the south and southeast of the country experienced a much higher rate of environmental degradation than the rest (see Figure **4.21** in the Supporting Information).

Mining corporations hastily expanded their operations in the territories of these already vulnerable communities. As Fig. 4.2 shows, the number of mining concessions in Mexico increased from 375 in 1990 to 669 in 2000 and 1226 in 2010. As mentioned above, many of them overlap with the lands of *ejidos* and *comunidades agrarias.* The number of exposed communities increased from 4 in 1990 to 43 in 2000 to 256 in 2010, particularly in the West and Northwest of Mexico (Jalisco, Michoacan, Sonora, and Sinaloa states). Fig 4.3 presents the time-series of concessions across different regions. Figures 4.4 and 4.5 show the geographic overlap of mining concessions and rural communities for all the country.

[3]In the Supporting Information (Table **4.2**) I show the results of a linear regression model using the number of titles as dependent variable and the percent of the land corresponding to communal ownership as the key regressor, using clustered standard errors at the village level. The results show that for every one-standard-deviation increase in the independent variable, there is 0.10 SD increase in the outcome.

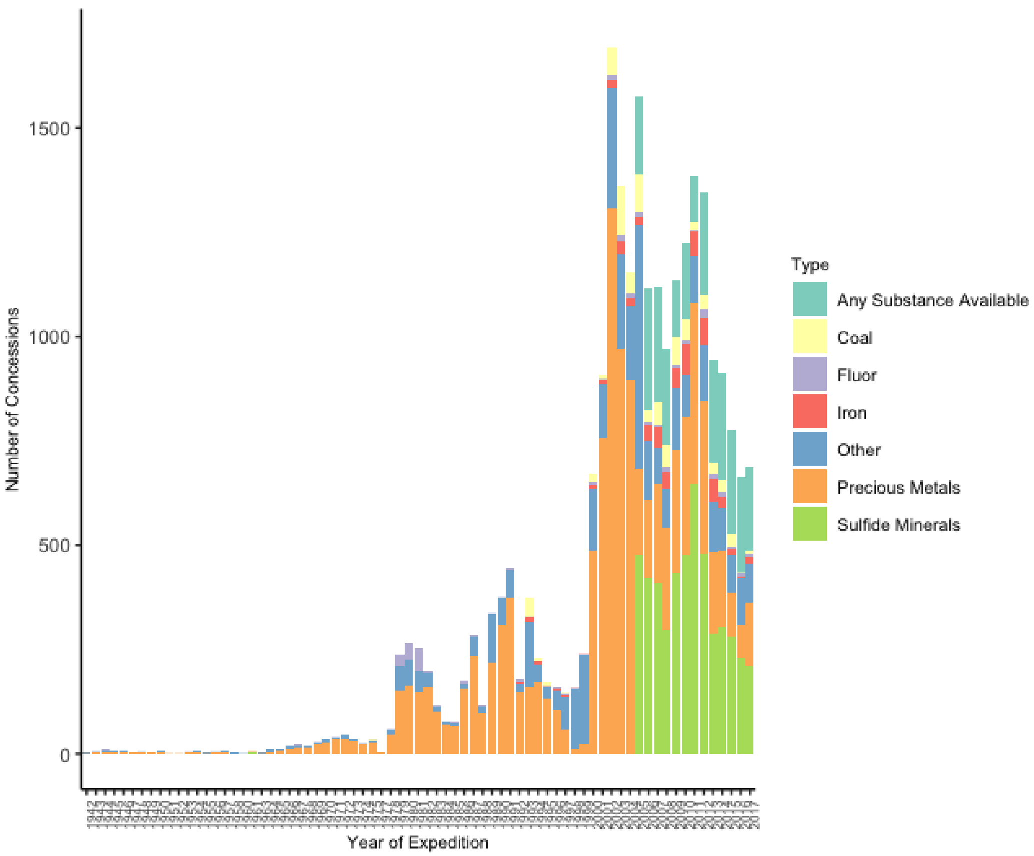


Figure 4.2: **Expansion of mining concessions from the early 19402 to 2017 for all Mexico.**

The typical affected community looks quite different from the average non-affected one along key dimensions related to the outcomes of interest. First, they tend to be larger in territory. Moreover, despite not being statistically different regarding absolute population, mining-affected villages are less densely populated than non-affected ones. They are also more isolated geographically, as they have a higher mean elevation and are farther away from small and medium-sized cities. In ecological terms, although they have a smaller share of their territory covered by primary vegetation, they have a larger potential for commercial forestry activities. Finally, they are socioeconomically different as well: mining-affected communities had lower nighttime luminosity at the beginning of the period of analysis (before the treatment) and slightly lower levels of literacy and access to basic public services. See

Figures **4.19** and **4.20** in the Supporting Information.

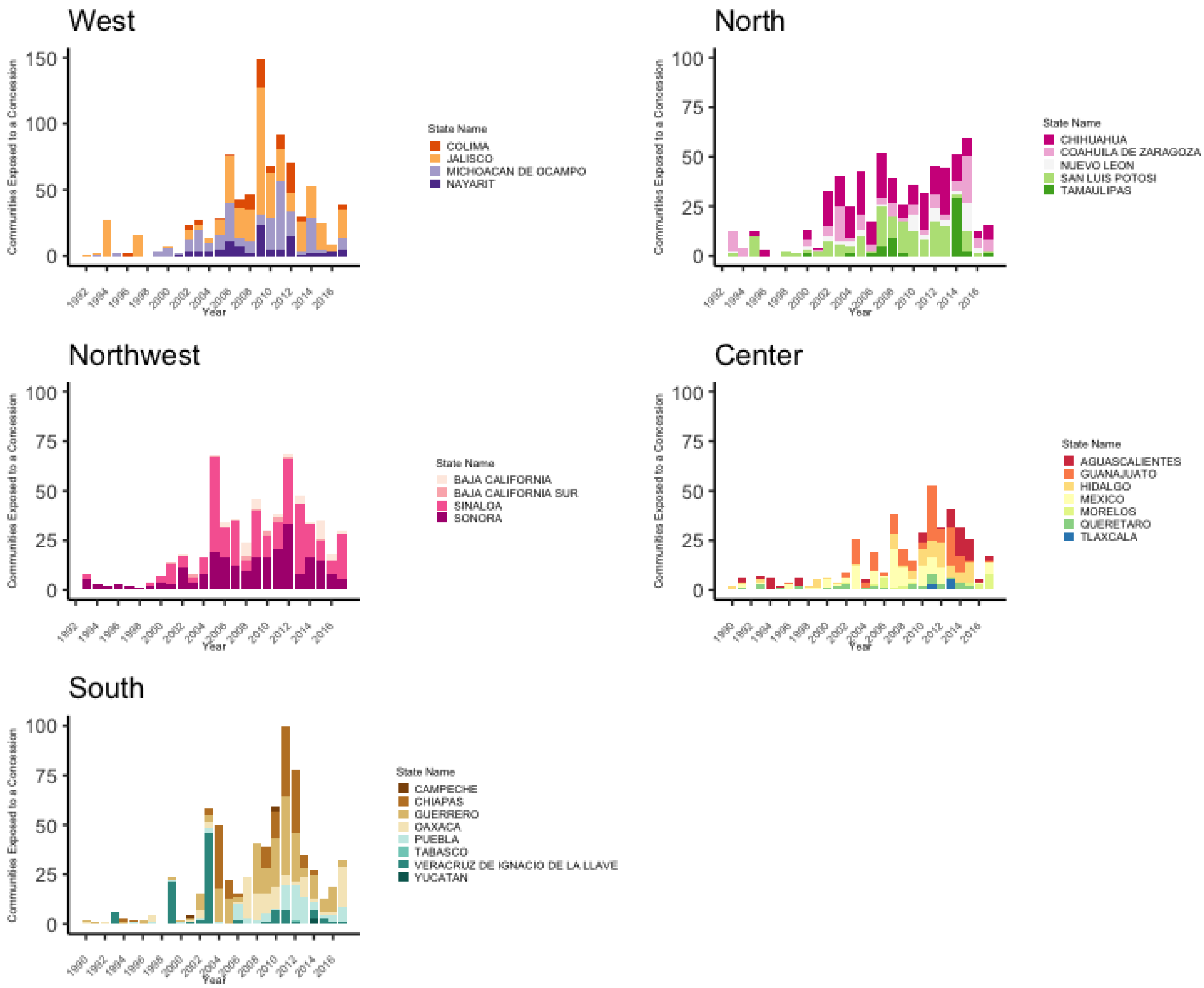


Figure 4.3: **Expansion of mining concessions from the early 19402 to 2017 for different regions of Mexico.**

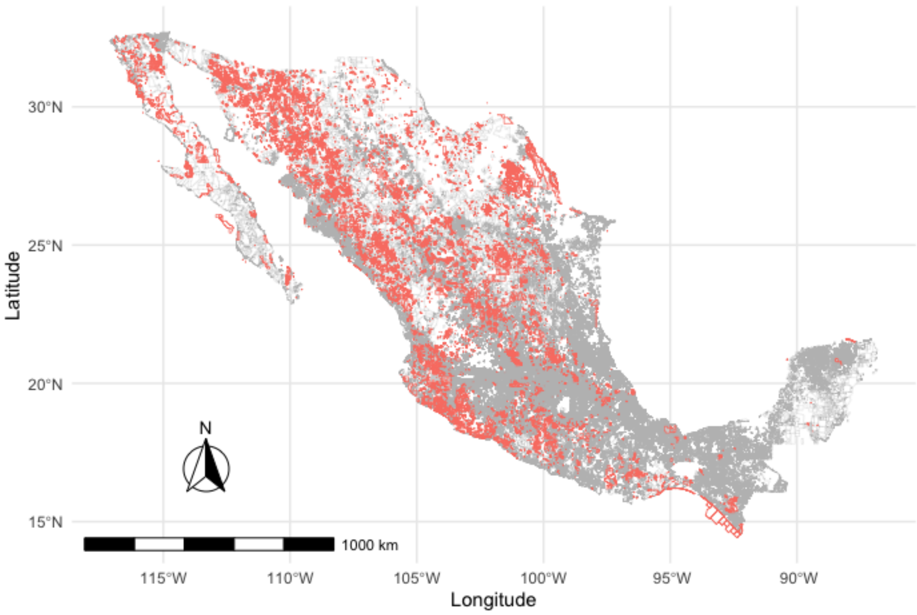


Figure 4.4: **Geographic location of *ejidos* and *comunidades agrarias* and mining concessions**. Spatial distribution of the 32000 rural communities (in grey) and mining concessions (in red).

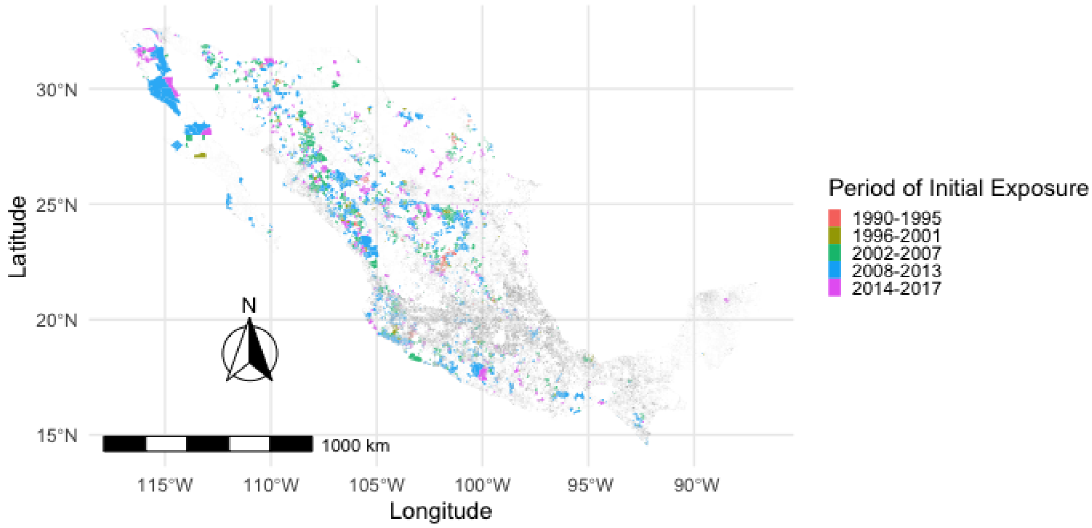


Figure 4.5: **Geographic location of *ejidos* and *comunidades agrarias* exposed to any mining concession**. Spatial distribution of the 32000 rural communities under analysis by their period of initial exposure to any mining concession.

4.5.2 Impacts of Mining Concessions in the Short-Term

I divide the staggered differences-in-differences analysis in short (1-5 years) and medium (6-10 years) terms. As explained above, the main estimator I am employing is the group-time average treatment effect proposed by Callaway and Sant'Anna (2021), which I summarize using two methods: (1) an event-studies analysis and (2) a cohort-based analysis.

In the short-run, my findings point out to an outstanding consequence of exposure to a mining concession among rural communities in Mexico. There is an immediate and pronounced decrease in the overall levels of economic activity, measured with nighttime luminosity. At its lowest point, the coefficient (-0.65) is approximately 0.1 standard deviations in the outcome variable or 31% of its mean value. As Figure 4.6 shows, the effect is negative for most of the years and, in general, the simple average treatment effect (ATT) is -0.31, with a 95% confidence interval from -0.38 to -2.45.

The first cut of the analysis shows that rural communities exposed to extractive industries suffer from a decrease in their economic output immediately after the establishment of a mining concession. Figure 4.6 also shows that this shock is not permanent, as the impact of exposure to a concession is no longer statistically significant ten years after the beginning of the project.

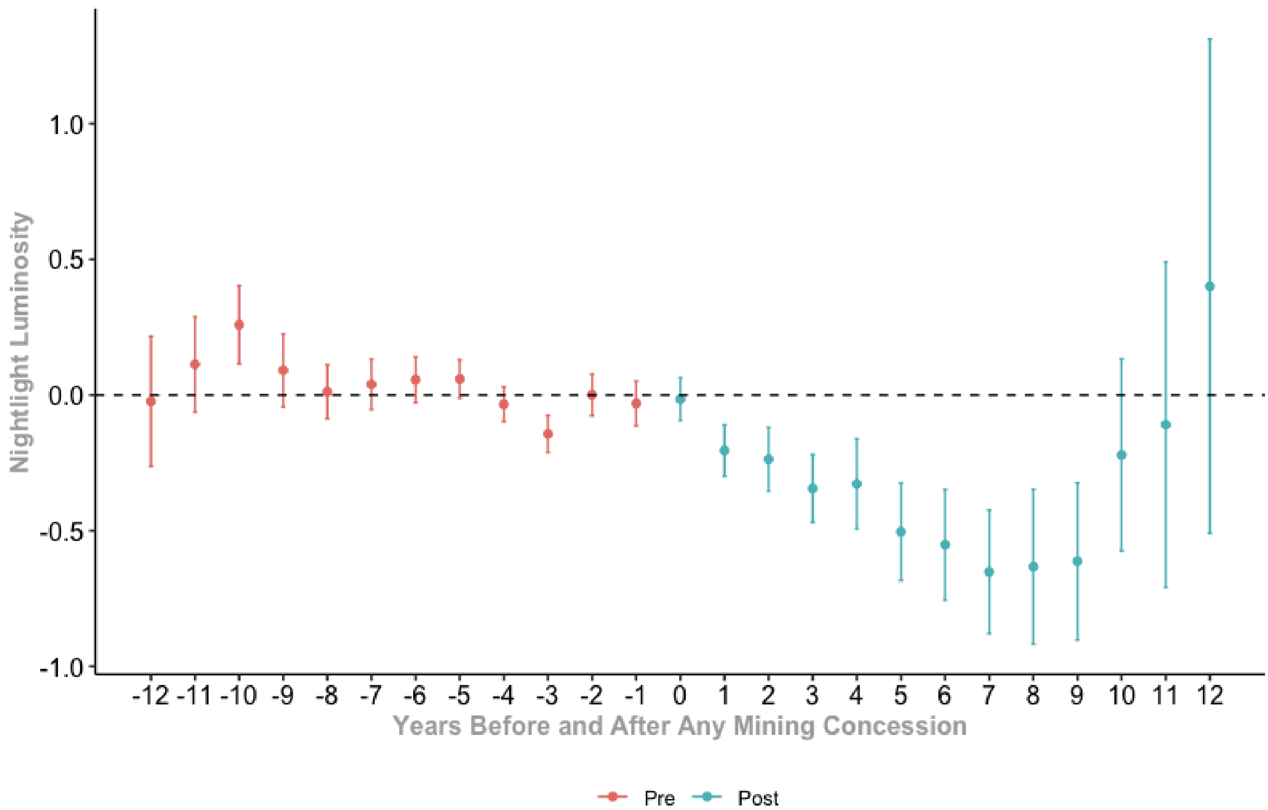


Figure 4.6: **Staggered differences in differences: nighttime luminosity**. The X-axis shows the lags and leads around the time of exposure to any mining concession. The Y-axis shows the average nighttime luminosity per year on a scale from 0 to 62. The statistical model comes from Callaway and Sant'Anna (2021)

There are two potential explanations behind this finding. First, several scholars and journalists have documented the severe human costs of many of these operations, including violence and displacement, whose impacts could be reflected in economic outcomes. Other scholars have measured the effects of crime on the economy (Robles et al., 2013). Second, it is also possible that, as several journalistic accounts explain, communities find it difficult to engage in their usual economic activities, such as agriculture, livestock production, and forestry, once a mining corporation establishes in their territory, due to environmental degradation (Perez et al., 2021).

In summary, an analysis of the short-term impacts of mining concessions suggest that even the presence of these land grabs—regardless of their production status—affects the economic livelihoods of the communities where they operate. These impacts are very similar when I subset to only producing concessions and projects related to gold and silver (two highly valuable metals). Moreover, an analysis of the effects of extractives on agricultural subsidies suggest that a reduction in the ability to engage in primary activities (such as agriculture) may be driving the aforementioned impact on luminosity.

4.5.3 Impacts of Mining Concessions in the Medium-Term

I divide the medium- and long-term impacts of exposure in political and environmental. Politically, communities whose territory overlaps with extractive industries experienced a substantive increase in their demand for individual goods, specifically the number of private titles per square kilometer. As mentioned above, there is a negative relationship between this variable and the share of a community's territory that its inhabitants steward in common—as opposed to individual parcels, which are *de facto* private.

As Figure 4.7 shows, the relationship between exposure to extractives and the number of individual land titles per square kilometer does not occur until a few years after the establishment of the concession. By years 5-6, the relationship is both statistically significant and substantively relevant. By the end of the period of analysis (16 years after exposure to a mining concession), the coefficient is equivalent to 0.16 standard deviations of the outcome and two times its mean value (6.05 and 1.99 titles per square kilometer, respectively). That is, it peaks right immediately after the strongest effect of concessions on the economic livelihoods of communities. As with the previous outcomes, the effect is driven by villages affected in particular years (the coefficient for specific cohorts is stronger than for other cohorts), as shown in the Supporting Information.

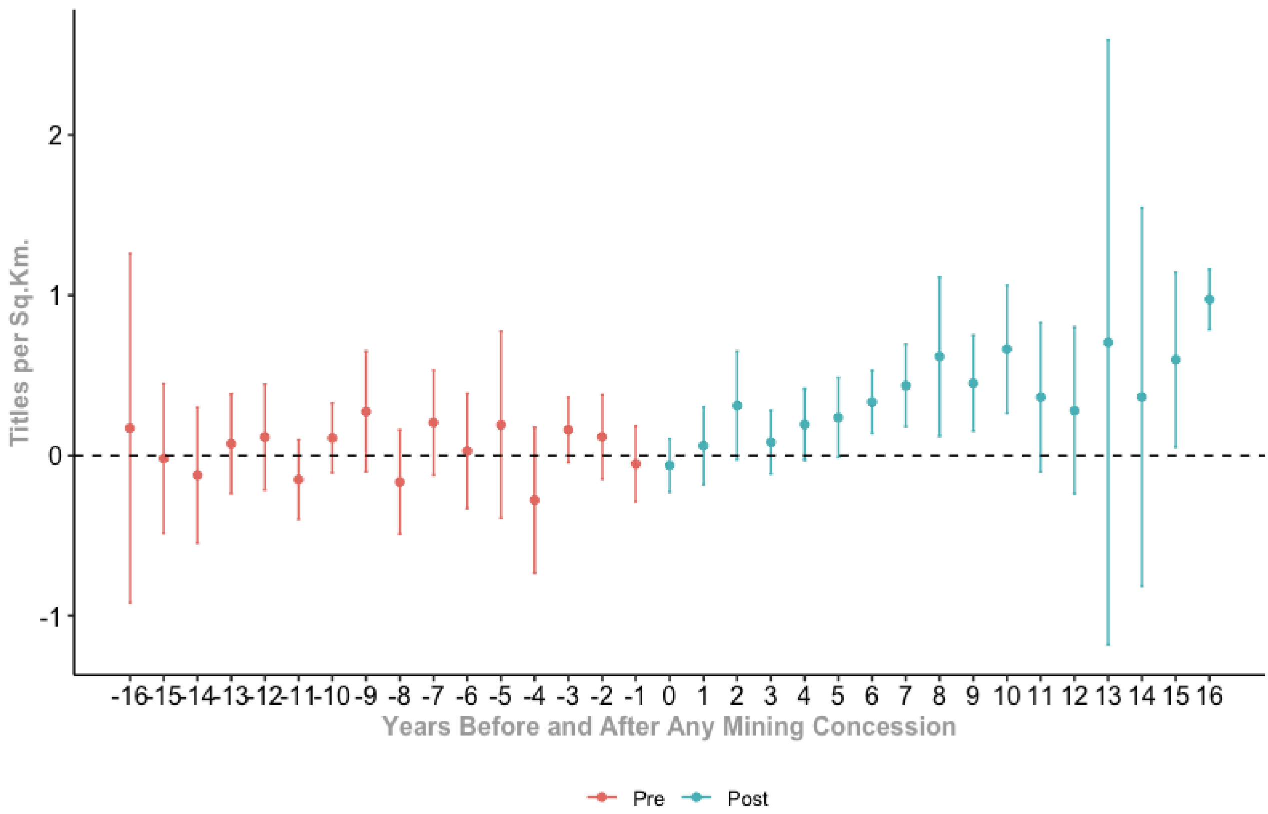


Figure 4.7: **Staggered differences in differences: private parcel titles**. The X-axis shows the lags and leads around the time of exposure to any mining concession. The Y-axis shows the number of private titles per square kilometer issued by the community. The statistical model comes from Callaway and Sant'Anna (2021)

In contrast, we do not see any significant change in the probability of privatizing part of the community by transitioning to full ownership or *dominio pleno* (see Fig. 4.8). As explained before, communities have not employed this legal procedure as government officials initially expected. Instead, it has remained a relatively rare phenomenon. Mining does not seem to play a big role, even for the small number of these events.

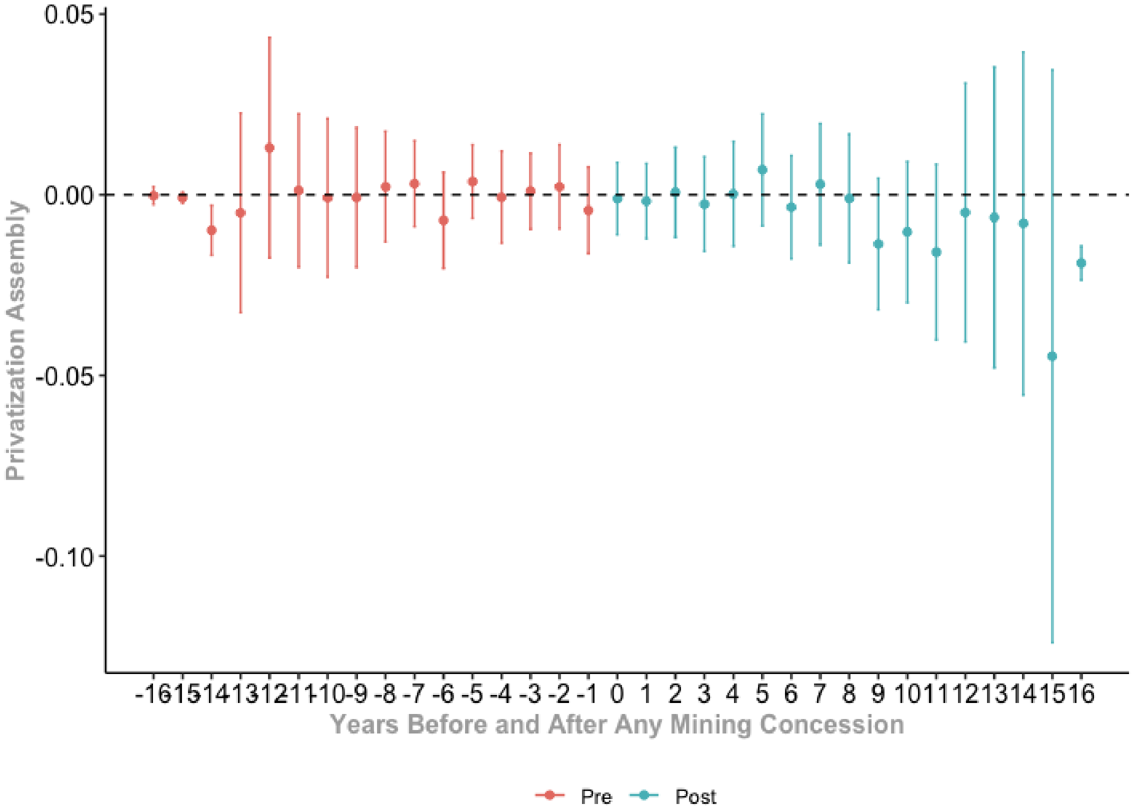


Figure 4.8: **Staggered differences in differences: privatization assembly**. The X-axis shows the lags and leads around the time of exposure to any mining concession. The Y-axis shows the linear probability of holding a privatization assembly within the community. The statistical model comes from Callaway and Sant'Anna (2021)

Finally, the environmental impacts of exposure to mining concessions are the most puzzling. First, contrary to conventional wisdom, we do not see an increase in the rate of deforestation in affected communities. Second, instead, there is a small, but statistically significant decrease in tree cover loss, particularly in medium-to-long run (Fig. 4.9). In summary, while most of the short-term impacts of extractive industries are economic, the consequences in the longer-run are mostly political and environmental.

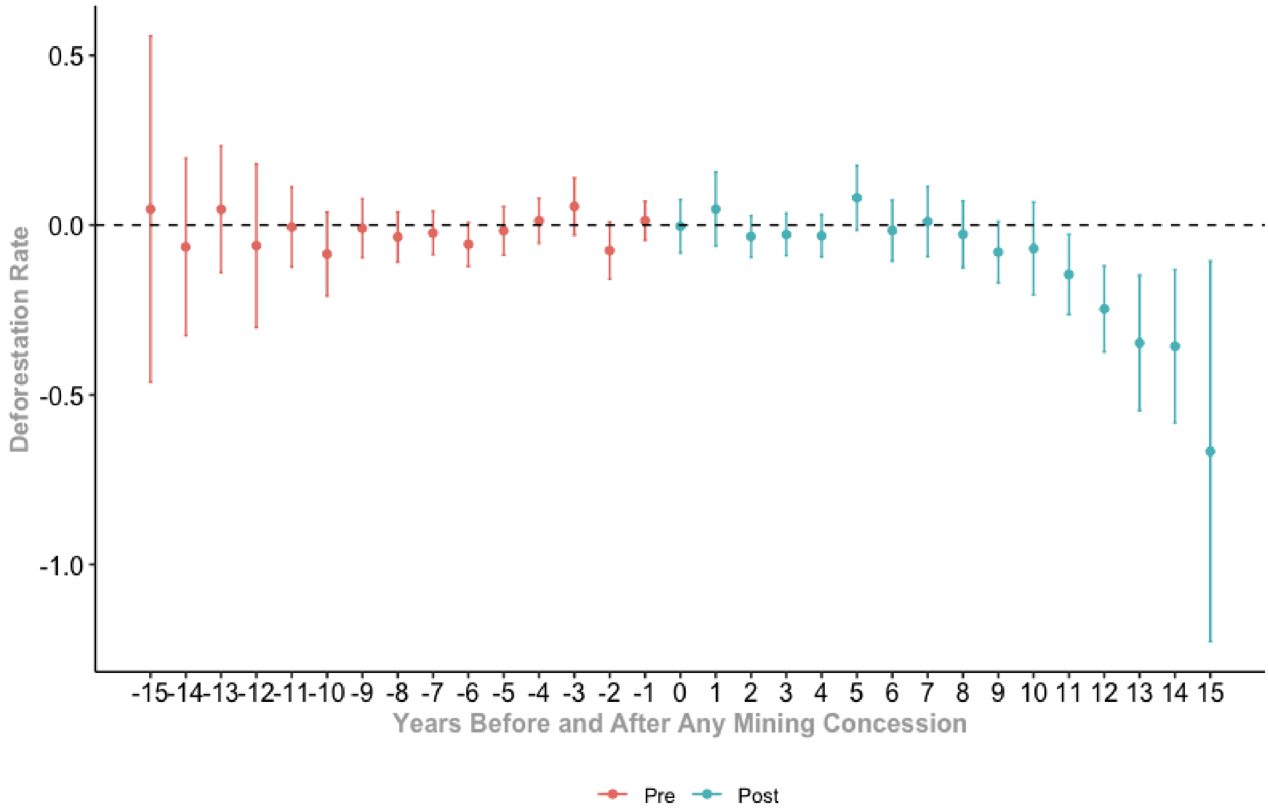


Figure 4.9: **Staggered differences in differences: tree cover loss**. The X-axis shows the lags and leads around the time of exposure to any mining concession. The Y-axis shows the annual rate of tree cover loss using data from Hansen et al. (2013). The statistical model comes from Callaway and Sant'Anna (2021)

4.6 Discussion and Conclusions

The global expansion of extractive industries, including mining, oil and gas, large-scale agriculture, and massive infrastructure projects, is one of the most consequential challenges facing local communities worldwide. Mexico represents an ideal case to analyze these impacts. As a leading exporter of highly valuable commodities, multiple international and domestic companies in these sectors have established operations in the country. In doing so, they have infringed upon the constitutional and international rights of thousands of *ejidos* and *comunidades agrarias*. In this chapter, I leverage the quasi-exogenous timing of the establishment of mining concessions to understand how they impact key economic, political, and environmental aspects of these communities' livelihoods.

Descriptively, I find that mining concessions tend to affect already vulnerable communities. Exposed villages tend to be more isolated, farther away from large population centers, and have lower coverage of basic public services, including education and sewage. The results from the staggered differences-in-differences analysis suggest that these economic projects have short and medium-term impacts on the communities they overlap with. First, they are associated with a decrease in the overall levels of economic activity, measured with satellite imagery.

In the medium-term, my findings show that the impacts of exposure to mining concessions include also political and environmental factors. Politically, communities that suffer from the presence of a mining corporations have a larger demand for private goods than non-exposed communities. This increase in the number of individual parcel titles starts 5-6 years after the initial exposure and coincides with the strongest impact of mining on economic activity. As mentioned above, I take this as evidence of weakening communal political institutions, which, as several scholars have argued, are associated with better stewardship of the commons. Nonetheless, my results show that communities are resilient, as they are not more likely to engage in privatization efforts (holding an assembly to transition to full ownership) after being exposed to a concession.

The findings related to tree cover change and mining concessions are more puzzling. The small, but statistically significant decrease in deforestation could reflect two issues. First, multiple studies have shown a strong relationship between agriculture expansion and deforestation. In Mexico, farming is still the main source of income for the vast majority of these communities—and in many the *milpa* has an important political and cultural meaning (De Frece and Poole, 2008; Torres-Mazuera, 2015a; Lawrence et al., 2019). Therefore, by reducing the ability of communities to engage in agriculture and other productive activities, mining concessions may, unexpectedly, reduce the stress associated with this particular driver of deforestation.

Another reason is that the differences-in-differences estimator is unable to capture changes in deforestation for mining concessions where extraction is actually occurring. As mentioned above, only a small fraction of these projects are in the operation stage, according to data from the Ministry of Economy. Future research could further analyze this question using a difference-in-discontinuity design at the pixel level. Specifically, this exercise would restrict the sample to only a buffer around producing concessions and then measure deforestation before and after the establishment of said project. Nonetheless, regardless of the results of this exercise, my findings show that even only the overlap with an extractive project can affect the socio-environmental systems of communities.

Taken together, the descriptive and analytical findings of my study suggest that the impacts of extractive industries, in particular mining, are complex and can take several forms. Overall, mining concessions in Mexico have been associated with the erosion of communal livelihoods, evidenced by a drop in nighttime luminosity and by an increase in the demand for private goods within the community. In this paper, I aim to go beyond the existing literature and study the consequences of extractive development in a more holistic way.

There are several limitations to this paper, which I expect to address in the next iteration. The first one relates to measurement. The key concept I study is *communal livelihoods*, which includes economic, political, and environmental conditions at the community level. As mentioned above, the data I employ to approximate the overall levels of economic activity has some limitations. For the next iteration of the project, I plan to add other satellite-derived measures of land productivity, which vary across space and time.

The second limitation is about a missing component in my concept of *community livelihoods*. According to several journalistic accounts, two of the most relevant consequences of mining operations are, on the one hand, the expansion of criminal violence and, on the other, impacts on public health due to air and water pollution. For the next iteration of the paper I will employ fine-grained data at the locality level from the Ministry of Health and the National Water Commission to study the effects of exposure to mining concessions on a wide array of mortality outcomes, including violence from criminal organizations and diseases related to chemicals used by the mining industry.

4.7 Supporting Information

4.7.1 Data Sources

Variable	Description	Source
Tree Cover Loss	Annual rate of forest loss as a percent of the total forested area of a community in 2000	(Hansen et al., 2013)
Nighttime Luminosity	Average nighttime luminosity on a scale from 0 to 62	NASA
Subsidies per Sq. Km.	Amount of farming subsidies received from the federal government per square kilometer	Mexico's Ministry of Agriculture, Livestock, and Rural Development
Land Titles per Sq. Km.	Number of *certificados de derechos parcelarios* or individual parcel titles issued within the community by square kilometer	Mexico's National Agrarian Registry
Communal Lands Privatization	Binary variable that takes the value of 1 when the community held an assembly to privatize part of it (*asamblea de dominio pleno*) and 0 otherwise	Mexico's National Agrarian Registry
Elevation	Average elevation of the community in meters above the sea level	Digital maps available through the `elevatr` package in R
Forest Cover in 2000	Percent of the total area of a community covered by forest in the year 2000	(Hansen et al., 2013)
Total Area	Total area of the community in square kilometers	National Agrarian Registry
Distance to Closest Urban Center	Linear distance from the centroid of the community to the closest locality of 10,000 or more inhabitants	INEGI
Area Suitable for Forestry	Percent of the community's total area suitable for forestry, according to the categories defined by Mexico's National Forest Commission	CONAFOR
Area Suitable for Conservation	Percent of the community's total area suitable for conservation, according to the categories defined by Mexico's National Forest Commission	CONAFOR
Exposure to Mining Concessions	Binary variable that takes the value of 1 when any mining concession overlaps with more than 10% of the community's surface and 0 otherwise. Robustness check include different thresholds.	Ministry of the Economy
Exposure to Gold and Silver Mining Concessions	Binary variable that takes the value of 1 when any gold or silver concession overlaps with more than 10% of the community's surface and 0 otherwise. Robustness check include different thresholds.	Ministry of the Economy
Access to Basic Public Services	Percent of the community's population with access to sewarage, schooling, and sanitary housing	INEGI

4.7.2 Descriptive Figures

4.7.2.1 Time Series of Key Variables

Figure 4.10: Total surface under any time of mining concessions from 1942 to 2017 in hectares.

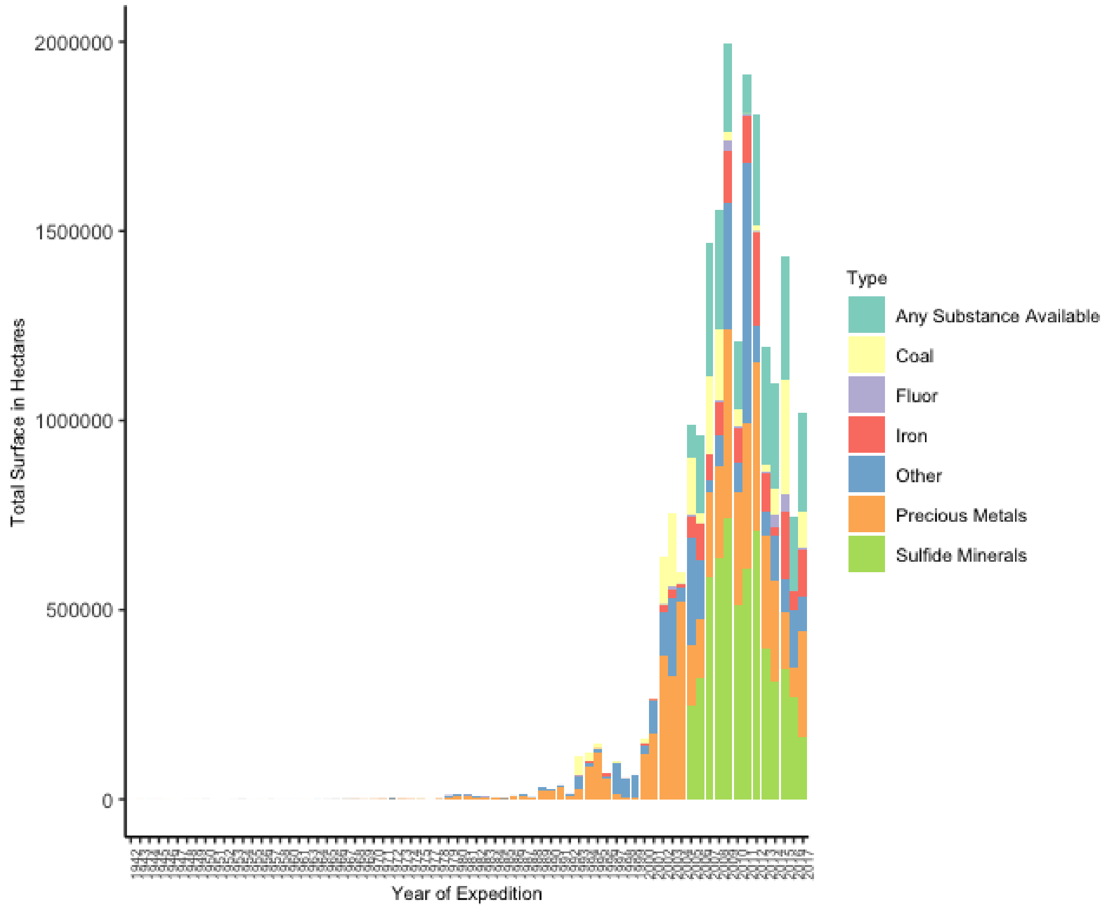
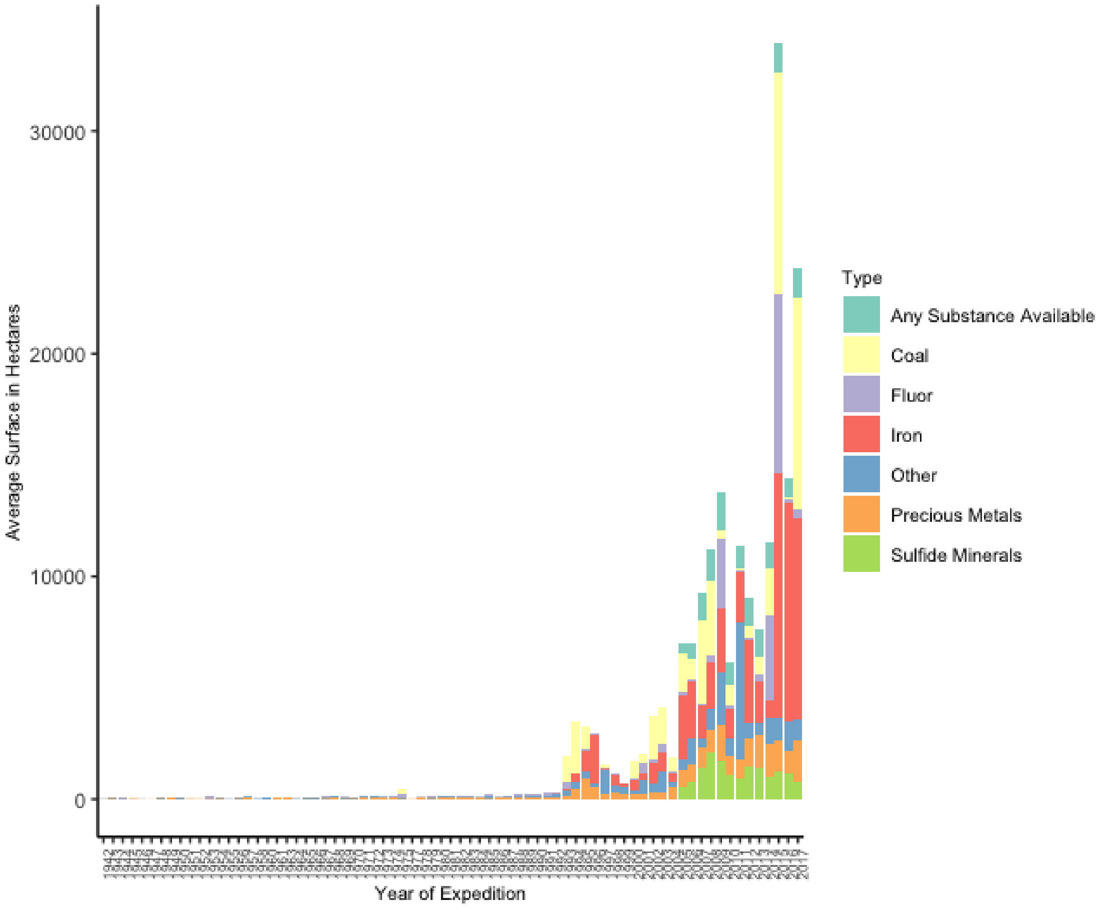


Figure 4.11: Average extension of mining concessions per year from 1942 to 2017, separated by type of mineral extracted.



4.7.2.2 Maps

Figure 4.12: **Mining Concessions in Communal Lands**. This map shows, in green all *ejidos* and *comunidades agrarias* with more than 10% of their surface covered in primary vegetation in the year 2000. In red, it shows all mining concessions approved as of 2017.

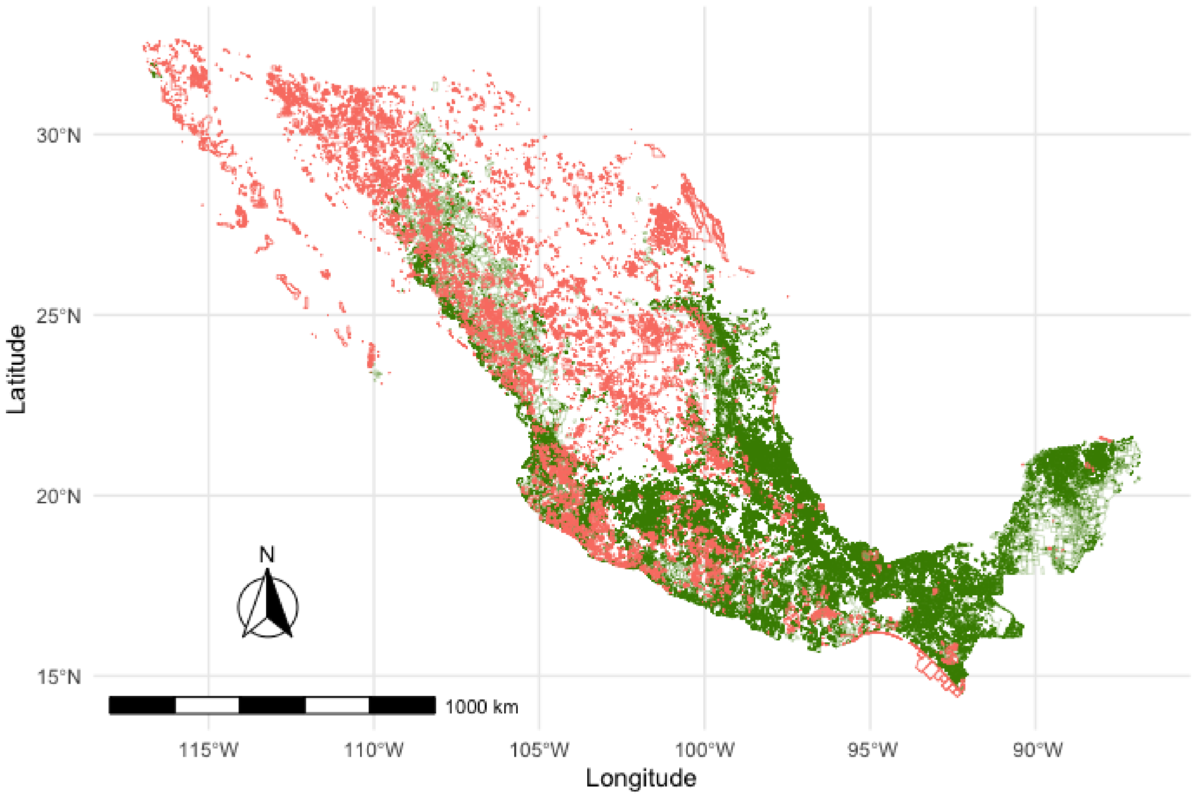


Figure 4.13: **Mining Concessions in Communal Lands**. This map shows, in green all *ejidos* and *comunidades agrarias* with more than 30% of their surface covered in primary vegetation in the year 2000. In red, it shows all mining concessions approved as of 2017.

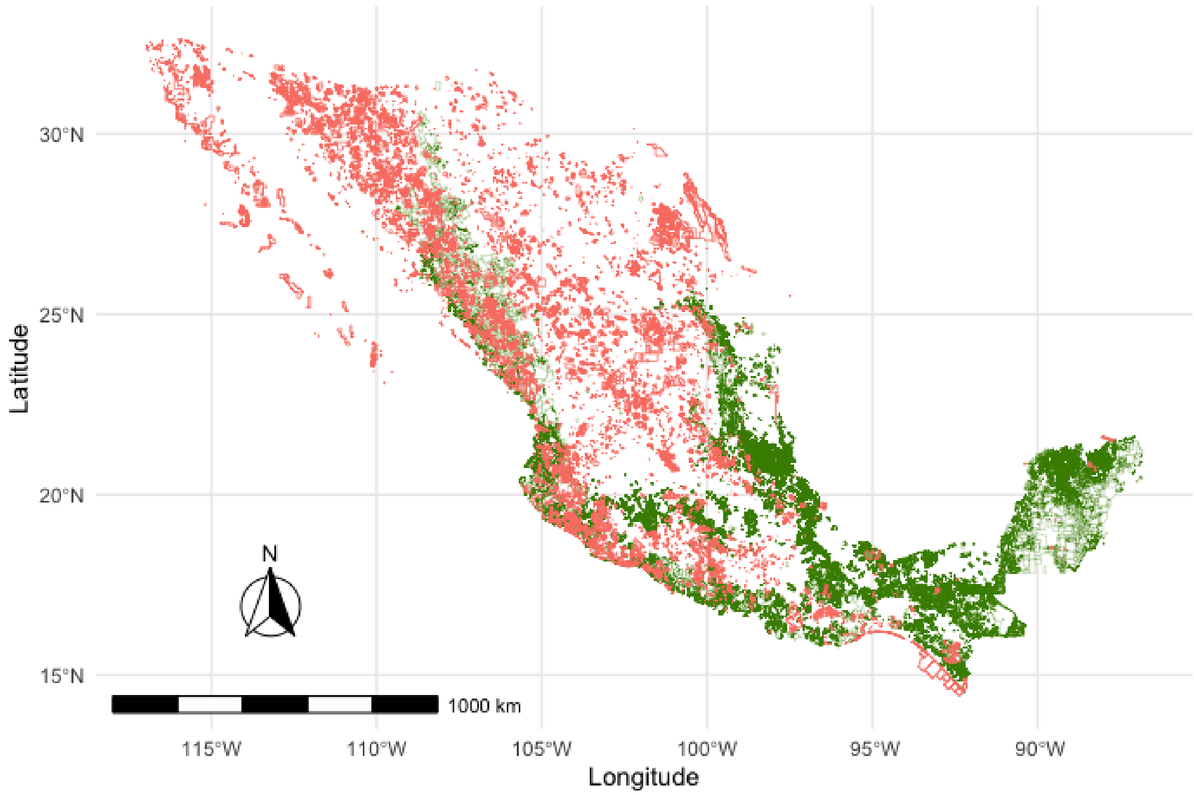


Figure 4.14: **Mining Concessions in Communal Lands**. This map shows, in green all *ejidos* and *comunidades agrarias* with more than 50% of their surface covered in primary vegetation in the year 2000. In red, it shows all mining concessions approved as of 2017.

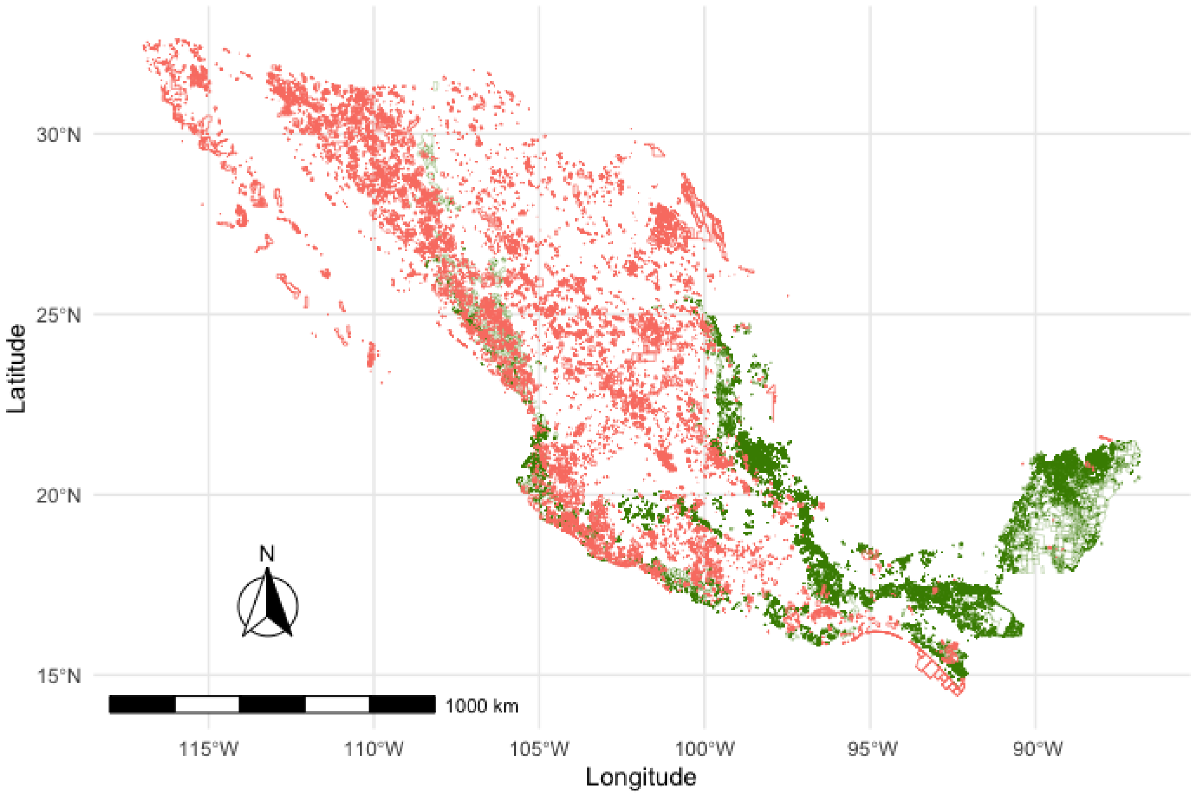


Figure 4.15: **Geographic Distribution of Treatment**. This map shows all forest agrarian communities with more than 10% of their surface overlapping a mining concession by period of exposure, starting in 1990 to 2017.

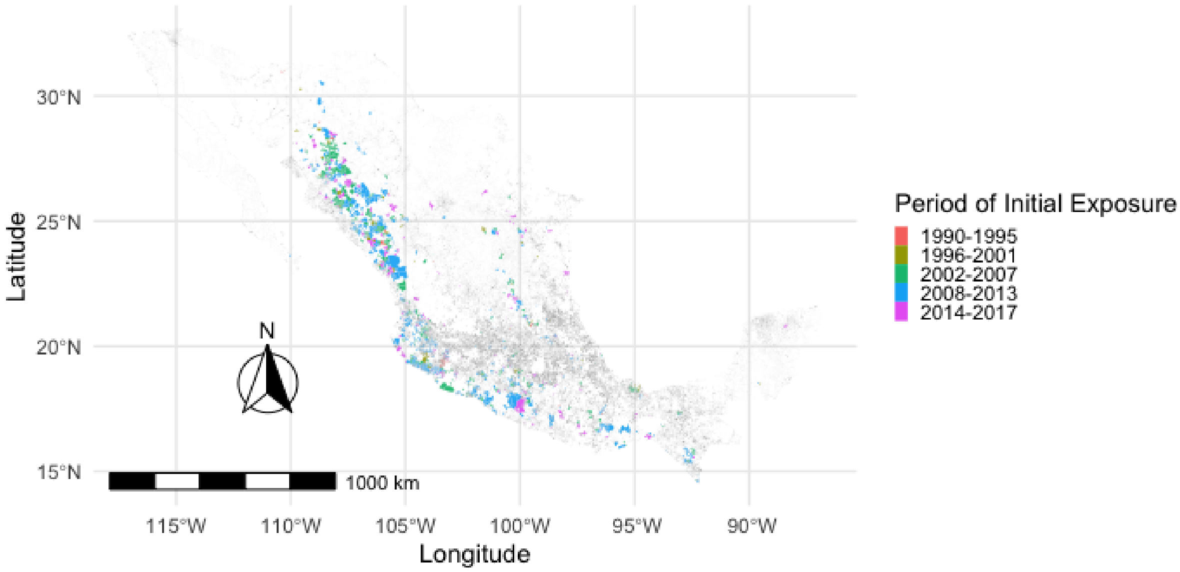


Figure 4.16: **Geographic Distribution of Treatment**. This map shows all agrarian communities with high commercial forestry potential having more than 10% of their surface overlapping a mining concession by period of exposure, starting in 1990 to 2017.

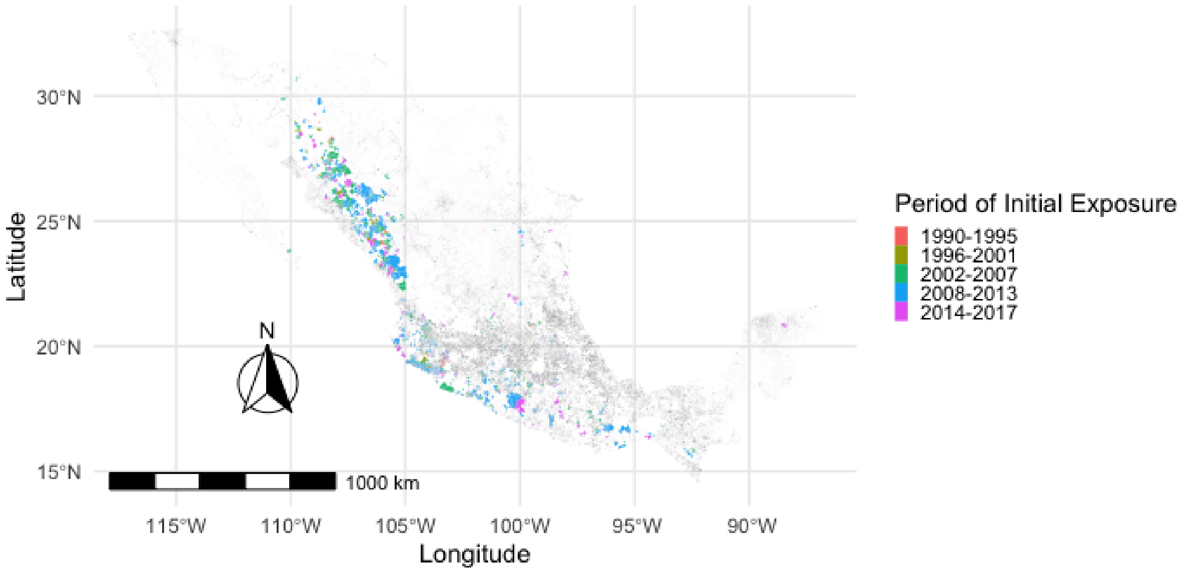


Figure 4.17: **Geographic Distribution of Treatment**. This map shows all agrarian communities with high biodiversity having more than 10% of their surface overlapping a mining concession by period of exposure, starting in 1990 to 2017.

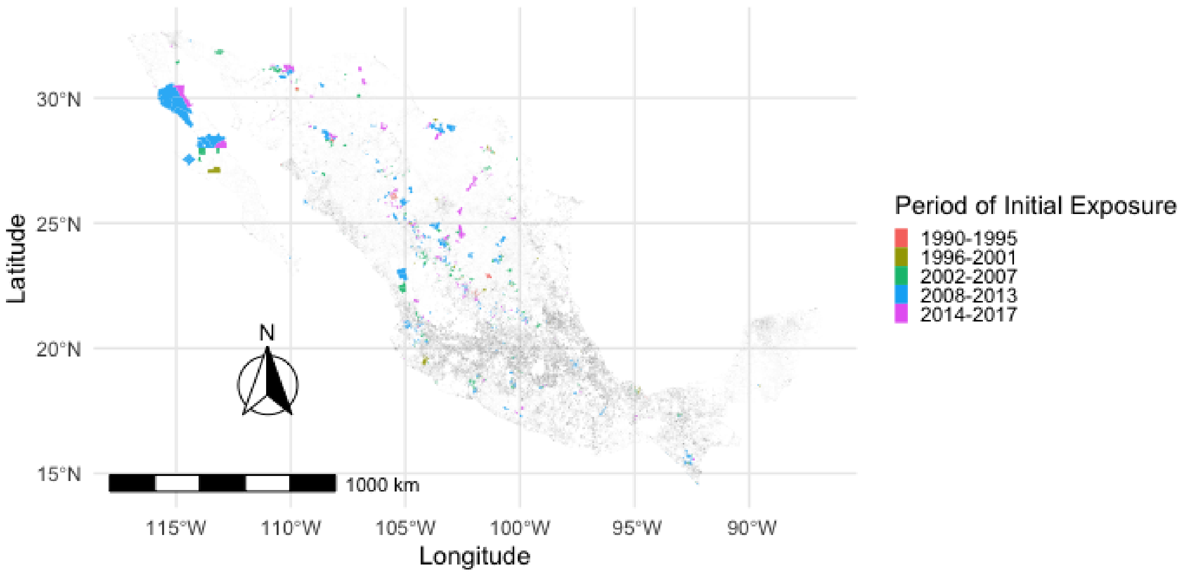


Figure 4.18: **Balance between villages exposed to any mining concession ("treated") and villages not exposed to a mining concession ("control") in key covariates**

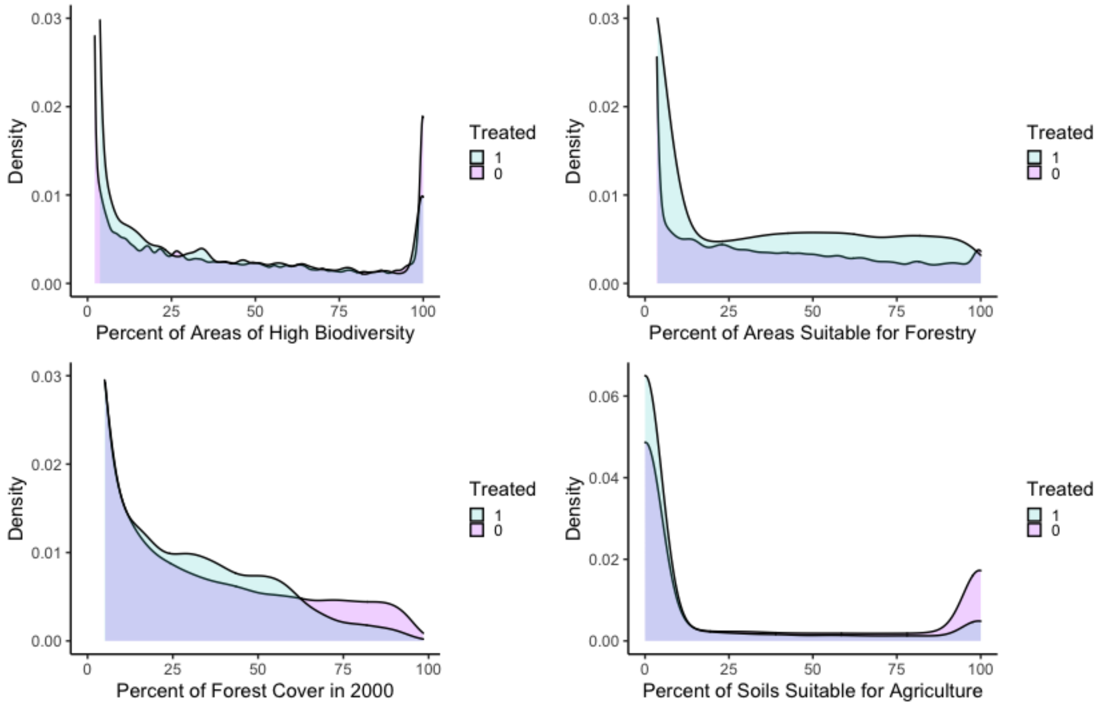


Figure 4.19: **Balance between villages exposed to any mining concession ("treated") and villages not exposed to a mining concession ("control") in key covariates**

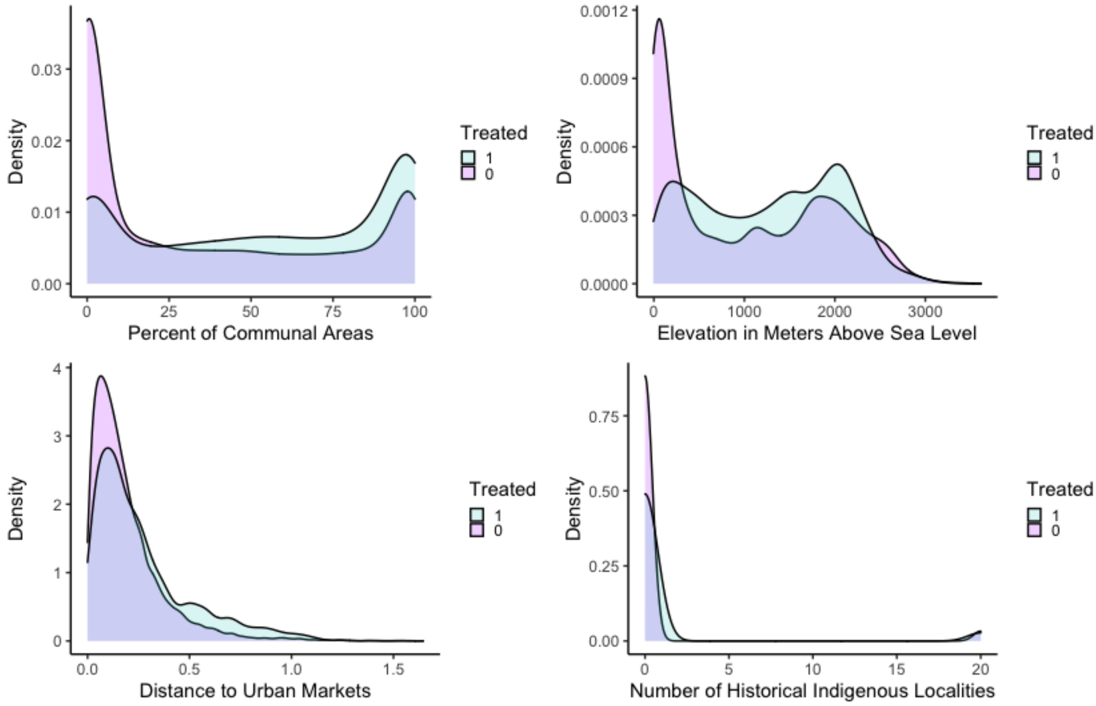
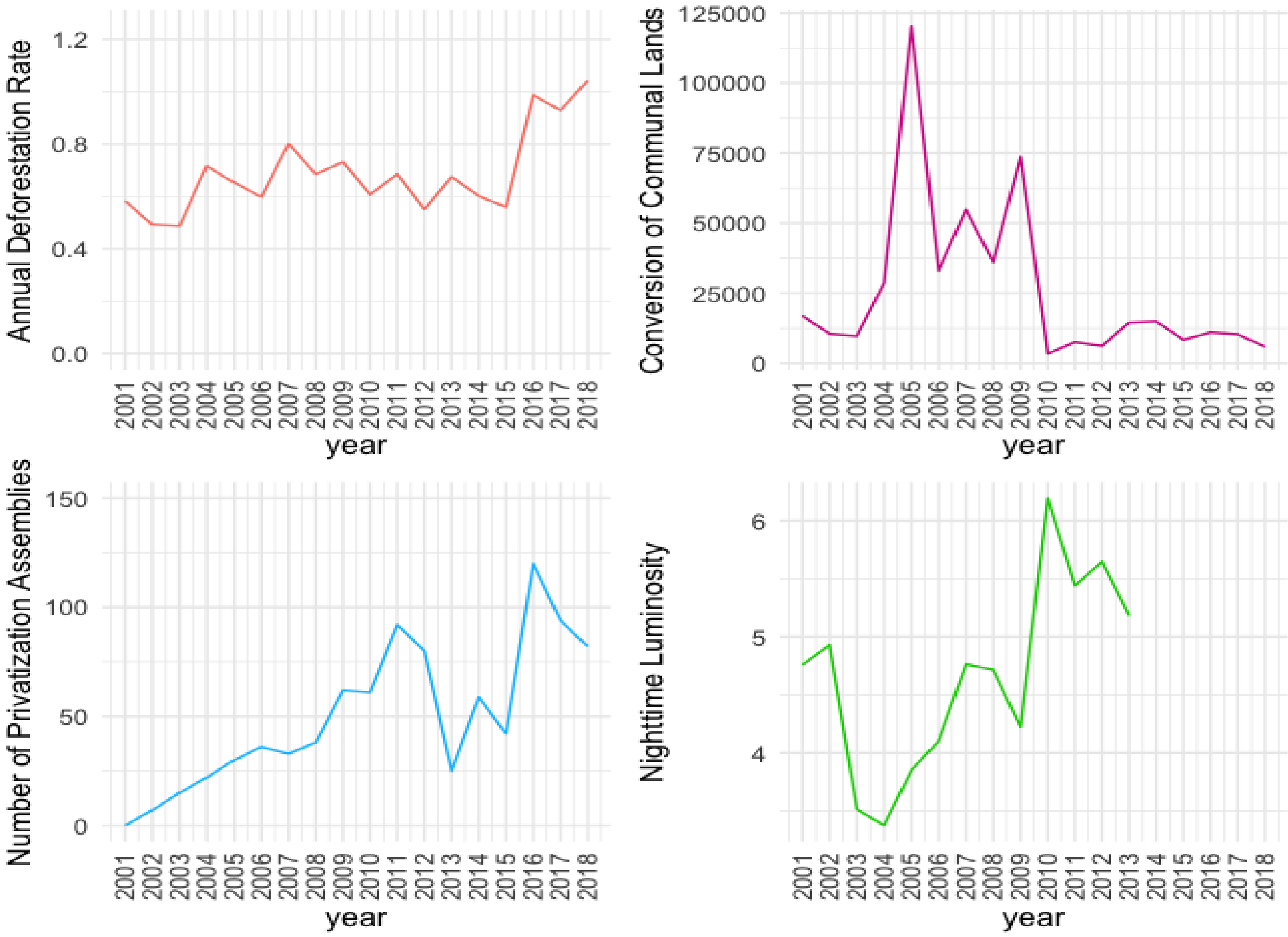


Figure 4.20: **Time-series of selected outcomes.** Top left: average annual deforestation rate across all forest communities in Mexico from 2001 to 2018. Top right: total number of hectares of communal lands converted to any other land use across all forest communities in Mexico from 2001 to 2018. Bottom left: total number of privatization assemblies across all forest communities in Mexico from 2001 to 2018. Bottom right: average nighttime luminosity across all forest communities in Mexico from 2001 to 2012.



4.7.3 Robustness Checks

4.7.3.1 Event Studies / Gold and Silver Concessions

Figure 4.21: **Event-studies plot for nighttime luminosity**. The outcome variable is the nighttime luminosity. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

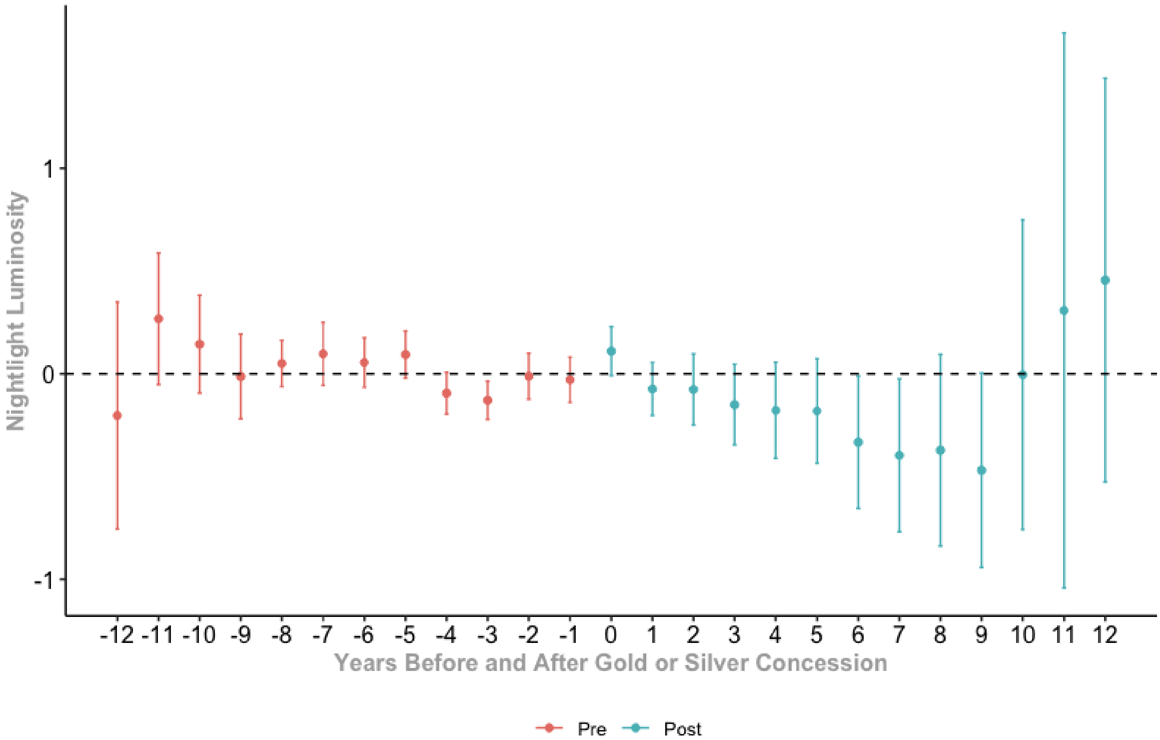


Figure 4.22: **Event-studies plot for individual land titles**. The outcome variable is the number of individual titles *certificados de derechos parcelarios* per square kilometer. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

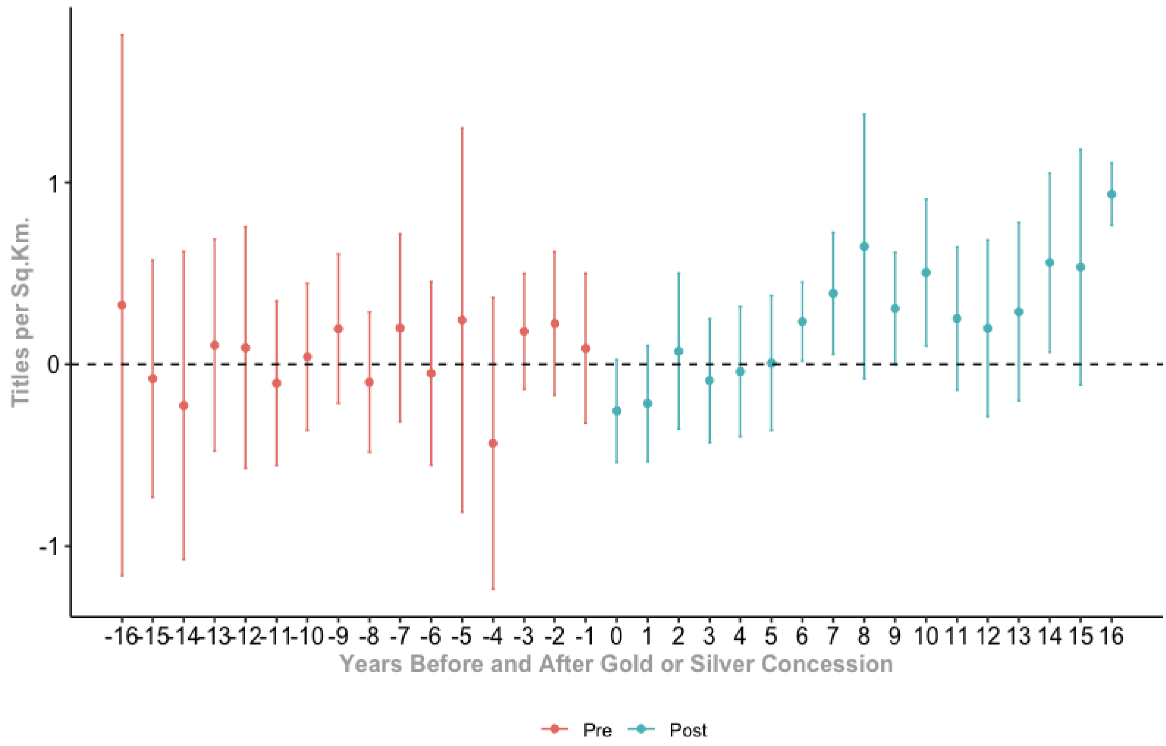


Figure 4.23: **Event-studies plot for deforestation**. The outcome variable is the rate of tree cover loss. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

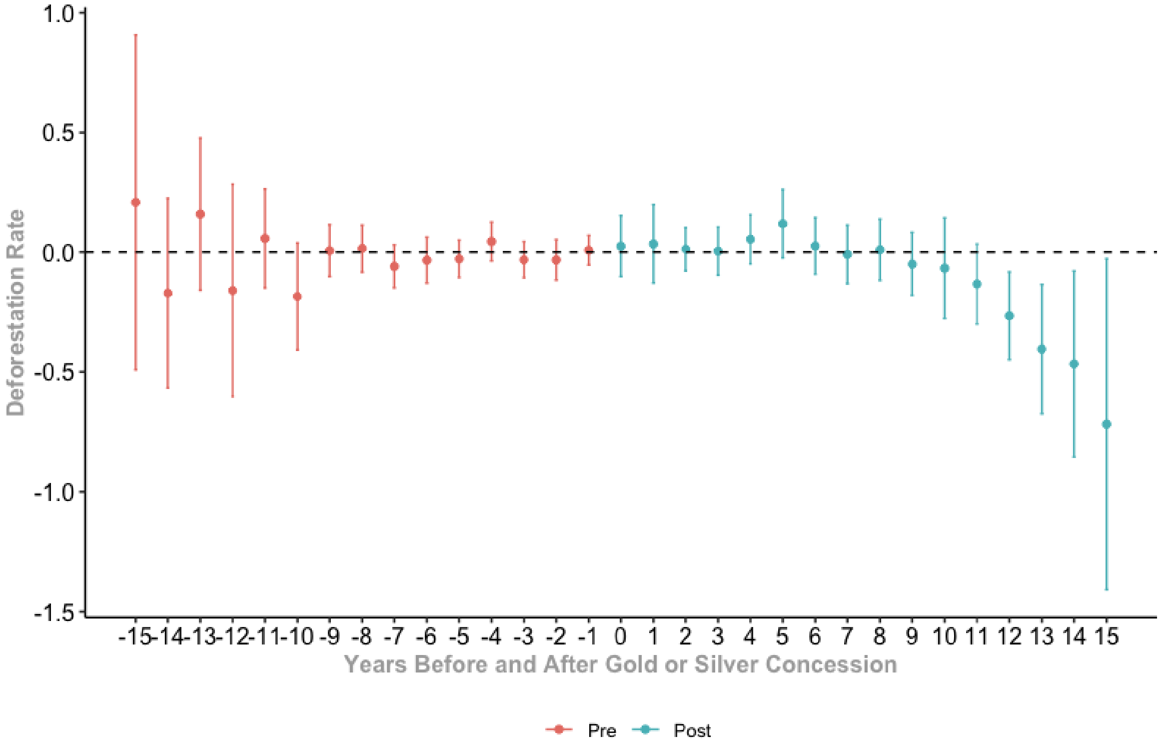
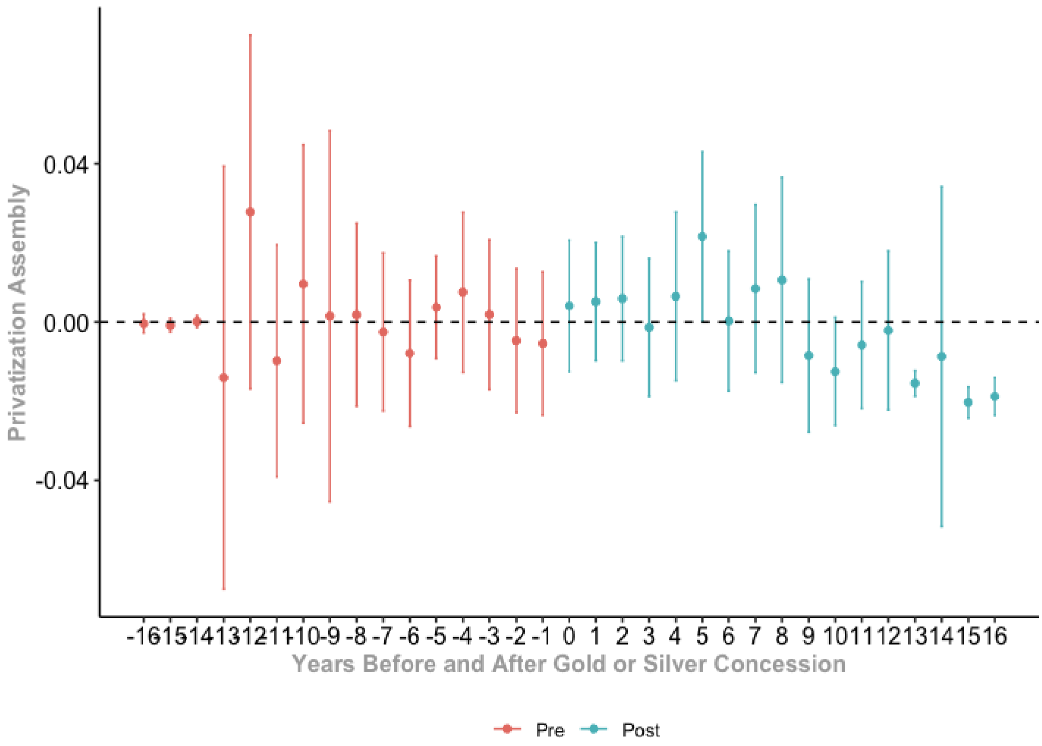


Figure 4.24: **Event-studies plot for privatization assembly**. The outcome variable is the linear probability of holding a privatization assembly within the community. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)



4.7.3.2 Cohort-Year Analysis / All Mining Concessions

Figure 4.25: **Cohort-year plot for nighttime luminosity**. The outcome variable is the average nighttime luminosity measured with satellite imagery. The main independent variable is the timing of exposure to any mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

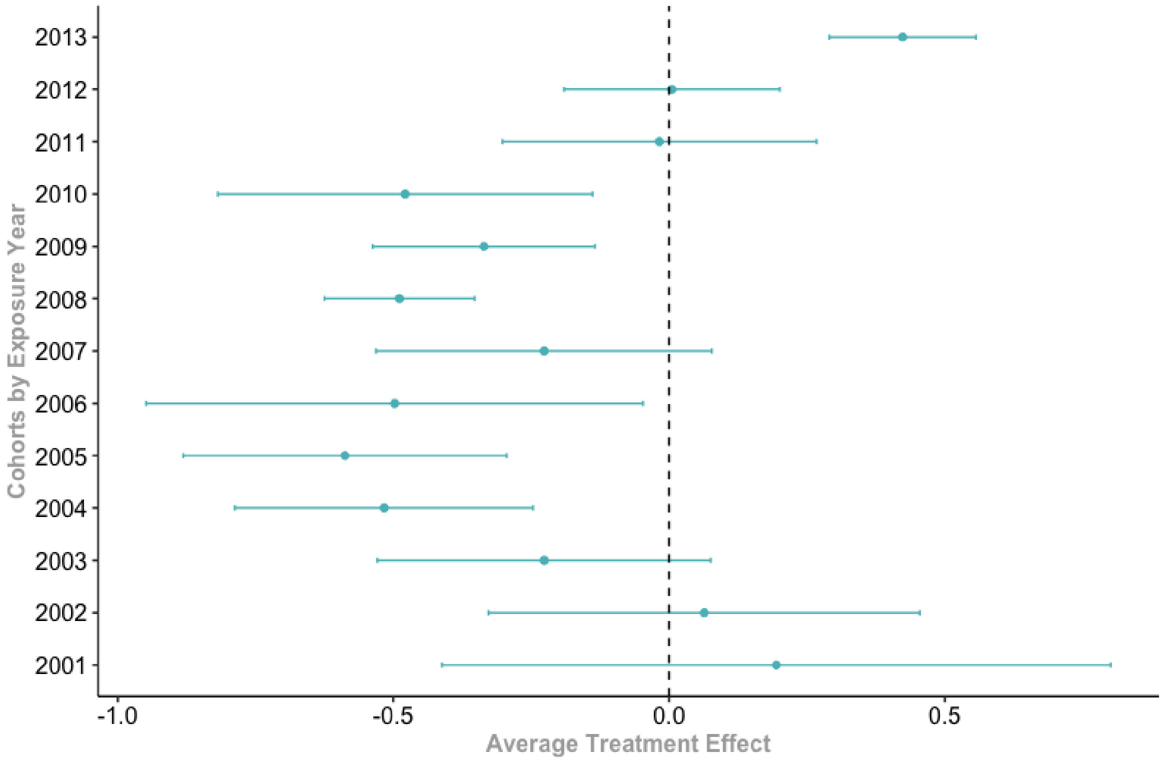


Figure 4.26: **Cohort-year plot for individual land titles**. The outcome variable is the number of individual titles *certificados de derechos parcelarios* per square kilometer. The main independent variable is the timing of exposure to any mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

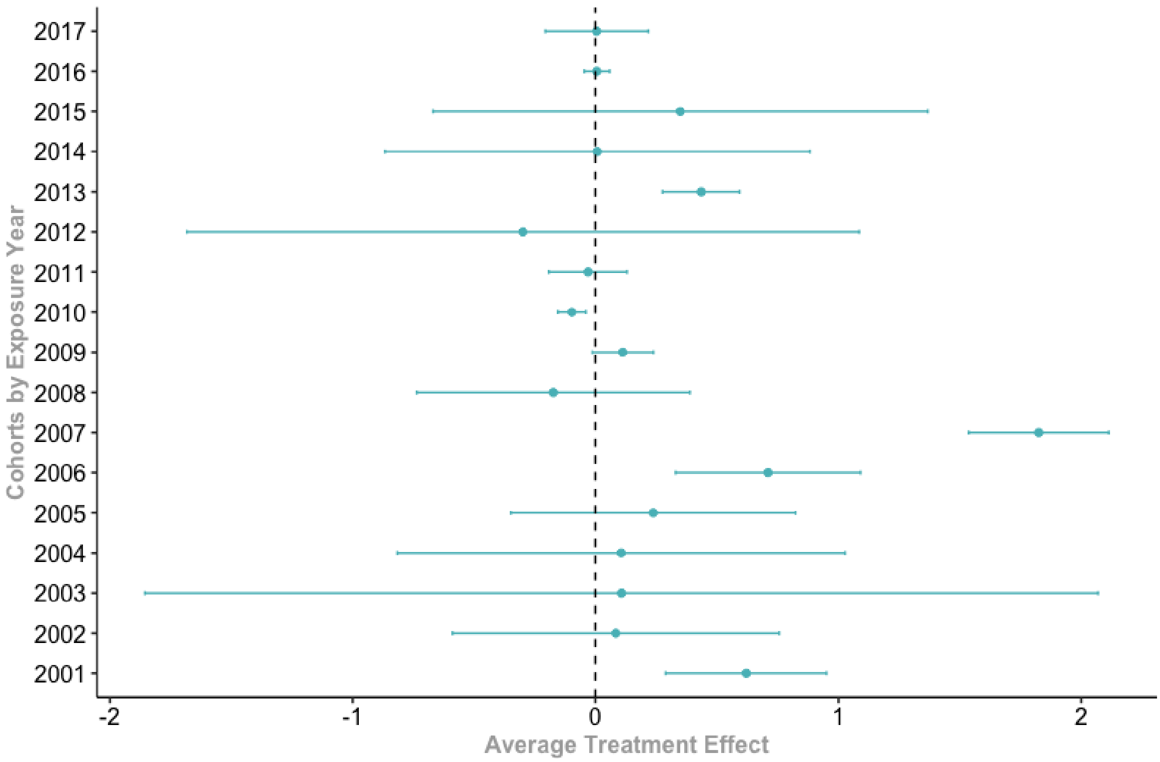


Figure 4.27: **Cohort-year plot for deforestation**. The outcome variable is the rate of tree cover loss. The main independent variable is the timing of exposure to any mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

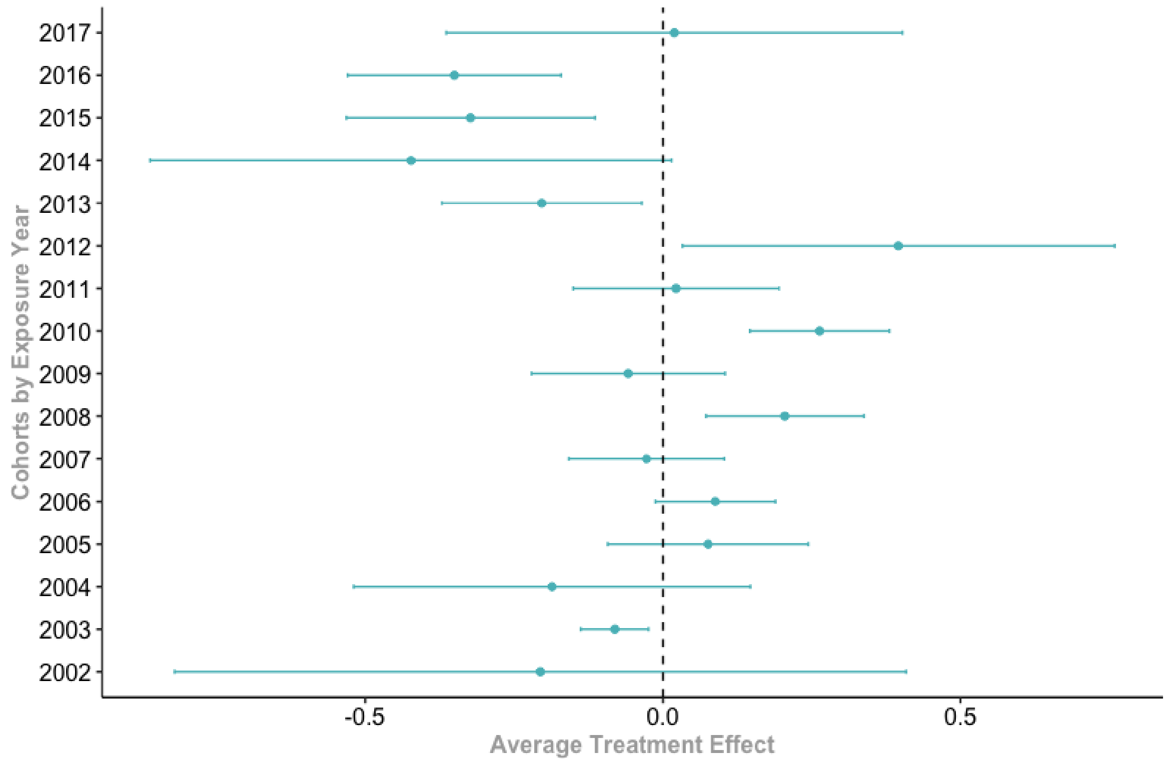
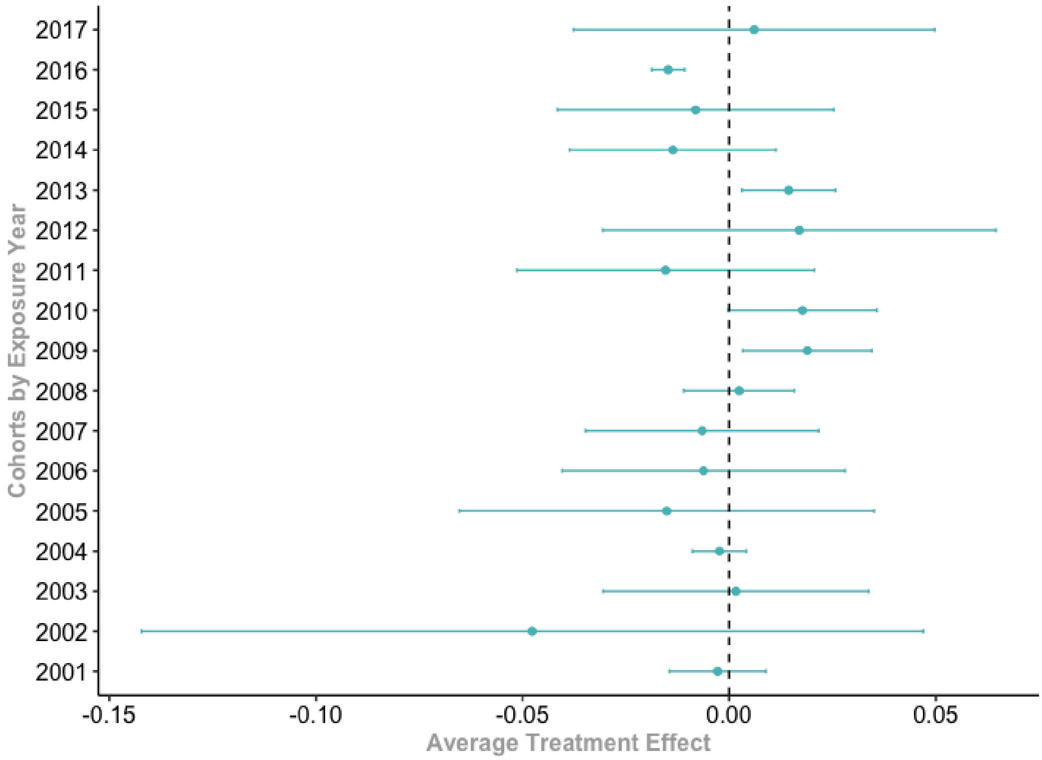


Figure 4.28: **Cohort-year plot for privatization assembly**. The outcome variable is the linear probability of holding a privatization assembly within the community. The main independent variable is the timing of exposure to any mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)



4.7.3.3 Cohort-Year Analysis / Gold and Silver Concessions

Figure 4.29: **Cohort-year plot for nighttime luminosity**. The outcome variable is the rate of tree cover loss. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

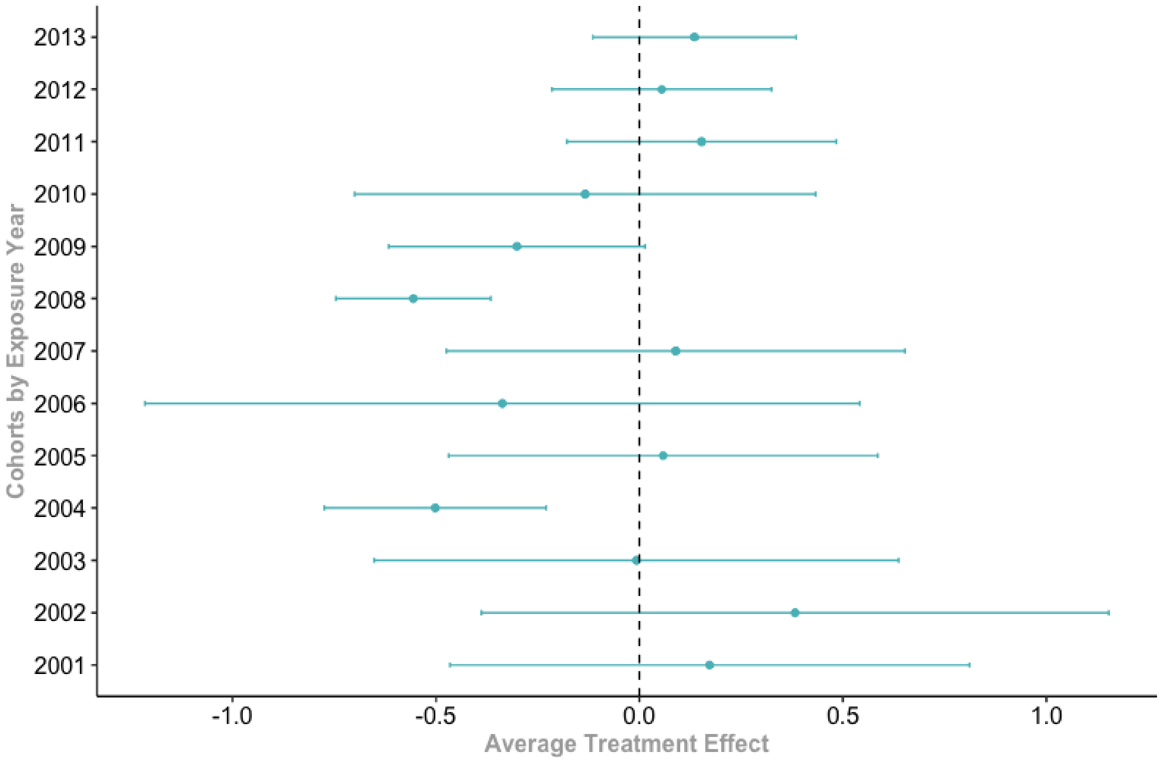


Figure 4.30: **Cohort-year plot for deforestation**. The outcome variable is the rate of tree cover loss. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)

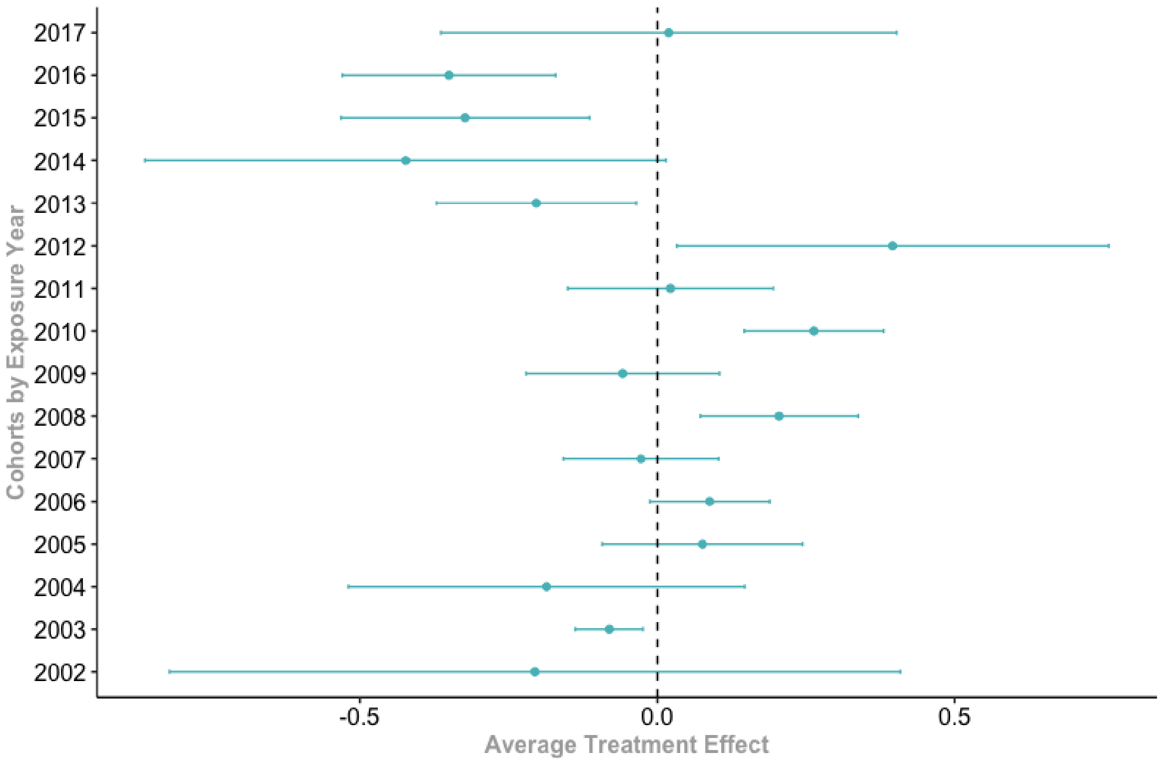
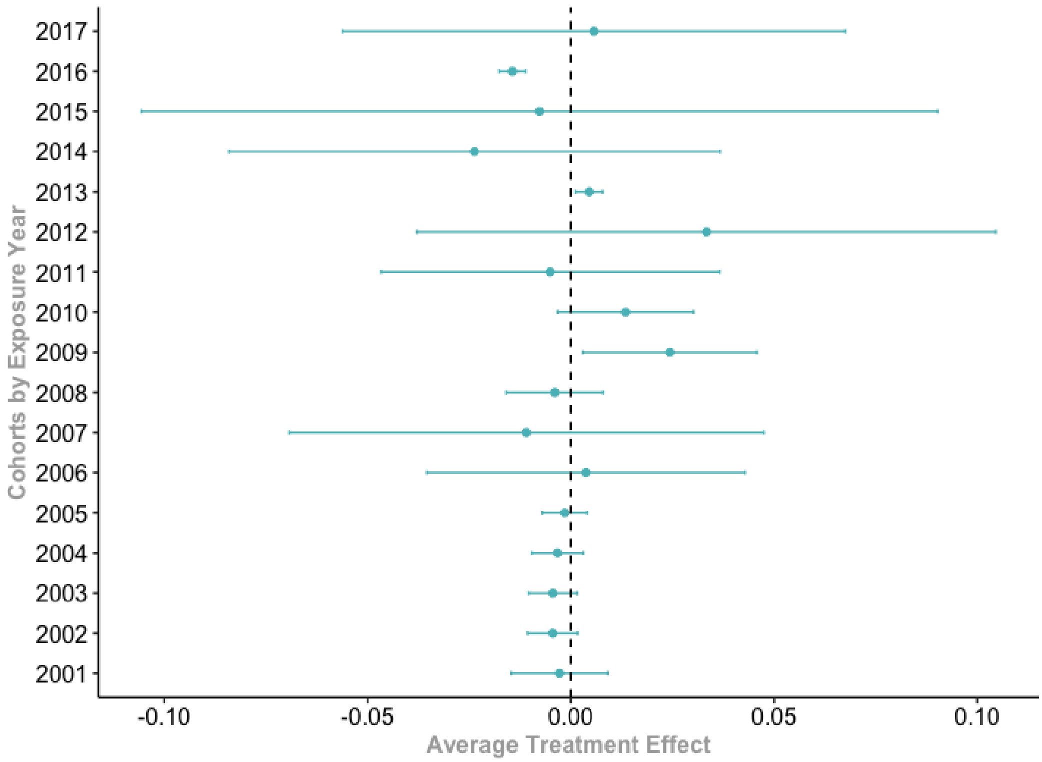


Figure 4.31: **Cohort-year plot for privatization assembly**. The outcome variable is the linear probability of holding a privatization assembly within the community. The main independent variable is the timing of exposure to any gold or silver mining concession. The estimation method uses a staggered differences-in-differences approach following (Callaway and Sant'Anna, 2021)



4.7.4 Additional Tables

	Model 1	Model 2
Log Farming Subsidies (MXN)	1.6794***	
	(0.1338)	
Farming Subsidies (MXN)		0.0015***
		(0.0001)
Village Fixed-Effects	Y	Y
Year Fixed-Effects	Y	Y
Num. obs.	285329	285329
R^2 (full model)	0.1956	0.1955
R^2 (proj model)	0.0009	0.0009
Adj. R^2 (full model)	0.1355	0.1355
Adj. R^2 (proj model)	−0.0737	−0.0737
Num. groups: village_id	19810	19810
Num. groups: year	15	15

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 4.1: **Agricultural subsidies and deforestation**: the dependent variable is the annual rate of tree cover loss. The independent variable is the amount of farming subsidies from the PROCAMPO program received per square kilometer. Both models include village fixed-effects to account for unobservable confounders as well as year-fixed effects to control for shocks common across all communities.

	Model 1
(Intercept)	−1.3102***
	(0.0082)
Share of Communal Lands	−0.0082***
	(0.0002)
R^2	0.0886
Adj. R^2	0.0886
Num. obs.	30121

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 4.2: **Communal Lands and Private Titles**: the dependent variable is the total number of individual parcel titles (*certificados de derechos parcelarios*) per square kilometer. The independent variable is the percent of the community's total surface that communities initially agreed to devote to the commons as opposed to private parcels upon accessing their official land titles.

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