# Oaxaca and global forest governance: Indigenous autonomy, local institutions, and forest outcomes in Southern Mexico

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## Abstract

Oaxaca is the most biologically- and culturally-diverse state of Mexico, and considered by many to be a source of best practices for the role of Indigenous peoples in forest governance. Utilizing an original data set containing census and remote sensing information, I construct a set of empirical tests to assess the impact of indigenous peoples and decentralized local institutions on forest loss in Mexico. Recognizing the great biological and cultural diversity of Mexico, I employ an ecoregion sampling technique to understand trends in different vegetation regimes and to understand better how local institutions influenced forest loss between 2000-2015 by looking within shared watersheds crossing the Oaxacan border. The results indicate that, contrary to strategies based on targeting simply the presence of Indigenous peoples, Indigenous households weakly correlate with forest loss, while Oaxacan autonomous Indigenous municipalities, which retain meaningful influence on local institutions, consistently have lower forest loss across national, regional, and ecoregional samples.

**Keywords:** forests, climate change, REDD+, Oaxaca, Mexico, Indigenous communities, local institutions

## Resumé

Oaxaca est l'État du Mexique le plus diversifié sur le plan biologique et culturel et considéré par beaucoup comme une source de bonnes pratiques pour le rôle des peuples autochtones dans la gouvernance forestière. En utilisant un ensemble de données original contenant des informations de recensement et de télédétection, je construis un ensemble de tests empiriques pour évaluer l'impact des peuples autochtones et des institutions locales décentralisées sur la perte de forêt au Mexique. Reconnaissant la grande diversité biologique et culturelle du Mexique, j'emploie une technique d'échantillonnage d'écorégions pour comprendre les tendances des différents régimes de végétation et pour mieux comprendre comment les institutions locales ont influencé la perte de forêt entre 2000 et 2015 en regardant dans les bassins versants partagés traversant la frontière d'Oaxaca. Les résultats indiquent que, contrairement aux stratégies basées sur le simple ciblage de la présence de peuples autochtones, les ménages autochtones sont faiblement corrélés à la perte de forêt, tandis que les municipalités autochtones autonomes d'Oaxaca, qui conservent une influence significative sur les institutions locales, enregistrent systématiquement une perte de forêt plus faible à l'échelle nationale, régionale, et des échantillons écorégionaux.

**Mots clés:** forêts, changement climatique, REDD +, Oaxaca, Mexique, communautés autochtones, institutions locales

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## Resumen

Oaxaca es el estado de México con mayor diversidad biológica y cultural y muchos lo consideran una fuente de mejores prácticas para el papel de los pueblos indígenas en la gobernanza forestal. Utilizando un conjunto de datos original que contiene información censal y de teledetección, construyo unas pruebas empíricas para evaluar el impacto de los pueblos indígenas y las instituciones locales descentralizadas sobre la pérdida de bosques en México. Reconociendo la gran diversidad biológica y cultural de México, utilizo una técnica de muestreo de ecorregiones para comprender las tendencias en diferentes regímenes de vegetación y interpretar mejor cómo las instituciones locales influyeron en la pérdida de bosques entre 2000 y 2015 al observar las cuencas hidrográficas compartidas que cruzan la frontera de Oaxaca. Los resultados indican que, contrariamente a las estrategias basadas en apuntar simplemente a la presencia de pueblos indígenas, los hogares indígenas se correlacionan débilmente con la pérdida de bosques, mientras que los municipios indígenas autónomos de Oaxaca, que mantienen una influencia significativa en las instituciones locales, tienen consistentemente una menor pérdida de bosques a nivel nacional, regional, y muestras ecorregionales.

**Palabras clave**: bosques, cambio climático, REDD +, Oaxaca, México, comunidades indígenas, instituciones locales

## 1. Introduction

Climate change, and political efforts to address it, are reconfiguring relationships between people and forests, and also between levels of government charged with forest stewardship (Bäckstrand and Lövbrand 2006; Moser and Boykoff 2013). This is especially true in 'developing' countries, which contain the majority of the world's remaining intact forest ecosystems. It is transparently a problem for political ecologists focused on the interrelationship between power, economics, and natural resources (Adger *et al.* 2005; Taylor 2014). This article addresses political ecology debates in forest management in Oaxaca, Mexico from the perspective of evolving international forest carbon institutions and markets.

With mounting evidence of social and ecological challenges brought about by climate change and the advancing efforts to assess and measure carbon emissions and sinks, forests have been recognized as globally important parts of any effort to remove and sequester $CO^2$ in the atmosphere (Busch *et al.* 2019; de Jong *et al.* 2000). This has led to an expanding interest in tropical forests in particular and the kinds of institutional, cultural, and economic prerequisites for successful and equitable management of the resources, environmental services, and conservation goals to which they contribute (Dauvergne and Neville 2010).

Building on national experiments with payment for ecosystem services (PES) schemes, the United Nations and the World Bank are currently beginning ambitious forest carbon plans which seek to transfer resources from 'developed' countries to tree-growing 'developing' areas. The UN's Reducing Emissions from Deforestation and Degradation (REDD+) program and the World Bank's Forest Carbon Partnership Facility (FCPF) see such a transfer as 'win-win'—forests in tropical areas are regrown with funds from 'developed' nations as a way of offsetting costly and time-consuming national emissions reductions. In ideal form, such a scheme would compensate locals, create rival, non-extractive economic value for forests, and at the same time offset continuing and historical emissions.

These programs work by paying farmers for capturing carbon (by ton of $CO^2$ sequestered) and, as such, it is imagined as a reward for results. Just what and how to measure, however, remain controversial. The simplest and cheapest way, measuring only the change in forest carbon, does not address concerns over elite capture and neglects other conservation goals (Caplow, *et al.* 2011; McDermott and Ituarte-Lima 2016). The + on REDD+ was added to reflect these broader goals, a move which both deepened the commitment to community and biodiversity goals, and also, paradoxically, created greater need to strengthen state capacity to monitor, report, and verify (MRV).

Although longer-standing debates remain over the efficacy of PES, community participation, and state capacity for MRV (Bossière, *et al.* 2017; Gupta, *et al.* 2012), there have been many practical experiments with REDD+ (over a thousand by 2015) and, more generally in the sense of payments for forest carbon, through other national-level PES schemes. These examples are important to assess given the place which forest stocks

and avoided deforestation took in the official national accounting regimes, and in proposals for mitigation plans mandated by the Paris Climate Accords.

Mexico has largely been a source of positive examples in the REDD+ assessment literature and further back in debates over PES and community forestry (Bray 2013; Alcorn and Toledo 1998). Southern Mexico, in particular, has a large and diverse population of Indigenous peoples living in and around forests, with varying degrees of recognition of their institutions as well as varying amounts of insulation from national and global forces (Hernandez-Diaz 2006). Indigeneity is also a recognized overarching category of identity, along with European and *mestizo*, and continues to play a role in Mexican politics (i.e. it is a category under active interpretation and debate, not an understanding wholly imposed by outside researchers). This analysis looks at data on Indigenous peoples and forest outcomes in Mexico as a whole, and then at Oaxaca and its neighbors in Southern Mexico through a series of statistical tests to generate an empirical baseline for such theories at the scale of the municipality, the smallest administrative unit in the Mexican system, usually about the size of a US county, containing one major locality, or *cabecera,* and potentially one or more smaller settlements.

Mexico has considerable forest resources, most of which are held in common property regimes through *ejidos* and *nucleos agrarios*, institutions for management of common property recognized in the Mexican constitution (Klooster 2003; Gonzalez 2012). These communal institutions became central to forest management in the 1980s, where national government logging concessions were largely devolved back to municipalities, *ejidos*, and regional community forestry initiatives (Chapela 2005; Corbera *et al.* 2009). Mexico has thus been positioned by this early experience to take advantage of developments in international forest payment regimes, and has become one of the central pilot locations of REDD+ and other carbon-forest transfers (Libert-Amico and Trench 2016; Rantala *et al.* 2014).

The Mexican experiment has largely been seen as successful, especially compared to other developing regions in Africa (Beymer-Farris and Bassett 2012) and Southeast Asia (Kashwan 2015; Larson and Petkova 2011), both in terms of slowing deforestation and in terms of meaningful local participation (Ramirez Reyes 2018; Garcia-Lopez 2019). In particular, the southern Mexican state of Oaxaca, simultaneously the poorest state in Mexico and the most culturally and biologically diverse, is seen by many as presenting a potential model for global forest conservation and, now, forest carbon PES (Bray, *et al.* 2006; Barsimantov and Kendall 2012).

This is, however, a tricky set of lessons to generalize, given the particularity of the Oaxacan experiment, even within Mexico itself. This is because Oaxaca has a unique form of local governance which is recognized by the state and national level governments in Mexico, called *usos y costumbres*, or traditional governance. *Usos* is more than the *ejido*, or common property arrangements, although in practice it is tangled with it—*usos* systems, while very diverse, ban political parties and set up parallel assemblies for decision-making alongside the standard municipal government positions (Hernandez-Diaz 2007). Close to 4/5 of Oaxaca's nearly 600 municipalities chose this system by referendum after a change in the state constitution made it legal in 1994. It was an option only possible by referendum in communities with pre-Columbian descent, agreeing on a single set of *usos y costumbres* (thus often ethnically homogeneous and rarely in large cities), and only within Oaxaca.

This article leverages the special nature of Oaxacan municipal governance to understand the relationship between Indigenous peoples, local institutions, and forest loss as a set of potential lessons for the implementation of REDD+ and other carbon PES accounting schemes in Southern Mexico and more broadly in the developing world. It does so by analyzing municipal forest outcomes between 2000-2015 and their relation to the percent of self-identified Indigenous households in the municipality, first across Mexico and second across the borders of Oaxaca and neighboring municipalities in other states of southern Mexico.

In this sense, there are two questions presented in the course of the narrative about Mexico and Oaxaca: 1) a primary question about how we measure where Indigenous people are located and 2) whether autonomous local institutions perform better on forest outcomes than similarly Indigenous areas without recognition. The article proceeds roughly in this order, by thinking about the concept and measurement of indigeneity in Mexico through an initial sample of all Mexican municipalities, comparing the household- and language-based indicators to municipal forest loss, then focusing in on a more institutional question through the specific study of forest loss and municipal autonomy regimes in Oaxaca and their comparison with municipalities in neighboring states. Whether households or language are better indicators, areas with recognized local

sovereignty had measurably less forest loss, taking into account other relevant demographic and ecosystem indicators.

To better compare like ecosystems and groups of people, I test at both of these scales by political boundaries, then conduct each test by ecoregion, first assessing municipal forest loss and indigeneity across Mexico by biome (forest type) and, later looking across municipalities by watershed along Oaxacan borders. The empirics here support claims in both practitioner and critical research that empowered local communities with meaningful forms of participation, as often found in Indigenous communities in Oaxaca, can become meaningful players in evolving nested and multi-level forest carbon institutions (Iniciativa Comunidades 2011; Kashwan and Holahan 2014).

At the more granular scale of municipalities in southern Mexico, Oaxaca itself is far from homogenous, recognizing 16 Indigenous languages and housing a great amount of linguistic, historical, and cultural diversity. This diversity is in itself an interesting question, since the uniqueness of the Oaxacan experiment has implications for how its lessons generalize, which is essential for understanding their contribution to debates over climate reforestation goals and PES schemes like REDD+. The diversity of the Oaxacan institutional experiment and the biological richness of Mexico, however, also give researchers tools for gaining more interesting insights into the conditions for success of REDD+ (rather than simply whether it is a bad idea or not in theory) and better empirical tools for comparing similar groups by the kinds of resources and ecological services their particular forest biomes provide.

To understand what such a more detailed subnational and ecosystem-based sampling can yield, I am asking two fairly straightforward empirical questions—1) do municipalities in Mexico with more Indigenous households or speakers of Indigenous languages have less forest loss? and 2) do municipalities of Mexico with recognized local government have less forest loss?

These results show that, in a national survey of municipalities, Indigenous households are actually weakly correlated with *more* forest loss, a contradictory finding and a puzzle for narratives relying on the presence of Indigenous peoples (measured as households or speakers of Indigenous languages) as necessary and sufficient conditions for successful forest management, rather than focusing on their influence over politics and management of resources. This is crucial to think in these more contextual terms since any successful PES scheme will rely on them to translate investment and theoretical promise into meaningful climate goals and empowered, healthy local communities. While the regional samples demonstrate a great diversity of experience within Mexican Indigenous communities and across dominant forest biomes, the results here indicate that empowered local institutions are more reliably correlated with better forest outcomes.

## 2. Oaxaca, forests, and REDD+

The central organizing question of this article is the relationship between Indigenous peoples and local institutions, and how this relationship affects the accomplishment of social-ecological goals like carbon sequestration and PES through reforestation. This question is important to understand better for several reasons related to democratization, decolonization, economic development, public service provision, and fiscal authority (amongst others). It is also key to understanding how political decentralization affects ecological outcomes, which themselves are tied to social goals and human security (i.e. 'sustainable development' or 'ecological services').

The question also has a very practical edge—given that industrialized nations may arguably owe assistance to developing regions based on historical responsibility for carbon emissions and the unequal benefits of ecological extraction, how and at what level of government can such funds be spent effectively to achieve desired carbon sequestration, strengthen ecological resilience and biodiversity, and to provide the social co-benefits and integrated landscape planning strategies necessary to make them the 'win-win' that some in the academic and practitioner literature claim they could be?

In the case of PES for forests like REDD+ and the World Bank's FCPF, this bears directly on the pragmatic question of who to pay for results, and at what scale to establish the technical competency to account for and manage forests. This problem has been with REDD+ and most international conservation funding programs since the beginning. Given corrupt officials and orthogonal national development goals, should the

nation-state be the beneficiary of such payments? If not, can local communities develop the technical skill to create baselines and monitor progress? Initially, forest regeneration was seen as a cheap and efficient way of mitigating carbon emissions (Lederer 2012; Turnhout *et al.* 2017), and although there has been growing acknowledgement of the complicated social-ecological processes involved in this strategy (Bremer *et al.* 2014; Garcia-Lopez and Antinori 2018), so too has the urgency of addressing climate change after decades of inaction. As such, growing acceptance of forests as mitigation strategies has been catalyzed by inclusion in the landmark Paris Climate Accords in 2015 (Muller 2016; Corbera and Schroeder 2017).

Forest carbon payment programs were introduced as a compromise between rich and poor nations early after the UN Framework Convention on Climate Change (UNFCCC) meetings in 1992. REDD+ in particular is seen as a compromise between Annexes of the Conference of the Parties (COP) of the Kyoto Protocol, and, beginning at COP 11 in Cancún, as a way of activating the Clean Development Mechanism (CDM) introduced by the Kyoto Protocol (Allen and Dauvergne 2013). From early formalization it has been seen by many in the 'developing' Annex as a way of keeping forests (and the ecological services they provide) healthy while addressing issues of global inequality. This has been controversial—many see payment for forest carbon as an expansion of the state and 'carbonization' of forests to the exclusion of use rights for forest-dependent communities and other conservation goals like biodiversity and native species protection that might be ignored in a purely carbon-focused forest PES program (Corbera 2012; Ribot, *et al.* 2006; Bee 2019).

Mexico in general and Oaxaca in particular are interesting settings for understanding the relationship between these theories and assessing their practical effects on forest outcomes. The question approached here is whether targeting programs to areas where Indigenous peoples live, or their languages remain spoken is sufficient. By moving to the municipal scale and utilizing new sampling techniques based on ecological situatedness, the tests below highlight contexts (both institutional and ecological) within the Mexican and Oaxacan experiences that can be compared to similar institutions, biomes, and other watershed-based sampling in other national contexts. In focusing on the borders of Oaxaca, where similar Indigenous groups and continuous forests spill across political boundaries, the strongest argument for the importance of recognized, autonomous, local institutions is generated.

In Mexico there is a long history of community management of forests by Indigenous peoples, first in *de facto* ways during colonial rule and the era of private forestry concessions throughout most of the 20th century, and since the 1980s in resurgent forms of recognized community forestry enterprises (CFE) which include mandates for integrated planning and regional forest institutions that involve serval communities as stakeholders alongside NGOs, the state, and national governments. This is supported by the *ejido*, a form of communal property enshrined in the Mexican constitution which creates deliberative institutions to manage, distribute, and regulate common land.

In Oaxaca, the Mexican state with the highest percentage of Indigenous peoples as well as the most biodiversity, these common property institutions are supplemented by and organized around autonomous municipal governments operating on *usos y costumbres*, a status which was recognized officially by the Mexican state in 1994 and accepted by referendum by 4/5 of the nearly 600 municipalities in Oaxaca. The form and content of *usos y costumbres* varies drastically based on the particular norms of the community, which, in Oaxaca could be one of 16 recognized ethnic groups with pre-Columbian descent and their own language. *Usos* communities, however, do have a common structure—they ban parties from participation in elections, limit the sale and financialization of land, have a parallel municipal assembly selected by traditional methods, and create community work roles as a prerequisite to running for mayor and other municipal office.

Thus, Oaxaca contains a unique kind of institutional experience in the Mexican context which is especially interesting to political ecologists because it also contains a significant amount of forest ecosystems and, conversely, a diverse set of Indigenous peoples working to understand how to express local customs through the common autonomy framework. The planning document created for REDD+ in Oaxaca in 2011 is particularly illustrative of the possibilities this opens. It stresses participation of locals and reinforcement of existing institutions and norms (Kanowski, *et al.* 2011). Because Mexico is an important pilot site for REDD+ and a pioneer in CFE and forest PES since the 1980s, finding generalizable lessons from the Mexican perspective for global debates is vital. Because Oaxaca is the only state where local institutions are

'autonomous', the internal variation within Mexico itself and across forest biomes offered here may help analysts disentangle Indigenous and local institutions.[2]

As Indigenous movements become more internationally powerful and active and gain rights to consultation and language, and, in parallel, the urgency of mitigation and adaptation in the face of climate change grows, understanding the relationship between Indigenous and local priorities in global forest carbon schemes becomes more important and globally-relevant to decisions about funding, co-benefits, and MRV in REDD+ and other forest carbon PES schemes. Few are opposed to paying to offset greenhouse gas emissions by planting trees—the debate is really about the feasibility of realizing such programs, their co-benefits for local forest users and ecosystem resilience, and the side-effects of thinking of forests as capital. That such regimes, even before REDD+, have succeeded and become best practices in Oaxaca is both interesting and complicated to interpret in the context of other places.

While the Oaxacan example is particular, and in some ways impossible to replicate even in Mexico, the diversity of *usos* in practice and the differential outcomes across Oaxacan borders (despite the continuity of ethnic groups and watersheds) point to the importance of local institutions as building blocks for legitimate and participative forms of nested institutions evolving to deal with forests and climate change. More than simply common property, as in the *ejidos* of the rest of Mexico, Oaxacan municipal autonomy places the importance of recognized local sovereignty that any global REDD+ strategy balancing state capacity for MRV (at multiple scales) will require centrally, with the flexibility to adopt existing institutions and norms in a local context.

That such nested, multi-level, and at times polycentric institutional relationships either already exist or may be inevitable as responses to climate change, makes the Oaxacan example both interesting and important relative to both the rest of Mexico and to radically different political contexts with similar ecological characteristics around the world. The particular content of Indigenous systems evolving over time in southern Mexico is not strictly replicable. But this focus on creating institutions that allow for the expression of Indigenous norms while addressing issues of state capacity necessary to measure, report, verify, and sanction also stresses the need for such nested institutions to be organized around strong local and regional governance, implying a principle of subsidiarity, or solving issues at the lowest scale possible.

Unlike much of the forested world, Oaxaca has few official national conservation areas. This does not mean that there are no protected areas, however. Forests are largely inhabited, usually by Indigenous and rural communities (Hayes 2006). This presence both complicates simple top-down conservation of parks, which often assumed or enforced 'people-less' protected areas, and provides potential lessons for REDD+ implementation, as Indigenous areas are often characterized by communal property, long-standing land tenure, and forms of traditional governance that stress participation and stewardship. Responding to criticism of REDD+, the UN has attempted to build in safeguards for local participation and enhanced focus on co-benefits and the livelihoods of forest peoples (the + in REDD+), which, following the UN Declaration on the Rights of Indigenous Peoples (UNDRIP 2007), emphasizes the central role of Indigenous peoples and a need for consultation and co-management in conservation planning and implementation (McGregor, *et al.* 2014; Milne, *et al.* 2019).

This emphasis on Indigenous peoples is potentially confounding as well. If resilient social-ecological forest outcomes depend on the presence and influence of Indigenous people, how might best practices be reproduced in places without this cultural inheritance? If such membership is *all* that is necessary, why do we continue to see degradation and deforestation in areas populated by Indigenous peoples around the world? REDD+ is both a response to this precarity and a statement about the potential of such communities, which may at first seem paradoxical. To understand the differences in outcomes within and between Indigenous communities, as well as to think about the potential generalizability of any individual forest governance regime to other places, we may need to instead look at institutions, and in particular the capacities to monitor, report, and verify and how these practices engage and utilize local norms. This concern, crucially with regard to the

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[2] By this I mean that *ejidos* are spread throughout Mexico, and especially in southern Mexico. The difference produced by formal recognition and banning of parties may be more easily discernible where like groups (operating *ejidos* on both sides) straddle a border with Oaxaca where one side had the ability to choose an autonomous system).

global changes entailed in climate change, is multi- and cross-level in nature, and includes the national state, local government, and regional coordinating bodies.

While REDD+ has been controversial, it has also entered the mainstream of international climate politics post-2015 Paris. Once seen as a 'cheap and easy' solution, PES for forests now must tackle a wealth of interrelated problems—instead of simply assigning protected status to parks and monitoring how they grow trees, REDD+ now has to think about the people living there, both to attend to their social development and more global changes related to climate change and biodiversity loss. That these problems have been increasingly recognized as complex is one reason why Indigenous and local institutions have often been amalgamated by REDD+ proponents. This is important—Indigenous peoples control or live in areas with more forests and often have more participatory and local institutions. For a variety of potential reasons, however, the promise of Indigenous communities for managing globally important resources is not always realized.

Clearly, the presence of 'Indigenous' peoples is not necessary and sufficient in itself in some overarching cultural sense (it obscures the diversity of groups under the umbrella term) or in the institutional sense (which assumes they always have effective local governance). This article looks to tease apart and understand the relationship between Indigenous and institutional currents supporting PES like REDD+, so it is worth briefly outlining what these terms will mean in the context of this article. The term Indigenous can have a very ambiguous reference, especially in areas with no clear 'first people' or colonial 'other' that amalgamates groups. It is often used in 'developed' countries in a racialized and cultural way, in practice coming to represent an oppositional ideal to Western/Northern societies and ways of life. Despite the ambiguity of the term, Indigenous peoples have increasingly become relevant in politics in the developing world and with reference to environmental politics especially. In the Western/Northern tradition of green thought, Indigenous peoples were often romanticized as 'closer to the land' or 'unpolluted by industrial society,' a designation which is both praising and patronizing to the people it refers to (Snyder 1974; Acosta 2016).

Beyond such 'noble savage' narratives, some commentators have focused on the philosophical worldviews or practical engagement over time with particular ecosystems as potential models for re-imagining industrial green politics, or as a pragmatic lesson for crisis times in which people and communities will of necessity live in closer relationship with the land or perish, a kind of 'defensive localism.' Indigenous systems and communities are often seen as highly vulnerable, but as an inspiration for community management and a change in worldviews (Berkes 2017; Gudynas 2011; Viveiros de Castro 1998). A parallel kind of interpretation, that I follow here, focuses on the institutions that these social contexts might produce. This is a pragmatic move—it is hard to perceive worldviews (and we are prone to romanticize them) and institutions are potentially reproducible in other places (where the specific context, history, and norms of particular Indigenous peoples are not). This current of thought draws heavily on common pool resource economics, which focus on legitimacy, trust, and MRV capacity and show that many communities which a few 'modernist environmentalists' would call 'backwards' actually have resilient institutional solutions to environmental management (Ostrom 1990; Anderies *et al.* 2004; Nagendra and Ostrom 2012).

Importantly, neither of these arguments, vulgarly cultural or institutional, precludes the other, *per se*. A more institutional interpretation stresses the role of participation in creating legitimacy in the formulation of the 'rules of the game', but it does not devalue the potential contribution of Indigenous communities—it also stresses the efficiency of local people in creating relevant and effective systems of monitoring, sanctioning, or enforcement. By separating them in the abstract here I only emphasize a) differences in their strategies for reforestation and b) that the generalizability of the institutional argument (in spite of the path dependence of any one example) becomes more plausible as the diversity of experience is explored in more granular detail.

In the tests that follow, I first think briefly about how to measure indigeneity through the lens of municipal household data from across Mexico, then put those indicators (household and language) into conversation with forest type and municipal forest loss data for 2000-2015. Investigating the surprising results of Oaxacan municipalities in greater detail, I then move to look at Oaxaca and its neighbors, ending with a comparison of similar groups within cross-border watersheds.

## 3. Evidence

The tests conducted here utilize an original dataset of social and ecological factors constructed from remote sensing of forests between 2000-2015 and data from the national Mexican and state of Oaxaca governments, to try and understand the relationship between Indigenous communities, local institutions, and forest outcomes.[3] The two basic hypotheses of this effort follow from these positions described above: 1) that if theories focused on the presence of Indigenous peoples are primary, we should expect that areas with more self-identified Indigenous households and active speakers of Indigenous languages to have less forest loss; and 2) that if robust local institutional elements are also important, we should expect that municipalities in Oaxaca, which recognizes Indigenous autonomy at the municipal level, should have less forest loss than similar Indigenous areas in other states of southern Mexico.

Each of these hypotheses has a sub-test demonstrating the potential of ecoregion sampling for modifying the analysis, in the first case testing for Indigenous households nation-wide across dominant forest types; in the second case testing for relative correlation of *usos* and *partidos* systems with forest loss within watersheds that cross the Oaxacan border. Thus, the analysis becomes more specific and fine-grained with each iteration. After explaining the data and methods I do two general tests, each with an additional run based on the ecoregion sampling technique. First, I query the relationship between self-identified Indigenous households and forest loss across the universe of Mexican municipalities. I then look within these national trends by forest biome type, both to put together like groups by dominant forest type (important because some are exploitable commercially, i.e., useful in CFE, and others are not, some are vulnerable to fire and others not, etc.) and to further target future research in particular areas and forest types. This type of sampling also helps to understand differential carbon content and rates of growth of native trees, both of which are important for REDD+ and other pay-for-forest programs.[4]

In the second test I focus on Oaxaca in particular, first looking at how Oaxacan autonomous municipalities compare nationally to other municipalities and then within southern Mexico, then analyzing relevant differences between municipalities sharing watersheds that cross the borders of Oaxaca into the neighboring Mexican states of Guerrero, Puebla, Veracruz, Tabasco, and Chiapas. Groups within these watersheds share bioregional settings and contain similar ethnic groups, further establishing the similarity of municipalities *except* for recognized Indigenous governance. The results are interesting and show that *usos* is significantly correlated with less municipal forest loss, while the percentage of Indigenous households is actually weakly associated with *more* loss. That the *usos* remains significant across the different samples and tests indicates the central importance of empowered local institutions, and implies that generalization from the example of Oaxacan local institutions (and not a blanket category of 'Indigenous') is possible and potentially meaningful for global debates like those surrounding REDD+.

*Data*

Data used in this analysis comes from four primary sources:

**A and B:** Demographic information and shape files for municipal and state limits in GIS came from INEGI, principally from the 2000 and 2010 Mexican census. Information from the Oaxacan Elections Institute about municipalities with *usos y costumbres* has been appended to these files, coded as 1 for recognition of Indigenous autonomy and 0 for municipalities on the party system of governance.

The first test is about the relationship between areas with greater populations of Indigenous peoples and the rate of forest cover loss (Figure 1). Municipalities in Mexico are of varying size, but usually around the size of a county in the US. They are also numerous, over 2,000 in Mexico on a whole (of which Oaxaca contains

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[3] It is clear that the years before and after the transition to *usos* in 1994 would be a preferable period, however, the limits of municipalities in Oaxaca are too small to capture relevant details from older satellite imagery. While these kinds of analyses could be done at the state level, this would hide the internal variation at the municipal scale within Oaxaca which I am attempting to leverage.

[4] For instance, pines on average grow much faster and thus are preferred by many tree farmers, even though they contain less carbon, are more susceptible to fire, and are largely inappropriate for planting in most tropical wet broadleaf forests relative to other native choices.

almost a quarter), and may include more than one population center. At this municipal level many urbanized municipalities have very little coverage, as seen on the plot below. I omit municipalities with under 10% coverage, eliminating the long tail in the Initial Coverage plot.

**Municipal Coverage Lost**
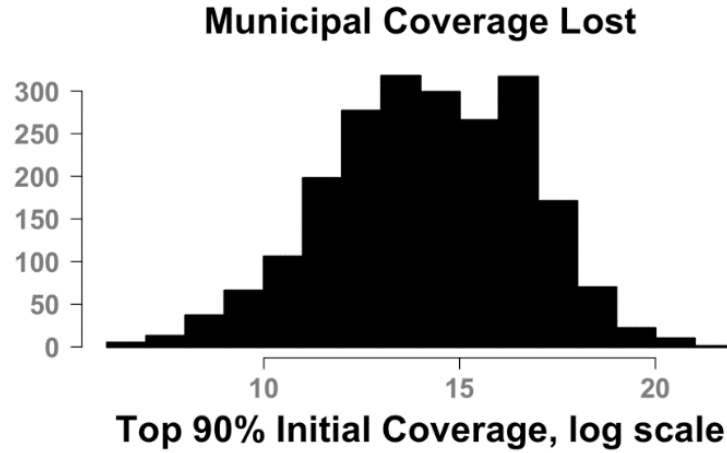


Figure 1: Municipal coverage lost across Mexican municipalities.

Measuring Indigenous identity in Mexico is a delicate endeavor. Households and language are highly correlated in the census data—that most of the mass of the plot in Figure 2 falls below the correlation line is evidence of mixed language households. This shows that measuring the presence of Indigenous peoples with the language criteria do not include all individuals who claim an Indigenous identity.

**Ind. Households and Language**



Figure 2: Comparing 2010 Mexican census data on Indigenous households and Indigenous language spoken.

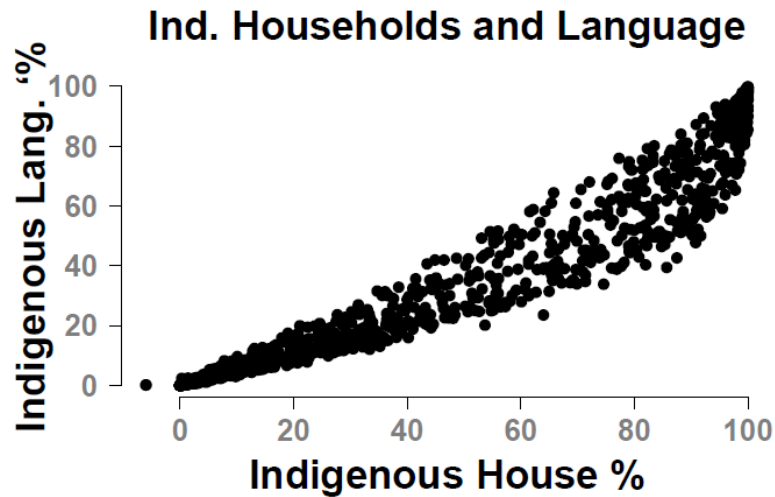Across Latin America, 'indigeneity' has a somewhat narrower, if still contentious, definition than its application in Africa, Asia, and Europe. This relates indigeneity to pre-Columbian peoples, making the term both racial in a broad sense of descendants of peoples living prior to European colonialism, and not necessarily tied to continuing use or vibrancy of a language (although they are certainly related). This is why I use the self-identified percentage of people living in Indigenous households rather than language indicators in the rest of this study. Field work in Oaxaca carried out by the author, and this broader data sample, show that many areas still self-identifying as 'Indigenous' and still sorted from the outside as racially or culturally 'Indigenous' do not always retain their languages.[5] Regardless of which indicator for measuring indigeneity is selected, Oaxacan *usos* communities with recognized autonomy have measurably less net loss, so this contribution of the article is not dependent on this choice.

**C:** Forest data from the University of Maryland associated with Hansen *et al.* (2013) is publicly available for download in 10x10 degree tiles at 30-meter resolution and accessible as a continuous raster through the GoogleEarthEngine working GUI, which the author accessed with permission as a registered developer. This data does relatively better in forested regions than deserts, as it codes forest coverage as 5m tall canopy closure. It also records all loss, including forest fires, which are more prevalent in certain vegetation and climate biomes (such as Baja California's unique-to-Mexico Mediterranean climate), a trend which shows clearly in the national loss maps.

Forest loss remote sensing data was accessed via agreements with NASA and USGS through the LANDSAT satellite remote sensing system, and includes initial coverage scored from 0-100, total forest gain over the period, and yearly loss and gain totals (Hansen, *et al.* 2013), which I aggregate to a net percentage lost, resulting in a net gain in some areas over the period. All forest data was accessed through the GoogleEarthEngine code editor API, reclassifying initial cover to a 0,1 dummy at a 25% threshold. Using GoogleEarthEngine allows for easier analysis at the national and international levels as it eliminates the need to download enormous raster files in overlapping tiles.

**D:** Finally, I utilize data from the World Wildlife Fund/Nature Conservancy ecoregions project, first their Terrestrial Ecoregions, which have been sorted into categories based on dominant vegetation type to compare like communities and compute contributions to carbon sequestration which have become important to programs like the UN REDD+ (Olson, *et al.* 2001; Abell, *et al.* 2008). I also use their Freshwater Ecoregions project to sort municipalities within and across the Oaxacan border to better understand in what regions *usos* performs better or worse against Indigenous household information and the relative influence of roads and initial cover. As many Indigenous groups share watersheds that cross political borders, this allows a better comparison of like groups while allowing for targeted follow up research on why certain areas do better or worse, or why some particular element of some *usos* systems is important to explaining the internal variation within Oaxaca and across its borders.

*Methods*

Because the Hansen forest data is in 30-meter square blocks, measures of initial cover percentages based on more exact area measurements from official INEGI shape files at times appear as more than 100% in the data, in fact up to a maximum of 124%. This is pronounced in coastal areas due to the higher detail of the .shp polygons limits files, tracing fractal coastlines. Because the measurement scheme is the same over time, this discrepancy does not affect the location of estimates. It was checked to see if results persist when these municipalities are excluded, and .14% of municipalities that have such greater percentages are listed in Figure 6 for transparency.

After accounting for the initial forest cover percentage, the key dependent variable in this analysis is the Net Percentage of Forest Lost (Figure 3), a measure produced by subtracting municipal zonal statistics of total

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[5] Zapotecs in the Oaxacan central valleys region, for instance, have lost more speakers and have fewer people who do not speak Spanish compared to Mixe and Mixteca regions in more remote locations—both are Indigenous, but with different and specific identities and experiences of the term.

gain from total loss measures derived in GoogleEarthEngine from the Hansen forest dataset, then dividing the result by initial cover. This net loss percentage helps to understand effects of loss across municipalities of different sizes, but does create major outliers in urban environments and other places where very little initial cover is registered. In order to address this, I exclude all municipalities with under 10% initial coverage from analysis, because if these areas are not 'forested' in any meaningful sense, the theory cannot be plausibly tested.



## 2000-2015 Net Forest Loss by Municipality Percent of Initial Cover

Net Forest Loss Rate
- -5.889 - 0.003
- 0.003 - 0.009
- 0.009 - 0.021
- 0.021 - 0.063
- > 0.063

Haines
Source: Hansen/UMD/NASA/USGS, INEGI
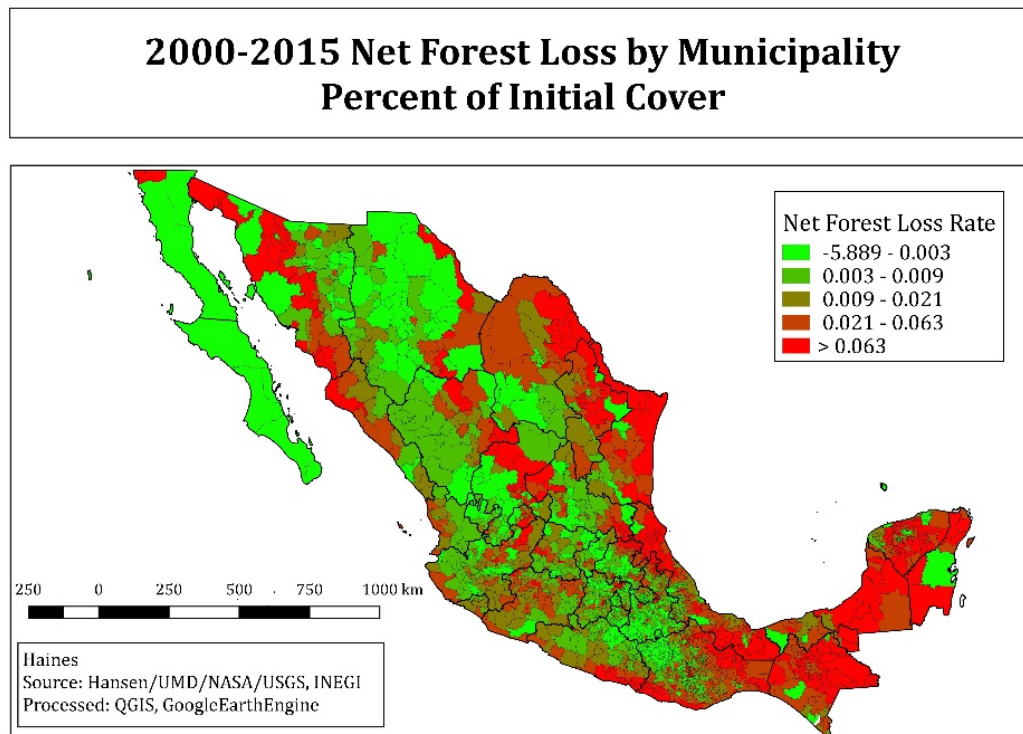Processed: QGIS, GoogleEarthEngine

Figure 3: Forest loss by Mexican municipality.

In part because forest loss has been shown to be highly influenced by environmental variables and in part because comparison across forest biomes may provide more interesting generalization and targeted future work, I refine each hypothesis by terrestrial and fresh water ecoregion (Figures 4 and 5), first by looking across municipalities with similar vegetation types to account for differential fire and regrowth rates, and second by looking at the difference between municipalities within the same watersheds across the Oaxaca border. These ecosystem-based samples give a finer grained understanding of the quantity of carbon stored or released by particular forests, also allowing for methods that sort similar ethnic groups that are likely to share watersheds in many areas of southern Mexico.

I then perform these two tests and two subtests across the different political- and ecosystem-based samples of Mexican municipalities, using OLS regression to understand the relationship between dependent (forest loss) and independent variables (Indigenous households and autonomous institutions), alongside key covariates like initial cover, presence of a federal free highway, and several other basic demographic indicators such as population. The results of these analyses follow.
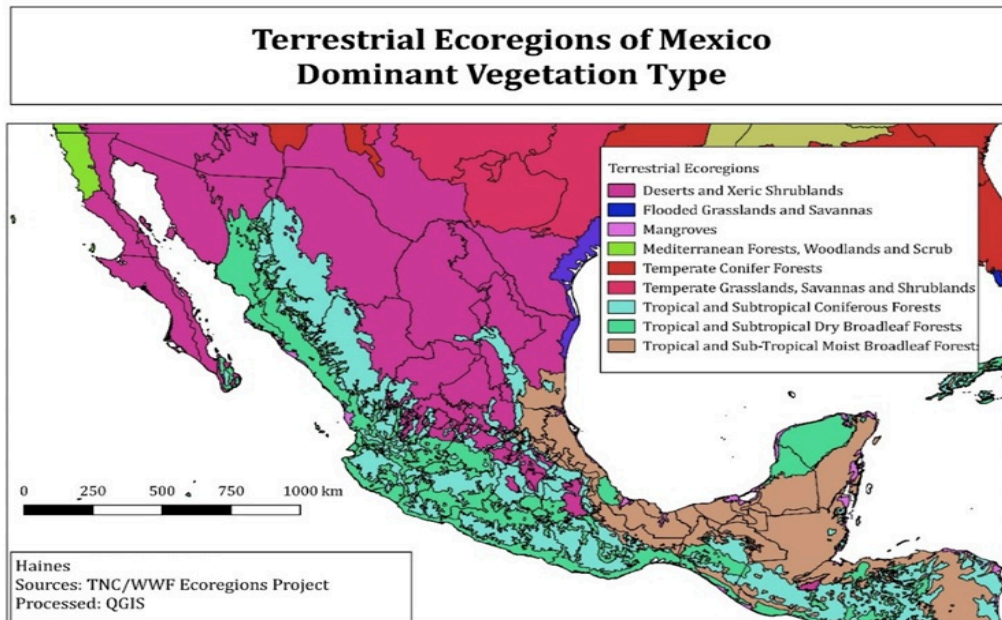
Figure 4: Terrestrial ecoregions by dominant forest type with Mexican state borders in black.
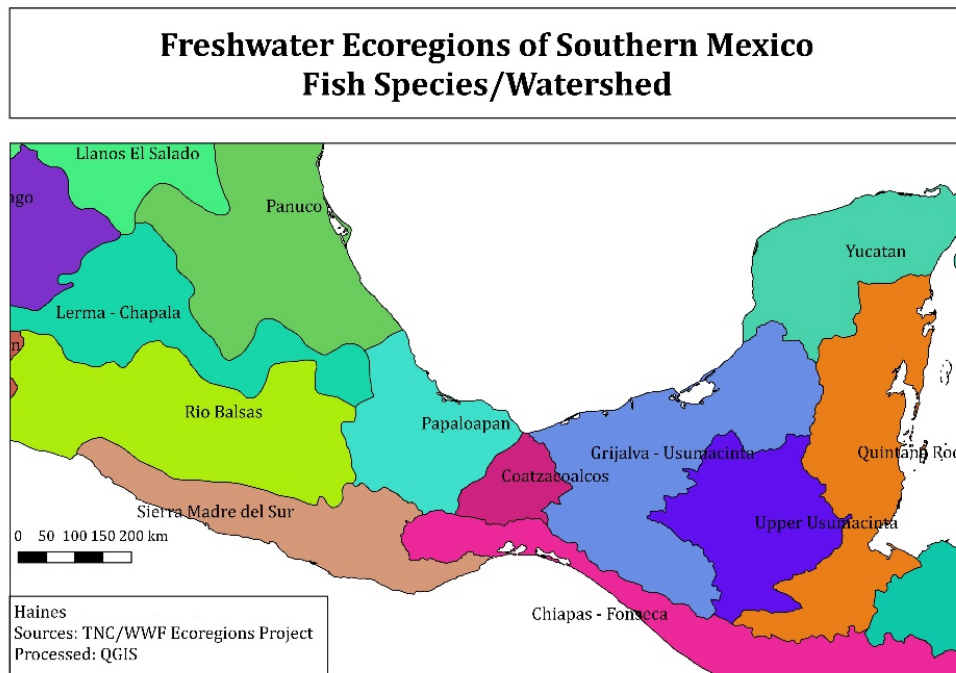


Figure 5: Freshwater ecoregions of Southern Mexico by watershed and fish species.

## 4. Results

Forest loss was not evenly distributed across the states of Mexico (Figure 6). Areas of Southern Mexico, including Oaxaca, experienced greater loss rates than desert regions, in particular. This is partly because vegetation in desert/xeric areas does not always reach the 5m threshold for cover in the Hansen data. It is worth noting that the fact that Baja California stands out on the map is due primarily to fires, rather than land use change or human exploitation. Another obvious reason is the economic value of the kinds of trees growing in these areas and, further, the relative disempowerment of local communities *vis a vis* national and corporate interests. Oaxaca contains some of the tropical forests most impacted by each of these trends but shows different trends from the rest of Southern Mexico. This shows that there is a greater diversity of forest ecosystems there (and indeed much of the gain noted comes from non-tropical forests), and better governance of similar resources. I try to focus on the second one of these insights in the cross-border, within-watershed tests, and the results show the continued influence of autonomous local institutions.

Table 1: More than 100 Percent Geos

| State | More Than 100% |
|---|---|
| Aguascalientes | 0 |
| Baja California | 0 |
| Baja California Sur | 0 |
| Campeche | 0.364 |
| Chiapas | 0.356 |
| Chihuahua | 0 |
| Coahuila | 0 |
| Colima | 0.100 |
| Distrito Federal | 0 |
| Durango | 0.051 |
| Guanajuato | 0 |
| Guerrero | 0.012 |
| Hidalgo | 0.250 |
| Jalisco | 0.024 |
| Mexico | 0 |
| Michoacan | 0.027 |
| Morelos | 0 |
| Nayarit | 0 |
| Nuevo Leon | 0.020 |
| Oaxaca | 0.174 |
| Puebla | 0.152 |
| Queretaro | 0.111 |
| Quintana Roo | 0.778 |
| San Luis Potosi | 0.190 |
| Sinaloa | 0.111 |
| Sonora | 0 |
| Tabasco | 0 |
| Tamaulipas | 0.047 |
| Tlaxcala | 0 |
| Veracruz | 0.146 |
| Yucatan | 0.660 |
| Zacatecas | 0 |

Figure 6: Percentage of initial forest cover lost between 2000-2015 by state. 'More than 100% geos'.

*Test 1: Measuring Indigeneity*

Examining the raw municipal data, without conditioning on baseline characteristics, there appears to be a weak positive relationship between the proportion of the population that speaks an Indigenous language and the total percent of net coverage loss (Figure 7). Rather than the lower forest loss which cultural theories would predict, instead there is actually a weak positive relationship. In regressions-testing the relationship of the percent of the population living in Indigenous households to forest loss rates, this weak positive relationship persists, and regressions show that there is more impact from initial cover and federal road measurements. This result is repeated across the different samples queried here.

|  | Dependent variable: |
| --- | --- |
|  | TotalLossR * 100 |
|  | % Net Loss |
| % Ind Households | 0.015*** |
|  | (0.004) |
| 2010 Population | 0.00001*** |
|  | (0.00000) |
| % Initial Cover | 2.184*** |
|  | (0.399) |
| Federal Road | 1.356*** |
|  | (0.257) |
| Constant | 0.746*** |
|  | (0.273) |
| Observations | 1,874 |
| $R^2$ | 0.060 |
| Adjusted $R^2$ | 0.058 |
| Residual Std. Error | 5.080 (df = 1869) |
| F Statistic | 30.064*** (df = 4; 1869) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

Figure 7: Indigenous households and forest loss at national level.

Investigating the idea that more Indigenous people has a positive effect on forest loss, adjusted for population, the data shows instead that there is a weak relationship between household identification as Indigenous and forest loss. This relationship is present whether the household or language indicator is used, and it persists in models adding further demographic covariates like sewerage, percent of residents born in the municipality, and illiteracy, as well as more orthogonal geographic measures like total area, all of which showed no statistically relevant relationship with forest loss. Instead, there is a small but discernible effect, which appears contradictory and persists even when related to this suite of social variables.

Adding dominant vegetation type (Figure 8) is interesting, since the national sample amalgamates the super-biodiverse forest ecosystems while poorly measuring xeric and desert areas. Knowing the dominant forest type also helps understand the different rates of loss that are illustrated in the state net-loss maps above, especially the much higher rates in southern Mexican states dominated by hardwoods and moist-broadleaf, tropical vegetation. The xeric and desert category is inconclusive across categories, as expected for biomes with little vegetation tall enough to meet the Hansen data's parameters. This is in stark contrast to pine/oak and moist broadleaf forests, which saw the greatest effect of roads, initial cover, and Indigenous autonomy on their net

loss rates. Importantly, moist broadleaf forest dominates the regression, with 2.5% less loss in autonomous municipalities. This may have something to do with the relative prevalence of fire and drought in other biomes, and is a topic for further research.

| | % Net Loss | | | |
| --- | --- | --- | --- | --- |
| | TotalLossR * 100 | | | |
| | Dry Broadleaf (1) | Pine/Oak (2) | Moist Broadleaf (3) | Xeric/Desert (4) |
| Oaxaca | -26.718 (31.428) | -0.484*** (0.138) | -2.574*** (0.729) | -65.359 (368.651) |
| 2010 Population | 0.0001 (0.0002) | 0.00000 (0.00000) | 0.00000 (0.00000) | -0.0001 (0.0002) |
| % Initial Cover | -65.542 (46.418) | 1.986*** (0.222) | -2.900*** (1.037) | -167.612 (129.412) |
| Federal Road | -29.048 (25.782) | 0.498*** (0.147) | 2.067*** (0.572) | 54.207 (57.362) |
| % Ind Households | 0.176 (0.460) | 0.005*** (0.002) | 0.049*** (0.008) | -0.879 (1.939) |
| Constant | 65.824** (28.826) | 0.063 (0.158) | 5.217*** (0.918) | 51.277 (54.446) |
| Observations | 524 | 676 | 441 | 187 |
| $R^2$ | 0.008 | 0.152 | 0.100 | 0.015 |
| Adjusted $R^2$ | -0.002 | 0.146 | 0.090 | -0.012 |
| Residual Std. Error | 281.897 (df = 518) | 1.585 (df = 670) | 5.068 (df = 435) | 364.951 (df = 181) |
| F Statistic | 0.820 (df = 5; 518) | 24.076*** (df = 5; 670) | 9.709*** (df = 5; 435) | 0.544 (df = 5; 181) |
| Note: | *$p<0.1$; **$p<0.05$; ***$p<0.01$ | | | |

Figure 8: Local institutions and forest loss by region (national).

In these models, an indicator was added for whether or not the municipality was within the state of Oaxaca, and therefore whether its constituents at least had the chance to vote for the adoption of Indigenous customs at the local level. While Oaxaca has a consistent negative sign, it is only significant in Pine/Oak and Moist Broadleaf vegetation regimes, a specificity which allows for more pinpointed follow-up research (i.e. why institutions in these regions seem more effective, or to uncover the particular challenges in areas hardest hit by major forest loss). More focused analysis is needed on the contributions of loss and gain in those regions to global trends like species loss and climate change. It also justifies the second set of tests focused on institutions, where I break down the sample into Southern Mexico and cross-border watersheds of Oaxaca.

*Test 2: Oaxaca borders and watershed sampling*

While the forest loss data does not seem to support the argument that the simple presence of Indigenous peoples is conducive to managing forests, the 'institutions hypothesis', operationalized here as 'possessing recognized autonomous local forms of governance means less forest loss', is supported across the different samples. In the national sample, unlike Indigenous language and household data, municipalities with *usos y costumbres*, even when adjusted for likely demographic covariates, shows a consistent negative sign and

relatively large effect size. They show with a high level of significance that areas with *usos* institutions tend to have less forest loss (Figure 9). They also continue to show the influence of the percentage of initial forest cover, and the presence of federal roads.

| | % Net Loss | |
| --- | --- | --- |
| | TotalLossR * 100 | |
| | (1) | (2) |
| Usos y Costumbres | -1.774*** | -2.448*** |
| | (0.308) | (0.322) |
| 2010 Population | 0.00000*** | 0.00000*** |
| | (0.00000) | (0.00000) |
| % Initial Cover | | 1.838*** |
| | | (0.396) |
| Federal Road | | 1.095*** |
| | | (0.256) |
| % Ind Households | | 0.025*** |
| | | (0.004) |
| Constant | 3.436*** | 1.267*** |
| | (0.145) | (0.277) |
| Observations | 1,874 | 1,874 |
| $R^2$ | 0.027 | 0.089 |
| Adjusted $R^2$ | 0.026 | 0.086 |
| Residual Std. Error | 5.168 (df = 1871) | 5.005 (df = 1868) |
| F Statistic | 25.871*** (df = 2; 1871) | 36.306*** (df = 5; 1868) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |

Figure 9: *Usos* and forest loss (national).

These relationships are consistent across the ecoregion and Southern Mexico samples, with some interesting differences. The terrestrial ecoregion analysis demonstrated the relative good performance of Oaxacan municipalities in areas with moist broadleaf forests, and the cross-border watershed analysis shows the persistence of the weak positive relationship between Indigenous households and forest loss, and also the significance of autonomous local institutions in Oaxaca, especially in the Sierra Madre del Sur, shared with Guerrero and Puebla, and the Chiapas-Fonseca watershed, shared with coastal Chiapas. Despite smaller effect sizes, Papaloapan and Rio Balsas retain a negative sign and account for a reasonable amount of variance (Figure 10).

| | % Net Loss | | | | |
| --- | --- | --- | --- | --- | --- |
| | TotalLossR * 100 | | | | |
| | Southern MX | Chiapas-Fonseca | Papaloapan | Rio Balsas | Sierra Madre del Sur |
| | (1) | (2) | (3) | (4) | (5) |
| *Usos y Costumbres* | -2.861[***] | -2.455[***] | -0.832[*] | -0.638[***] | -6.091[***] |
| | (0.345) | (0.693) | (0.448) | (0.229) | (0.859) |
| 2010 Population | 0.00001[***] | -0.00001[*] | -0.00000 | 0.00000 | -0.00001 |
| | (0.00000) | (0.00000) | (0.00000) | (0.00000) | (0.00001) |
| % Initial Cover | 1.548[***] | -0.530 | -0.549 | 1.476[***] | -3.405[***] |
| | (0.490) | (1.278) | (0.662) | (0.494) | (1.303) |
| Federal Road | 1.073[***] | 1.609[**] | 2.594[***] | 0.070 | -0.400 |
| | (0.335) | (0.791) | (0.521) | (0.220) | (0.919) |
| % Ind Households | 0.014[***] | 0.005 | 0.014[**] | 0.008[***] | -0.017 |
| | (0.004) | (0.011) | (0.006) | (0.003) | (0.011) |
| Constant | 2.509[***] | 3.788[***] | 2.296[***] | -0.103 | 10.737[***] |
| | (0.380) | (0.897) | (0.549) | (0.211) | (1.222) |
| Observations | 1,221 | 87 | 280 | 187 | 228 |
| $R^2$ | 0.104 | 0.174 | 0.114 | 0.125 | 0.247 |
| Adjusted $R^2$ | 0.100 | 0.123 | 0.098 | 0.101 | 0.230 |
| Residual Std. Error | 5.082 (df = 1215) | 3.199 (df = 81) | 3.177 (df = 274) | 1.219 (df = 181) | 5.577 (df = 222) |
| F Statistic | 28.077[***] (df = 5; 1215) | 3.415[***] (df = 5; 81) | 7.062[***] (df = 5; 274) | 5.179[***] (df = 5; 181) | 14.533[***] (df = 5; 222) |
| *Note:* | [*]$p<0.1$; [**]$p<0.05$; [***]$p<0.01$ | | | | |

Figure 10: Local institutions and forest loss by region in Southern Mexico.

Further research could refine and improve the evidence shown here, in several ways. One way is simply by updating the numbers for forest loss from the new 2020 Mexican census. A more explicit spatial measurement and consideration of *ejidos* and *nucleos agrarios*, especially in the cross-border samples, would also be illuminating. Fire regimes and their effect on forest loss numbers in pine/oak and dry broadleaf forests would also be thought-provoking considering their relative worse performance. In sum, gaining granularity has exposed what we already knew, that this area and forest governance in general is complex and involves a diverse array of actors acting at different scales. This diversity, while challenging the generalizability of the answers, also provides analytic leverage where it can be utilized to explore internal variation, and where studies become more finely targeted to connecting the experiences of particular places to global trends. This more granular research program is of particular importance to the development of REDD+ and other PES strategies making decisions about who to fund at what level, and with what kinds of safeguards and prerequisites.

## 5. Discussion

This article negotiated claims about Indigenous peoples by generating evidence from forest loss trends in municipalities in Mexico. The results show that higher Indigenous language and household percentages are weakly correlated with greater forest loss. This makes some sense if one considers that Indigenous peoples are among the poorest and least empowered citizens of Mexico. Critics of 'extractivism' in developing countries

make the case that systemic racism and class power dynamics would explain why these communities might have important cultural characteristics that encourage ecologically-friendly behavior, one of key so-called 'post-material values', yet be systematically disenfranchised in a way that makes them more vulnerable to exploitation (Acosta 2016; Martinez-Alier 2000).

The results show that *usos* municipalities, not necessarily municipalities with higher proportions of self-identified Indigenous households or languages spoken, had less forest loss. They also demonstrate the influence of having resources (here modeled as percent of area initially covered in forest) and the ability to ship to major centers (here, as presence of a major federal road in the municipality), each of which were significant across most of the models. The percentage of Indigenous households, however, does not seem to be more than weakly correlated to *increased* forest loss in these tests, at any scale. This tells us something about the imprecision of the category (since *usos,* which tests well, requires proof of pre-Columbian descent) and the importance of local institutions for defending common resources.

For analysts and practitioners targeting reforestation resources, this study should encourage further research into pre-existing inequality between municipalities, the type and character of democratic institutions contained within *usos* communities, and developing more detailed records of fiscal revenue and spending powers. It also suggests using forest types and ecological indicators to group examples has potential gains in clarity and generalizability, illustrated in the national biome samples and the more fine-grained watershed-based sampling in the final tests across the Oaxacan border.

The article suggests that strategies for targeting PES and reforestation programs need to focus on resource governance, rather than simply the presence of Indigenous peoples, and that autonomous local institutions *matter* in a way which is both obvious and not clearly disentangled from linguistic and household identification measures. One could see these results as signaling three things:

1) that Indigenous categories themselves are not well-measured enough using language and self-identification methods,
2) that local institutions, perhaps regardless of indigeneity (and which cannot be separated in the case of Oaxacan *usos y costumbres*), do matter for understanding forest loss
3) that sampling techniques based on ecological categories like dominant vegetation type and watershed, can help identify specific problems and the contributions of different regions. They can also create specific measures for understanding the global effects of regional ecosystem degradation across national contexts.

Advancing this kind of analysis is important. REDD+ and other PES schemes need to make a decision about who to fund, and at what level, based on the efficient accomplishment of their goals. This requires both capacity for MRV and local legitimacy, a balance which has resulted in calls for nested institutions, rather than simply autonomous local or centralized state government. While REDD+ and other forest carbon exchange platforms bundle Indigenous communities and local institutions together, the results of the tests conducted here indicate that prioritizing funding to Indigenous communities with recognized local control of resources and robust forms of institutional participation, alongside advancing the capacity for measurement across scales, may be an important strategy for improving REDD+ performance. This emphasis on institutions is, importantly, linked to cultural norms and Indigenous communities, but implies that these are only necessary components and not sufficient for stopping forest loss without strong local governance anchoring multi-level, nested, and polycentric systems. This indicates the importance of strong subsidiarity in multi-level governance.

The tests show that similar areas with recognized autonomy have less net forest loss across scales. They also show that *ejidos* and common property regimes, which exist in great numbers across southern Mexico and nationally administer over 80% of Mexican forests, may not be as effective at stopping forest loss as local regimes with recognized parallel municipal assemblies and blanket bans on the participation of political parties. That these assemblies, in practice, also consist of *ejiditarios* and residents of *nucleos agrarios* in Oaxaca supports the suggestions of both critics and practitioners to use PES and REDD+ (in particular) as a means of reinforcing local norms and institutions.

This finding exists despite concerns about 'additionality', or whether REDD+ is activating new forest protection efforts, or simply supporting established ones from existing well-managed forests. Additionality is an interesting wrinkle—Mexican forest outcomes have been improving since the mid-1980s. Some feel that including existing biomass stocks in carbon emissions plans as offsets, actually lets countries like the US and Canada shirk some of their responsibilities, a proposition which is opposed by countries like India with large and relatively stable forest reserves. The 2015 Paris Accords, by allowing countries huge flexibility in how they construct and meet their goals, also gave opportunities to countries with existing forests in the developing world to claim these as credits or even to solicit direct payments for maintenance under the REDD+ framework. Oaxaca and Mexico in general stand to gain from this relaxing of additionality concerns.

This point is consistent with the idea that the North/West owes developing societies a kind of 'climate debt' due to its historical responsibility for $CO^2$ emissions, and the relative comfort with which those in the 'developed' world will experience the coming changes associated with climate change. Such an idea, that these programs are hard-won redistributive gains, butts up against much of the critical academic literature, where many, drawing on Foucault in particular, see enhanced carbon accounting as a mode of governmentality, what Luke calls 'environmentality' (Luke 1995). Instead of seeing it as a concession, these theorists see REDD+ as reinforcing existing power dynamics and 'carbonizing' or making fungible forest resources that have escaped state control to this point, especially in weak and corrupt regimes, and especially in those areas administered informally by Indigenous peoples (Baldwin 2003; Asiyanbi and Lund 2020).

The results here show that this claim may be better phrased as a concern for how Indigenous and local communities are empowered politically, through legitimate and effective local and regional institutions, to control their own forest outcomes. Such a change to more local political administration may be inevitable, and following Foucault further than some of critics may like, such changes also open up spaces for resistance and innovation.

Beyond a potential for resistance, there is still the need for effective MRV (monitoring, reporting and verification), which, due to the cost of creating scientific baselines and administrative capacity, may require central governments enhance national and subnational capacity, or at least not hinder it. In this context, complaints from critics that money expended so far has only been spent on bureaucracy reflects the sequence of such capacity building—REDD+ pays for results, so to get paid you have to measure. What resource economists suggest is that involving local and Indigenous communities in MRV and meaningful political decision-making will make the process more efficient (by enabling local monitoring and sanctioning mechanisms) as well as making it more legitimate (through participation and buy-in).

## 6. Conclusion

I have shown here that Mexico in general, and Oaxaca in particular, provide interesting insights into the potential for such institutions and localizing strategies. The question this article started with, however, remains: are these examples generalizable? At once they are clearly not, due to the specific and path dependent histories of Indigenous peoples, local autonomy, and ecological diversity. At the same time, in a more general sense, many things do seem to bear on global debates, especially the importance of 'fit' between strategies and institutions, the experience of decentralization since the 1980s, and advancing challenges to rural lifestyles posed by economic globalization and global climate disruption.

I have tried to show some of the potential lessons for REDD+ from the Mexican experiment, by looking at Indigenous and local institutions in a variety of ways and at different scales, and by demonstrating the greater contextual understanding and benefits from a more granular focus on municipalities and biomes as a base for generating a more generalizable set of lessons for global debates. The results of these tests imply the usefulness of the Oaxaca example, and stress the importance of strong subsidiarity as a base for effective multi-level and nested institutions dealing with the global ecological crisis.

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