Between the Global Commodity Boom and Subnational State Capacities: Payment for Environmental Services to Fight Deforestation in Argentina

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Abstract

Does subnational state capacity stop deforestation? The commodity boom of the 2000s significantly expanded the agriculture frontier in most provinces of Argentina, with devastating effects on native forests. Interestingly, some of the subnational governments that presided over the commodities supercycle also sought to reform the forestry sector to reduce rampant deforestation, despite promoting and benefiting from agricultural expansion. A national program to protect native forests through payment for environmental services (PES) was created to be implemented in local districts. We argue that the success of new forest protections is contingent on the capacity of subnational governments to implement the law. In our study, we find that changes in provincial deforestation rates are explained by the interaction of state capacity, on one hand, and high land prices driven by commodity pressures, on the other. Our research carries implications for students and practitioners of forest PES. Our findings underscore the fundamental role subnational state governments play in climate change mitigation and adaptation.

Can states effectively slow down deforestation? Land use and high prices of commodities push the agricultural frontier and are seen as historic culprits of deforestation around the world (Pacheco 2009; Godar et al. 2012). These factors are seemingly unstoppable forces. In fact, over the past twenty years, the world has witnessed dramatic losses in forest area, reported to be well over 300 million hectares (ha) globally.[1] The last two decades also coincide with a commodity

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1. See www.globalforestwatch.org/dashboards/global?category=forest-change, last accessed November 14, 2019.

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supercycle that greatly benefited exporters of raw materials in the developing world. Latin American countries, especially, saw their agricultural sectors transformed and expanded and reached some of the highest deforestation rates in the world. Paradoxically, some of the governments that presided over the commodities supercycle also sought to reform the forestry sector to reduce rampant deforestation, despite promoting and benefiting from agricultural expansion.[2] Argentina is such a case. Driven by massive soybean and grain exports, the country ramped up its agricultural production in the early 2000s and experienced some of the largest tree cover losses in the region. Yet, in 2007, congress passed a national forest law instituting a payment for environmental services (PES) program for all Argentine provinces that offers monetary incentives to landholders who conserve trees. More recently, provincial and national deforestation rates show a downward trend. Can PES schemes offset the effects on deforestation of an expanding agricultural sector? In this article, we answer this question by focusing on subnational governments and financial state capacity under a federal system.

A common tool to reduce deforestation across the globe, PES programs offer monetary incentives in exchange for a commitment by landholders to conserve the natural landscape. Critically, the effectiveness of PES rests on design, implementation conditions, and the ability to create *real* incentives for stakeholders to abstain from harmful activity (Boerner and Wunder 2008; Daniels et al. 2010; Boerner et al. 2014). We argue that one clear test of the effectiveness of any PES scheme is the capacity of local bureaucracies to administer them relative to the strength of the local agricultural sector.[3] Subnational capacity, which we measure in terms of the amount of money committed to the PES within each province, reveals the local government's ability to secure the implementation of the national forest law. We measure the relative strength of local farming through the total value of primary product exports as well as the maximum price of farm real estate per hectare by province.

We expect to find evidence of a trade-off between the effectiveness of subnational payments and demand for locally produced commodities and local farmland in deterring deforestation. We test our argument against an original database that includes subnational values of PES offered by provincial governments to landholders, a measure of bureaucratic specialization of the provincial disbursing agency, farmland prices by province, and the total amount of

2. For example, Ecuador implemented the PES program Socio Bosque in 2008, and Brazil adopted the programs Bolsa Floresta and Bolsa Verde in 2007 and 2011, respectively. Costa Rica, at the forefront of conservation and forest management in the region, adopted a PES scheme (the Pago de Servicios Ambientales program, or PSA) in 1997.
3. We acknowledge the controversies surrounding PES schemes, which include the United Nations–sponsored Reducing Emissions from Deforestation and Forest Degradation (REDD) program and cap and trade schemes. In particular, many critics argue that PES may result in the further commodification of environmental goods (see, e.g., Fuentes-George 2013; Bongiovanni Schmitz and Clover Kelly 2016). A thorough critique of PES is outside the scope of this article, however.

commodities exported by province. We also draw from significant field research carried out in the provinces of Formosa and Tucumán, belonging to two different forest regions in northern Argentina, and the national environmental secretariat, located in the capital city and the source of federal funding for subnational PES. We analyze the effect of subnational state capacity on deforestation rates for twelve of the twenty-three provinces of Argentina.[4] The results of our study show that there is a trade-off between the effectiveness of subnational state capacity to slow down deforestation and the strength of the agricultural sector. Indeed, PES disbursed by local governments curb forest cover loss. Furthermore, subnational funds with the most stringent conditions—no economic use of forest trees of any kind—and disbursed by environmental regulators with a sole green mission have a greater drag on deforestation. On the other hand, and regardless of the type of PES, our analysis also shows that the higher the value of farmland in a province, the greater the deforestation rate.

In contrast to many standard deforestation models where political variables are often absent, our findings indicate the importance of a well-funded and, to some extent, a specialized subnational state in the fight against climate change and in the adoption of both adaptation and mitigation policies. A recent surge in scholarship on subnational state politics supports this claim (Koehn 2008; Toni 2011; Giraudy 2012; Luna and Soifer 2017; Amengual 2015). This can be seen clearly with the case of Argentina's national Forest Law. As a vital mitigation tool across the world, the success of PES schemes hinges on local execution. By identifying key conditions under which state capacity matters for the implementation of forest PES in twelve provinces, our work makes an important contribution to the literatures on PES evaluation and subnational politics in federal systems. Subnational analysis is particularly significant in forest PES, given that under federal systems, natural resources are under provincial jurisdiction. To the best of our knowledge, no other study has a large sample of subnational units with variation in the degree of deforestation.

The article is organized as follows. In the first three sections, we discuss the political economy of deforestation in Argentina, why subnational state capacity is critical to fight it, and how the PES scheme of Argentina's Forest Law works, respectively. Next, we formulate our main hypotheses and discuss them in relation to standard forestry models and the literature on subnational state capacity. We then present the data and model specifications used to test our argument. We discuss the models' results and conclude with some ideas for future research and an examination of the policy implications of our study.

4. Our study includes the provinces of San Luis, Entre Ríos, Santa Fe, Córdoba, Tucumán, La Pampa, Jujuy, Corrientes, Salta, Formosa, Chaco, and Santiago del Estero. It excludes Buenos Aires, Chubut, Mendoza, Neuquén, Santa Cruz, Río Negro, and Tierra del Fuego, for which no deforestation data are publicly available. While deforestation data are available for Catamarca, La Rioja, Misiones, and San Juan, there are no reliable values for farmland prices for these four provinces. Consequently, we had to drop them from our empirical analysis.

The Political Economy of Deforestation

Despite the vast consequences of deforestation on vulnerable communities, political conflict, and global warming, the loss of forests continues at a dramatic pace across the developing world (Taubert et al. 2018; Fehlenberg et al. 2017). Argentina's rate of deforestation puts it in the top twenty countries in the world with the greatest loss of tree cover since 2001.[5] Out of eleven Latin American countries that have experienced losses of forest over a million hectares from 2001 to 2016, Argentina ranks seventh, with a total loss of 1,572,703 ha after Brazil—first in the world—and the region with a total loss of 35,912,089 ha, comprising Bolivia, Colombia, Peru, Mexico, and Paraguay. The decade of the commodity boom saw record years of deforestation, particularly for Argentina, which experienced the second greatest yearly loss in the region behind Brazil. Argentina cut approximately 400,000 ha of tree cover a year between 2004 and 2007, with a peak loss of 608,414 in 2008. Unlike other countries and regions where the extraction and export of timber are important drivers of deforestation, in Argentina, deforestation results from the expansion of the agricultural frontier, mostly due to the growth of soybean and other crops and the displacement of livestock to new lands in the north of the country (Dirección de Bosques 2002–2005; Fernández Milmanda and Garay 2019).

Deforestation, one of the most persistent environmental problems of the developing world and a key contributor to climate change, lies at the intersection of economic demands and state strength. On one hand, the main causes of deforestation are determined by increases in economic activity, especially in the agricultural sector (Pacheco 2009; Barber et al. 2014). On the other hand, laws that regulate land use in forest areas, established to limit illegal logging, usually rely on the readiness of local governments to implement and enforce them (Burgess et al. 2012). An understanding of the political economy of deforestation is needed to formulate policies that mitigate the determinants of climate change and global warming. Explaining deforestation also matters to the formulation of adaptation responses to reduce the vulnerability of forest-dependent communities. In the past, existing forest laws have not succeeded in slowing down deforestation or in deterring conflict (Roriz et al. 2017). We intuit that the amount of economic resources that a local state brings to bear against illegal logging will be critical.

Many standard deforestation models, developed by economists and forestry scientists, focus mainly on economic variables. That is, these analyses tend to model few political and social factors to predict the evolution of deforestation rates. Typical partial predictors of deforestation include land use, existing vegetation, commercial crops, and logging (Andersen et al. 2002; Roriz et al. 2017) as well as indicators of increased economic productivity, such as roads (Barber et al. 2014). However, there is a growing recognition of the need to study the role of the state, be it through the establishment of protected areas

5. See www.globalforestwatch.org/dashboards/global?category=forest-change, last accessed November 14, 2019.

(Barber et al. 2014; Allen 2015; Roriz et al. 2017) or the implementation of PES schemes or other incentives (Doherty and Schroeder 2011; Boerner et al. 2014). Incorporating the capacities of local governments should improve the accuracy of the deforestation models that show "inconsistency between trajectories and reality" (Dalla-Nora et al. 2014, 404). In this study, we try to close the "political gap" of deforestation models by examining the effect of subnational state monies and subnational bureaucratic specialization on the rate of tree loss.

Forest and State at the Subnational Level

National aggregates provide a useful measure to compare across nations, yet we know that within a country, there is great variation in tree cover loss. Because local regions are endowed with different climates, soils, and natural resources, investment in economic development will distribute unevenly across quality and type of land. The political capacity and will to curb deforestation will also distribute subnationally. We can visualize subnational differences in deforestation within Argentina in Figure 1, which shows the evolution of deforestation in recent years at the provincial level.

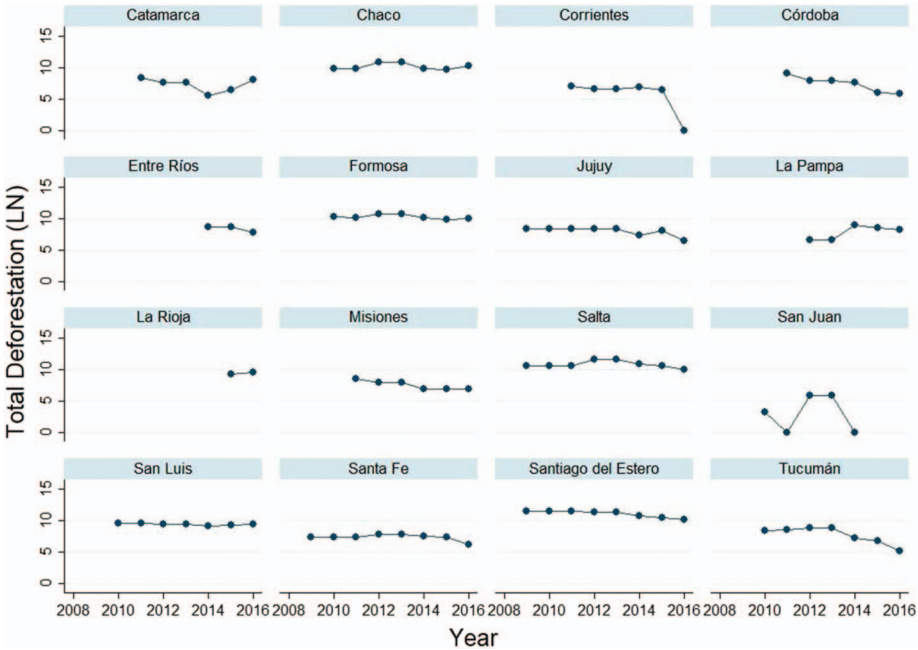

Figure 1
Natural Log of Total Deforested Hectares of Native Forests by Provinces, 2008–2016

Source: National Forests Directorate's Forest Assessment System Management Unit (UMSEF).

For example, the provinces of Chaco and Tucumán show contrasting patterns. Chaco experienced a gradual increase in its loss of tree coverage during the years 2008 and 2016, while Tucumán saw the reverse trend. Neither is a major exporter of soy products (Argentina's main commodity). The comparison between Chaco and Santiago del Estero, both of them belonging to the same forest region (Parque Chaqueño), shows somewhat similar patterns but with different overall trends. Whereas deforestation in the province of Chaco remains high and continues to rise slowly, Santiago del Estero—also with high rates of tree cover loss—is on an overall downward slope.

Existing PES schemes that target deforestation are restricted to subnational districts and are implemented typically by local (province or state) governments (Toni 2011; Kashwan 2015). This is so for government-financed PES programs such as the one contained in the Forest Law in Argentina and the Bolsa Floresta program in Brazil, as well as the internationally funded Reducing Emissions from Deforestation and Forest Degradation (REDD+), implemented in the Democratic Republic of Congo, Indonesia, and Brazil, to name a few (Burgess et al. 2012; Barber et al. 2014). Certainly there are different sources of funding for PES schemes: national governments, international governmental organizations, international foundations, and individual donor countries.[6] Yet, regardless of where the funds originate, local (i.e., subnational) governments are charged with the execution of PES schemes. Consequently, subnational states must decide on the size of the incentive, the selection criteria of beneficiaries, and the monitoring and enforcement of program requirements, among many other responsibilities. These critical tasks denote the importance of subnational state capacity in the adoption and implementation of antideforestation programs, such as the Argentine Forest Law PES program described herein.

The Forest Law in Argentina

The first PES fund distribution in Argentina's provinces began in earnest in 2010. Conservation plans, labeled PC, have the most restrictive conditions; management plans, or PMs, have fewer conditions attached. PC funds are disbursed by the provincial government to landholders who commit to conserving the forest land fully untouched. Like PC funds, monies distributed for management plans cannot be used to clear trees. However, unlike PCs, PM funding can be applied to utilize the forest land "sustainably" and even to pursue economic activities such as tourism and agroforestry.[7] Figure 2 shows the average amount of Argentine pesos disbursed for conservation and management plans across provinces between 2010 and 2016. Amounts are logged given that the nominal

6. See http://reddx.forest-trends.org/, last accessed November 14, 2019.
7. See the guidelines for developing conservation and management plans at http://recursosforestales.corrientes.gob.ar/assets/articulo_adjuntos/555/original/Cartilla_para_Profesionales_que_Formulan_Planes_en_Bosques_Nativos.pdf?1401202097, last accessed November 14, 2019.

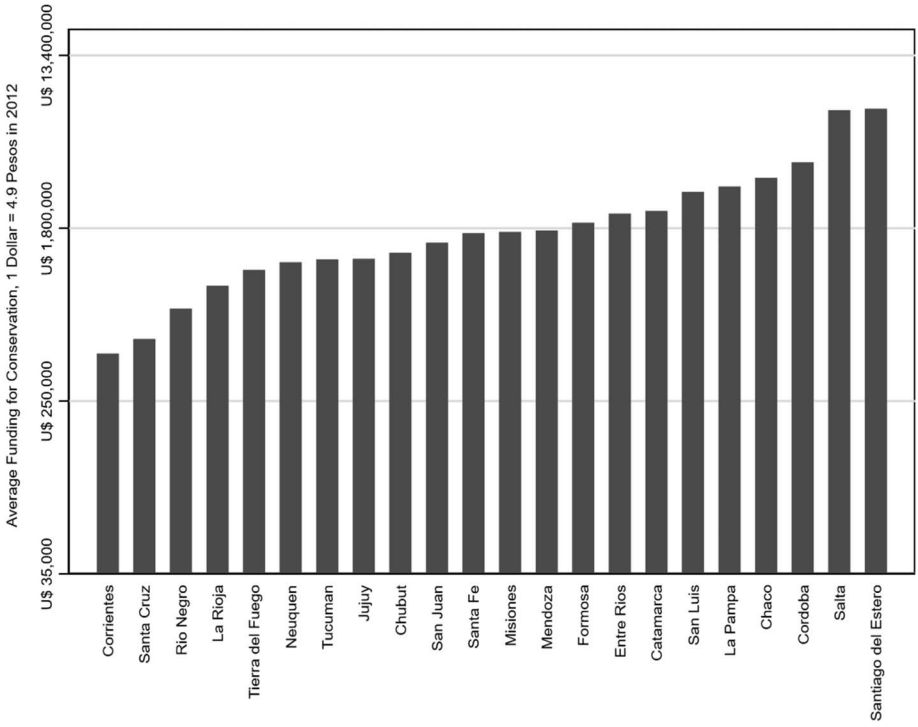

Figure 2
Average Funding for Conservation and Management (PC & PM) by Province, 2010–2016, in US$

Source: National Forests Directorate.

values grow exponentially, facilitating the analysis and visualization of the results. The figures show that there is great variation in how conservation and management monies are distributed across provinces.

How did Argentina adopt a nationwide, province-based PES program to stop deforestation? In 2007, the National Congress passed the Native Forest Protection Law, or Ley de Bosques Nativos (hereinafter the Forest Law) as the result of mounting social demands and the initiative of individual lawmakers (Gutiérrez 2017). In December 2002, the National Forests Directorate published a report on the First National Inventory of Native Forests (Dirección de Bosques 2002), which found the total hectares of remaining native forests to be 33 million. This report was disseminated by the media and used by social organizations that demanded politicians stop deforestation. Several environmental organizations, led by Greenpeace, mobilized for a law to be passed to protect the remaining native forests. In 2004, Representative Miguel Bonasso (an ally of President Néstor Kirchner and president of the Natural Resources and Human

Environment Conservation Commission of the Chamber of Representatives) proposed a declaration by congress requesting the executive suspend clearings until a protection law was passed. After the declaration was approved, Bonasso presented the Native Forest bill on May 30, 2006.

Environmental organizations and national environmental officials backed the Bonasso bill. In the opposition, representatives and senators of the so-called forest provinces (mainly Salta, Formosa, and Misiones), regardless of their party affiliation, opposed the Bonasso bill, alleging that it would undermine provincial autonomy to manage natural resources. In addition, agricultural producers expressed their opposition to any type of environmental regulation on forests. Despite this opposition, the protectionist actors in and beyond congress managed to obtain a majority within congress (i.e., Front for Victory) after granting some concessions aimed at reducing the resistance of provinces (chief among them the creation of the Native Forests Fund). Finally, the bill was approved by both chambers in November 2007.

The Forest Law set national minimum floors ("presupuestos mínimos de protección ambiental" in Spanish) for the protection of native forests in compliance with a 1994 constitutional amendment and the 2002 General Law for the Environment. Among other measures, Law 26331/07, or the Forest Law, introduced two major policy instruments that offered innovative tools over past legislation on the environment: (1) the Land-Use Zoning of Native Forests (Ordenamiento Territorial de Bosques Nativos, or OTBN) and (2) the National Fund for the Enrichment and Conservation of Native Forests.

The OTBN classifies lands with native forests according to three color-coded conservation categories (i.e., red, yellow, and green). Each province must approve its OTBN by law, which is to be revised and updated every five years. Once approved, each provincial OTBN has to be accredited by the National Secretariat of the Environment and Sustainable Development (SAyDS), which has to certify that every provincial OTBN meets the national standards set by the Forest Law in order for the provinces to access native forests funds.

Each conservation category has distinct land-use conditions, which in turn are determined by sustainability criteria given the forests' size, such as linkages to existing protected areas and subsistence uses for indigenous and peasant communities. Specifically, category I (red) areas are areas with very high conservation value, which cannot be transformed. Category I contains areas that, owing to their location, connectivity value, biological value, and/or river basin protection potential, are worth preserving in perpetuity, although they can be inhabited by indigenous communities or be the subject of scientific research. Category II (yellow) areas are areas with medium conservation value that, while degrading, can still reach high conservation value. These areas can be subject to the following activities: sustainable utilization, tourism, collection of natural resources, and scientific research. Category III (green) areas are areas of low conservation value that can be partially or completely transformed within the criteria established by the law.

The OTBN is complemented with other instruments (Aguiar et al. 2018; Fernández Milmanda and Garay 2019): (1) land-use change plans (required for any activity that involves clearing), (2) hearings and public consultations (also required for activities that involve clearing), (3) environmental impact studies (required for different types of activities), (4) monetary sanctions (for any infraction or breach of the law), and (5) the National Fund for the Enrichment and Conservation of Native Forests (intended to compensate only for activities that do not involve clearing and that favor the conservation, recovery, and/or sustainable management of the forests).

While all those instruments are important, the National Fund for the Enrichment and Conservation of Native Forests (from now on the Forest Fund or Fund) soon became, after the OTBN, a central piece in the implementation of the Forest Law, as becomes clear from our interviews and field observations (see also Di Paola 2011; Aguiar et al. 2018). For the national government (SAyDS), the Forest Fund is the main tool (if not the only one) that enables it to intervene in the application of the Forest Law in the provincial territories. For the provinces, it constitutes the Forest Law's main attraction, given that it allows them to obtain "fresh" funds, both for financing the landholders' management plans and for institutionally strengthening their own environmental agencies (see later). This explains, in part, why all the provinces approved their OTBN laws between 2008 and 2016, a level of compliance with a national law that is not very common in Argentina (Gutiérrez 2017).

The Forest Fund aims to provide monetary incentives to avoid furthering deforestation and to compensate landholders for the environmental services granted by native forests. Money from the fund is distributed to the provinces whose OTBNs have been approved by law and accredited by the SAyDS and follows a formula outlined by the Federal Environmental Council (COFEMA). COFEMA is made up of top representatives of the national and all provincial governments of Argentina. Funds allocated to each province have two separate aims: 70 percent of the money must be used to pay landholders that preserve or sustainably manage native forests (i.e., PCs and PMs); the remaining 30 percent is assigned to "institution building" for the subnational state agency in charge of implementing the Forest Law and managing the fund's resources (known as the application agency, it is typically the subnational ministry or secretariat with jurisdiction over environmental policy). The purpose of this 30 percent is to shore up the technical capacity of provincial bureaucracies. Indeed, COFEMA sought to overcome a central problem that was stressed by both national and provincial officials interviewed by the authors: the deficit in state capacity of the provincial agencies tasked with implementing and enforcing the Forest Law.[8] The Native Forests Fund's 30 percent institution-building component can be used to hire

8. Interviews by the authors with environmental officials in Tucumán (San Miguel de Tucumán, July 2016), Formosa (Formosa City, August 2018), and the national government (Buenos Aires City, September 2015, April 2016, July 2018).

personnel, to buy vehicles and equipment, and to support field-monitoring expenses.

To apply for money from the fund, landholders must submit a project to the provincial government for approval. According to the Forest Law and its regulation, landholders whose properties are within the areas zoned by the OTBN are eligible to apply to one of two different types of plans: the aforementioned PCs and PMs (Dirección de Bosques 2017).[9] PMs can be carried out in category II (yellow) and I (red) lands, while PCs can be executed in all three categories. Deforestation is illegal in both PCs and PMs, but PMs are less restrictive than PCs, as they authorize the economic activities permitted in category II (yellow) lands (tourism, collection, and the somewhat ambiguous "sustainable utilization" of forests), which are banned in category I (red) lands.

Study Hypotheses

We turn now to formulating our main hypotheses. To answer the study's research questions posed in the introduction of this article—whether implementing PES schemes makes a difference in deforestation rates or whether these rates result from the strength of the agricultural sector—we discuss the importance of local and political (i.e., the subnational state) variables in explaining deforestation. While many deforestation models include subnational economic data, they often are missing *local political* variables. Here we seek to combine both. Drawing from past studies on land use, environmental and subnational politics, and our own field research in the Argentine provinces of Tucumán and Formosa, we expect differences in subnational capacity—especially financial capacity—to help explain changes in provincial deforestation rates. Recent research in Latin America emphasizes the importance of subnational state capacity and/or local state–societal ties in policy regulation and enforcement (Giraudy 2012; Luna and Soifer 2017; Fernández Milmanda and Garay 2019). Increasingly, scholars seeking to explain political outcomes in environmental policy are focusing on the role of subnational bureaucracies and officials (Koehn 2008; Toni 2011; Allen 2015; Amengual 2015; Barrett 2015; Eaton 2017; Fernández Milmanda and Garay 2019).

Our expectation that greater subnational state capacity increases the effectiveness of PES is straightforward. As described in the preceding section, before landholders can become recipients of state monies in exchange for forest conservation on their land, the provincial government has to go through a number of technical steps, including classifying all native forests within the territory according to risk, which in turn determines the amount of federal funds received. The local government also initiates calls for applications to conservation and

9. In contrast to PCs and PMs, land- use change plans or PCUSs only apply to category III (green) lands, are mandatory for any land change planned, require the application of prior participation mechanisms, and are excluded from the Native Forests Fund.

management plans (PC and PM), decides who is awarded funding, distributes PES to landholders, and monitors fulfillment of the agreement. We claim that all of these steps require an able bureaucracy at the local level, which in turn can have an effect on the total amount of federal funding a province secures for forest conservation incentives.

We see the application of PES as sequential, with state capacity mattering throughout the process. A first step is the question of how certain provinces get more funds than others, which we argue is a function of preexisting state capacity. Next, the amount and effectiveness of PES funds are contingent on the funding initially secured by the province and its ability to continue investing in institutional capacity.[10] Consequently, we see more PES money as a proxy for more subnational state capacity. This matters because only aggregated PES can make a dent on subnational deforestation rates, and only technically abled provincial governments can provide more PES.

The subnational literature tells us that bureaucratic skills vary geographically in significant ways, especially in federal states (Escobar-Lemmon 2001; Wilson et al. 2008; Barrett 2015). As Luna and Soifer (2017) assert, "in much of the developing world, subnational variation characterizes state capacity. The reach of the state, in other words, is uneven across the national territory. Public goods are provided, regulations enforced, and order secured in some places within a country but not others" (1).

This intuition was confirmed in our field research in the provinces of Tucumán and Formosa. When we asked government officials from Tucumán how they dealt with rampant deforestation and managed the PC and PM funds, they emphasized the many technical challenges a small bureaucracy like theirs faced in environmental regulation and conservation.[11] For example, forest authorities in Tucumán indicated that their governments had to recruit and develop new technical skills to carry out the initial OTBN survey. A similar situation was reported in the province of Formosa, where officials in charge of approving and monitoring plans often have to rely on support from private consultants and landholders to collect information.[12] Smaller provinces have fewer resources available (such as skills, enforcement capacity, and, above all, financing) and often seek assistance from larger ones. Government officials in the Secretariat of the Environment in Tucumán forged ties with and sought support from their counterparts in the neighboring Salta, a larger province with greater state resources available.[13]

10. We thank an anonymous reviewer for this idea.
11. Interview by one of the authors of government officials in Tucumán in the Environmental Secretariat and the Division of Forests (San Miguel de Tucumán, Tucumán, July 2016).
12. Interviews by one of the authors of government officials from different agencies in Formosa (Formosa City, Formosa, August 2018).
13. In an interview, the government officials from Tucumán described some of the other challenges a small province faces in implementing the conservation and management plans. For example, they reported having difficulty reaching the public, especially smaller producers and communal landholders, to make them aware of Tucumán's call to apply for PC and PM funds.

Both provincial and national officials[14] stressed that the Native Forests Fund is important not only because it allows for compensating landholders for not clearing their lands but also because it helps upgrade provincial forest agencies' capacity to apply and monitor the PES program (and the Forest Law in general) thanks to the 30 percent of the fund assigned to institutional building.

Thus, our first main hypothesis is as follows:

> *H1: Subnational monetary incentives to stop logging will have a negative effect on deforestation.*

Landholders can submit two types of plans with more or less restrictive conditions (see from earlier discussion the difference between PC and PM). To reflect the difference in conditions of state monies (PC vs. PM), we further elaborate our main hypothesis as follows:

> *H1a: More restrictive subnational monetary incentives to avoid any economic activity in the forest (under any circumstances) will have a greater negative effect on deforestation.*

Recent studies on the state and environmental conservation have sought to test empirically the effect of bureaucratic skills and specialization on policy outcome (Carpenter 2001; Davidson 2001; Amengual 2015; Alcañiz 2016). We follow this research in assuming that agencies specialized in environmental issues will be more removed from the interests of the agricultural sector than other agencies with multiple missions:

> *H2: Provinces where the disbursing agency has an exclusive environmental mission will reduce deforestation further than provinces where the disbursing agency has a combined environmental–agricultural mission.*

The expansion of the agricultural frontier as a result of macroeconomic demands is recognized and decried by scientists and activists alike as a direct driver of land clearing (Pacheco 2009; Godar et al. 2012; Barber et al. 2014; Mangonnet et al. 2018; Fernández Milmanda and Garay 2019). Consequently, our two final hypotheses are based on economic pressures and the expansion of the agricultural sector:

> *H3: Higher farmland prices, as indicators of increased agricultural demand in the province, will have a positive effect on deforestation.*

> *H4: Greater volumes of primary products and energy exported from a province will have a positive effect on deforestation.*

We are particularly interested in how the empirical evidence for these two hypotheses behaves vis-à-vis our subnational state hypotheses. We expect these

14. Interviews by both authors of national environmental officials (Buenos Aires City, September 2015, July 2018, and Formosa City, Formosa, August 2018). Observant participation by one of the authors at the June 2018 COFEMA regular meeting.

two factors—the expansion of the agricultural sector and provincial bureaucratic capacity—to have the opposite effect on deforestation.

Data and Models

The dependent variable (DV) of our study is the annual rate of OTBN deforestation (ln) for each of the twelve provinces for which data are available for all of our variables. It includes all three OTBN categories (red, yellow, and green). The DV is the total loss of coverage by year and by province. As a robustness check, we also run models with UMSEF deforestation as an alternate DV, which is defined as the deforestation of OTBN lands *plus* other lands with native forests that, because of technical definitions, were left out from OTBNs.

The deforestation data are taken from the annual reports (2012–2018) and the online database of the National Forests Directorate's Forest Assessment System Management Unit (UMSEF).[15] Taking the First National Inventory of Native Forests (Dirección de Bosques 2002–2005) as baseline, UMSEF measures forest cover and land-use changes through remote sensing and GIS tools, using satellite images provided by the Argentine National Space Activities Commission (CONAE) and the US Geological Survey (USGS). As they are centered in annual land-use changes, UMSEF measurements allow for evaluating the conservation and loss of forests according to UMSEF's definition of forests and forest lands, but they do not allow for directly assessing forest degradation. UMSEF follows the Food and Agriculture Organization of the United Nations (FAO)'s definition of forest and forest lands known as FRA 2000.[16] Applied to Argentina, this definition comprises more forest land hectares that zoned by the provincial OTBNs. In its annual reports, UMSEF discriminates deforestation data for forest lands zoned by OTBNs (which we call OTBN deforestation) from deforestation data for forest lands under the FRA 2000 definition (which we call UMSEF deforestation and includes OTBN deforestation). To this day, UMSEF measurements provide the only systematic and uniform assessment of the evolution of deforestation in Argentina's provinces; they do not include two of the six Argentine forest regions (Patagonian-Andean Forests and Montes).

Our three main independent variables (IVs) are measures of state financial capacity: the annual total amount allocated to each province from the Forest Fund (total amount), the annual amount assigned to conservation plans of native forests (PC), and the annual amount assigned to management plans of native forests (PM). The source of these three variables is the National Forests Directorate, which has issued annual Forest Law Implementation Reports (and related documents) since 2013, with a special focus on the application of the Forest Fund in the provinces. The unit is Argentine pesos ($). *Total amount*

15. See http://snmb.ambiente.gob.ar/portal/, last accessed June 1, 2019.
16. See www.fao.org/forest-resources-assessment/past-assessments/fra-2000/en/, last accessed November 14, 2019.

combines the amounts assigned to PCs and PMs (70 percent) with the amount assigned to the institutional upgrading of the provincial application agency (30 percent). Our expectation is that money with greater state restrictions attached is more likely to have a negative effect on deforestation than state funds that partly subsidize landowners' production. We lag in one year the variables PC, PM, and total amount to capture their causal effect on deforestation. To facilitate the analysis, as explained earlier, we use the natural log of the main monetary IVs because the nominal values grow exponentially.

Our fourth state-related IV, subnational bureaucratic specialization, is a dichotomous variable that we code 1 when the subnational state agency in charge of disbursing PC and PM funds has an exclusive environmental mission, and 0 otherwise. Funds may be distributed by a provincial ministry with primary jurisdiction in environmental policy or by environmental regulators housed in provincial ministries of (agricultural and industrial) production. As a rough proxy of regulators' environmental specialization—which should shore up state capacity—we expect subnational bureaucratic specialization to have a negative effect on deforestation.

To capture the effect of agriculture and, especially, the 2000s commodities boom on deforestation rates, we include two variables in our study. First, the variable land value (US$) consists of the maximum price of farm real estate per hectare for each province. Higher land prices indicate increased demand in agricultural farming, which in turn should have a positive effect on deforestation rates. Land values were collected from a nationwide agricultural real estate broker. Second, yearly total provincial exports (US$) data were obtained from the Ministry of Economy of Argentina (MECON). Similar to land values, we expect this variable to reveal the international demand for commodities and consequently have a positive effect on deforestation.

We ran cross-sectional time series models to explain changes in the yearly rate of deforestation by province. We ran a set of models with fixed effects and another set with random effects. It should be noted that the fixed effects models control for any contextual effects within provinces, ensuring a conservative test of our models. We also used two separate measures of provincial deforestation to see whether greater subnational intervention has an effect only on OTBN deforestation or on non-OTBN as well. Following are our main results.

Results and Discussion

Table 1 reports coefficients explaining annual UMSEF deforestation rates. Because both the DV and the main independent variables are logged, coefficients can be interpreted as the rate of change in deforestation per unit of change in each IV. We can see that most of the study's main independent variables (PC, PM, and total amount of plan funds) behave as expected. That is, the disbursement of state monies at the subnational level has a negative effect on deforestation rates. In model 1, the natural log of PC is negative and significant, as well

Table 1
Annual UMSEF Deforestation Rates

	(1)	(2)	(3)	(4)	(5)	(6)
H1						
PM (ln)		−0.0192** (0.00751)				
PM (lag-ln)			−0.0148*** (0.00495)		−0.00802 (0.00770)	
Total amount (lag-ln)						−0.0147*** (0.00407)
H1a						
PC (ln)	−0.0227*** (0.00760)					
PC (lag-ln)				−0.0155*** (0.00512)	−0.00916 (0.00798)	
H3						
Land value (ln)	−0.0678 (0.224)	−0.181 (0.215)	0.181 (0.174)	0.286 (0.184)	0.257 (0.186)	0.337* (0.182)
H4						
Exports (ln)	−0.175 (0.161)	−0.141 (0.165)	−0.0671 (0.107)	−0.0871 (0.106)	−0.0746 (0.107)	−0.0779 (0.104)
Constant	4.853 (3.257)	5.102 (3.324)	0.373 (2.275)	−0.108 (2.311)	−0.112 (2.310)	−0.710 (2.287)
FE province	YES	YES	YES	YES	YES	YES
Observations	111	111	100	100	100	100
R^2	0.156	0.137	0.104	0.106	0.118	0.142
Provinces	12	12	12	12	12	12
LogLik	−55.97	−57.26	−5.729	−5.594	−4.951	−3.571

Note: The DV is the total loss of coverage by year and by province. Standard errors are in parentheses. It should be noted that fixed effect models tend to have a lower R^2 than random effect models and basic ordinary least squares because they discard information of variation across cases.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$. Correlation between PC and PM is 0.7913. Therefore, given that they are highly collinear, we ran them separately.

as the lagged variables for PM, PC, and total amount of plan funds, which all have the expected negative sign and are statistically significant in models 3, 4, and 6, respectively. Surprisingly, the variable exports, which represents the export pressure on the mostly commodity-producing provinces during the commodities boom, has a negative sign and is not statistically significant. However, land value does behave as predicted and is statistically significant: higher provincial land values increase deforestation rates by 0.337. Finally, it should be noted that both the coefficients of the natural log and the lagged PC variables show slightly larger magnitudes than the coefficients of the natural log and the lagged PM variables. This corresponds to our expectation that the more restrictive conservation plans should have a greater effect on reducing deforestation than the management plans.

Table 2 reports coefficients explaining annual OTBN deforestation rates and shows similar results to Table 1. Again, our main independent variables (PC, PM, and total amount of plan funds) appear statistically significant and with a negative sign, meaning that subnational PES have a negative effect on deforestation rates. Indeed, both logged and lagged variables behave as expected. Furthermore, while the natural logs of PC and PM are virtually of the same magnitude, with PM being slightly larger, the lagged variables show a stronger effect of the more restrictive plans (PC over PM). In more substantive terms, a 1 percent increase in the total amount of PES results in a 5.8 percent decline in the deforestation rate. If we look at the province of Chaco in the year 2011, this rate of decline would translate to 16,910 ha instead of the actual loss of 17,800 ha (without PES). That is, implementing PES would save 890 ha of native forest in Chaco, equivalent to approximately 127,270 trees, given the average tree density of the Parque Chaqueño native forest.

As expected, our export variable has a positive sign, but it is not statistically significant. Land value is a strong predictor of deforestation, showing high magnitudes and significance in all models 1–6. We speculate here that high land prices may be the key indicator of deforestation pressures and may be capturing the real effect of export demands on the provinces. Indeed, when we interpret this coefficient in more substantive terms, we reveal the devastation of high land prices. A 1 percent increase in the price of land in Argentina almost doubles the rate of deforestation. Again, in 2011, in the province of Chaco, this would entail a loss of 17,444 ha more on top of the actual 17,800 ha lost. In other words, by increasing land prices by 1 percent, we would see a loss of 2,494,492 trees, given the average tree density of the Parque Chaqueño native forest.

Finally, to test the effect of our subnational bureaucratic specialization variable (specialized ALA), we run two simple models of deforestation with the same two dependent variables from Tables 1 and 2 (UMSEF and OTBN deforestation rates). We expect subnational bureaucracies that distribute funding to be more effective in slowing deforestation rates when they have primary jurisdiction in environmental policy. Indeed, in model 1 (OTBN deforestation), we

Table 2
Annual OTBN Deforestation Rates

	(1)	(2)	(3)	(4)	(5)	(6)
H1						
PM (ln)		−0.074*** (0.0211)				
PM (lag-ln)			−0.0432** (0.0205)		0.0143 (0.0300)	
Total amount (lag-ln)						−0.058*** (0.0170)
H1a						
PC (ln)	−0.0713*** (0.0216)					
PC (lag-ln)				−0.067*** (0.0201)	−0.0785** (0.0310)	
H3						
Land value (ln)	1.768** (0.754)	1.817** (0.747)	1.375* (0.774)	1.848** (0.758)	1.891** (0.768)	1.987** (0.765)
H4						
Exports (ln)	0.0971 (0.407)	0.184 (0.406)	0.0365 (0.427)	0.0118 (0.405)	0.000294 (0.409)	0.0121 (0.404)
Constant	−7.992 (9.074)	−10.22 (9.113)	−3.773 (9.352)	−7.138 (8.994)	−7.283 (9.059)	−8.214 (9.013)
FE province	YES	YES	YES	YES	YES	YES
Observations	74	74	74	74	74	74
R^2	0.187	0.204	0.105	0.191	0.194	0.198
No. provinces	12	12	12	12	12	12
LogLik	−94.05	−93.27	−97.60	−93.88	−93.73	−93.55

Note: Standard errors are in parentheses. The DV is the total loss of coverage by year and by province.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$. Correlation between PC and PM is 0.7913. Therefore, given that they are highly collinear, we ran them separately.

Table 3
Deforestation Rates Using OTBN and UMSEF Data

	(1) OTBN	(2) UMSEF
H1: Total amount (lag-ln)	−0.0472*** (0.0170)	−0.0129*** (0.00384)
H2: Specialized ALA	−2.562* (1.314)	−0.398 (0.276)
H3: Land value (ln)	0.841 (0.549)	0.187 (0.143)
H4: Exports (ln)		−0.0615 (0.0766)
Constant	2.314 (4.574)	0.323 (1.286)
Observations	74	100
No. provinces	12	12

Note: Standard errors are in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

see that the specialization variable is negative and of a high magnitude as well as being statistically significant. Again, PES (total amount) behaves as expected and is negative and significant in both models. Land value, on the other hand, while again appearing positive, does not reach statistical significance. Readers should note that the specialization variable is constant within each province, thus making the models less robust and likely affected by contextual variables. Therefore, contrary to Tables 1 and 2, results from Table 3 should be interpreted with caution.

Conclusions

The results of our analysis show that deforestation can be slowed by PES distributed by local governments. Empirical results are consistent with our theoretical expectation that the disbursement of PES and related funding for "institution building" of provincial state agencies would have a negative impact on deforestation. Initially, we expected subnational funds with the most stringent conditions (PC)—that is, with no economic use of native trees of any kind—to be a greater drag on deforestation than less restricted plans (PM). However, models showed that there is little difference between the two plans, although the magnitude of the effect of PC on deforestation rates is slightly higher than the effect of PM. Empirical results are also consistent with our expectation that environmental regulators with greater bureaucratic specialization would be more effective in combating deforestation, although, as we stated earlier, this finding should be interpreted with caution. Surprisingly, no models showed significant coefficients for export pressures. On the other hand, high land prices are a strong predictor of deforestation rates.

Three related implications stem from our results. First, PES can counter the deforestation effects of an expanding agricultural sector. In other words, we

would have seen greater losses of tree coverage were PES not implemented in provinces. This finding is encouraging. Our intuition was that subnational state capacity mattered. We find that in a federal system like the Argentine one, indeed, provincial governments can help stop the loss of native forests when they have the proper resources. Second, land prices capture the real effect of agricultural expansion and export demands on provinces and are a brutal driver of deforestation pressures. As our models show, just a 1 percent increase in land prices can double the deforestation rate and result in the loss of millions and millions of native forest trees in only one year. Third, as high land values continue to drive deforestation even when states bring to bear their financial capacity to regulate forest conservation, policy makers may have to cap land values through direct measures, while also increasing the amount of PES and strengthening their monitoring.

As our models explain between 10 and 20 percent of annual deforestation rates, we speculate that much of the remaining variation may be explained by variables outside of our models, such as infrastructure and road development, urban settlements, and commodity prices. Still, we posit that the range of variation that our empirical analysis explains is in no way negligible.

With this study, we seek to contribute to the research on PES evaluation at the subnational level. We recognize that one obstacle to expanding subnational PES research is the availability of data, and we hope that our original database will contribute to future research on land use and subnational state capacity in Latin America. Furthermore, forest scientists have highlighted the inconsistent predictability of rigid forest models (Dalla-Nora et al. 2014). We hope to contribute also to the field of deforestation science by introducing subnational state variables. Future research, we hope, will help uncover the precise mechanisms through which PES, such as the ones studied here, help stop deforestation.

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