



The law is spider's web: An assessment of illegal deforestation in the Argentine Dry Chaco ten years after the enactment of the "Forest Law"

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ABSTRACT

Deforestation control is one of the major challenges worldwide. The aim of this study was to analyse deforestation under the Forest Law in the Argentine Dry Chaco ecoregion a decade after its enactment and to assess compliance with forest protection standards in this region. For this purpose, we overlapped the provincial land zoning maps with an annual plot level deforestation database and, for some provinces, with the rural cadastral cartography. Deforestation exceeding the values allowed by the Forest Law and the provincial zonings during this period totalized 722,782 ha (28% of the total deforested area in this period), of which 59,732 ha were deforested in high conservation value areas, 644,396 ha in medium conservation value areas and 18,654 ha in low conservation value areas. While Santiago del Estero was the province with the highest deforested area in medium conservation value areas, Córdoba was the province with the highest deforested area in high conservation value areas. Our results are an important step towards identifying discrepancies between the legal objectives and the observed results and represent an input to think about solutions to improve the environmental governance of the region.

1. Introduction

Deforestation has been framed as a wicked problem, i.e., a problem where there are political and moral issues among competing stakeholders, and where limited information is available for policy makers (Nikolakis and Innes, 2020). Policies to effectively reduce deforestation usually involve strong trade-offs between two conflicting interests: conservation and production (Angelsen, 2010). Large agricultural producers and stakeholders all along the agro-industrial chain are generally benefited by the conversion of forests to cropland or pastures (le Polain de Waroux, 2019), while such conversion often results in a loss of forest products for more vulnerable stakeholders and a reduction of the supply of ecosystem services valued at local level (Foley et al., 2007).

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Land-use regulations are a critical component of forest governance and conservation strategies (Stickler et al., 2013). In recent years, legislation to conserve the native forests of South America has undergone significant advances and reforms (Nolte et al., 2017b). In broad terms, these regulations can be divided fundamentally into two types: instruments of command and control, including mechanisms of coercion and sanction for those owners who do not comply with the rules of forest management and conservation (Holling and Meffe, 1996), and economic incentive instruments (e.g. taxes or subsidies), which create market-based mechanisms based

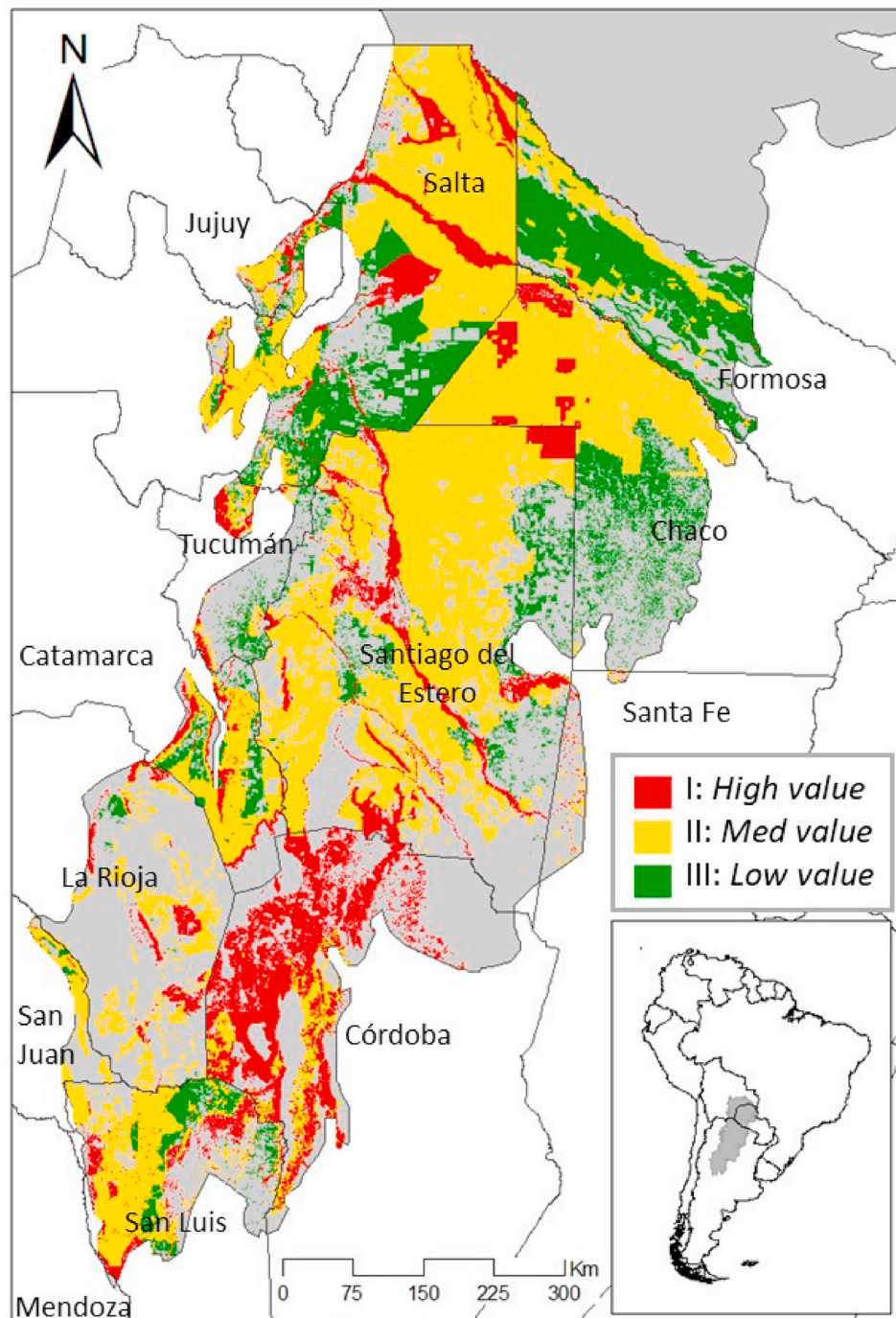


Fig. 1. Territorial Planning of Native Forests (OTBN) of each province belonging to the Dry Chaco ecoregion, Argentina. Areas of high (Category I), medium (Category II) and low (Category III) conservation value are represented in red, yellow, and green colours, respectively. According to the National Forest Law (N° 26,331) deforestation is not allowed in Category I and II, while in Category III it is allowed after the approval of a Land Use Change plan by the provincial authorities.

on sustainable supply-chain initiatives (Lambin et al., 2018). In the Brazilian Amazon, the combination of regulations through public policies and supply-chain initiatives, were successful for halting deforestation (Azevedo et al., 2017; Nepstad et al., 2014). However, in recent years, the rates have started to increase again (Carvalho et al., 2019; Fearnside, 2017). Thus, finding the appropriate institutional arrangements for halting deforestation, and determining their effectiveness, has become an active area of inquiry for solution-oriented research.

Although tropical forests were initially the main source of new agricultural lands, deforestation expanded soon into subtropical forests (Gibbs et al., 2010). In fact, the Dry Chaco ecoregion in South America is nowadays one of the regions with the highest rates of deforestation in the world (Hansen et al., 2013; Vallejos et al., 2015). The agricultural expansion in this region is currently one of the most challenging and worrying environmental problems in the Southern Cone, due to the speed of the changes, its ecological consequences and the social issues that it triggers. Forest cover changes in this ecoregion affect the provision of ecosystem services, including habitat maintenance (Mastrangelo and Gavin, 2014), climate regulation (Salazar et al., 2015), carbon storage (Gasparri et al., 2008), and water and energy balance (Amdan et al., 2013). At the local level, they also affect the flow of ecosystem services that support the well-being of local populations, causing conflicts over the use of resources (Mastrangelo and Littera, 2015). Transformations in the Chaco forests have become a substantial issue for policymakers as well as for civil society (Paruelo et al., 2011; Seghezzo et al., 2011).

The compliance with legislations that regulate the conversion of forests within a given jurisdiction may reflect the balance between the interests of different groups of actors and the asymmetries of power. Land use policies and subsidies that regulate deforestation in private lands have been conceptualized as distributive policies because they redistributes resources from rich to poor sectors of society (Lowi, 1972). Regulating deforestation in countries like Argentina, in which the economy heavily depends on the agricultural sector, is a huge challenge. As Svampa (2009) points out, there is a strong contradiction between the implementation of environmental policies and the measures taken by the governments to sustain economic growth based on the exploitation of natural resources.

2. The Argentine Dry Chaco

The Argentine Dry Chaco ecoregion (Olson et al., 2001) (Fig. 1) concentrates 80% of national deforestation (MAyDS, 2017). This region encompasses an area of 488,000 km² and includes twelve primary administrative units, called provinces. The climate is semi-arid and seasonal, with high temperatures in summer and low temperatures in winter. The rainfall is concentrated in the summer period, and varies between 400 and 700 mm per year, sharply decreasing towards the central portion and in the southwest of the region (Morello et al., 2012). The typical natural vegetation corresponds to xerophilous forest with three strata: a tree stratum dominated by *Aspidosperma quebracho blanco* (quebracho blanco) and *Prosopis* spp. (algarrobos), a tall shrub stratum dominated by legumes and zylophyllaceae and a herbaceous stratum dominated by megathermic grasses (Cabrera, 1976; Morello et al., 2012). The region also has “paleoalbardones” with vegetation cover and paleocauses of sandy soils, generally covered by aibe grasslands (*Elinurus* sp.), that cross through the forest matrix of the region (Torrella and Adámoli, 2006). Natural fire is an important factor that models the landscape at the regional level with a fundamental role in the dynamic equilibrium that exists between woody and herbaceous species, being responsible for numerous patches of grassland in the wooded matrix (Castillo et al., 2011). Fire is also manipulated by people for management purposes, to favour the regrowth of the grass on which the cattle are fed or to eliminate forested areas for agricultural purposes (Tálamo and Caziani, 2003).

The Chaco region has large areas with adequate conditions for crop production (such as soybean and corn) and meat (in cultivated pastures) that have a high global demand (Gasparri et al., 2013). This region also has high natural biodiversity coexisting with diverse cultures (Leake, 2008). Rural activities are carried out by rural actors of different size and composition, including capitalized farmers, small-scale farmers and indigenous communities (Baldi et al., 2015; Vallejos et al., 2020). Most of the native human populations of the Chaco do not possess formal land tenure rights and are being evicted due to agricultural expansion (Busscher et al., 2020). The conversion of forests to megathermic pastures or commodity crops are generally carried out by agribusiness companies (le Polain de Waroux et al., 2016), intensifying social conflicts and increasing inequalities in the region (Cáceres, 2015).

3. The forest law of Argentina

In the absence of appropriate regulations to protect native forests, in November 2007 the National Law N° 26,331 of “Minimum Standards for the Environmental Protection of Native Forests” (hereafter, the “Forest Law”) was sanctioned in Argentina to protect native forests at the national scale. This law was the first national experience of territorial planning that seeks to regulate land use at a national level. The Forest Law was fundamentally promoted by the major conservation NGOs of Argentina with the massive support of urban citizens identified with the conservationist agenda, and also by some indigenous and peasant political organizations (Cáceres et al., 2010; Seghezzo et al., 2011). Public participation was explicitly incorporated in the Law as an indispensable input to generate social consensus. The conservation of forests within the framework of the Law is pursued through two main tools: on the one hand, the environmental zoning of the territory to regulate the intensity and location of economic activities in forested lands and, on the other, economic compensations (i.e. payment for environmental services) to landowners that conserve remnant forests or manage them sustainably (Aguar et al., 2018).

Argentina is a federal country, and the National Constitution establishes that natural resources belong to the provinces (Article 124). The provincial authorities are obliged to subject their actions to the national laws, having, in turn, regulatory powers to complement the laws (Nonna, 2017). According to the National Forest Law (Law N° 26,331, Art. 6), each jurisdiction must achieve a Territorial Planning of the Native Forests (OTBN, its acronym in Spanish) existing in its territory within a maximum period of one year

from the enactment of the Law. The process must be participatory and consider ten Environmental Sustainability Criteria mentioned in the Annex of the Law (García Collazo et al., 2013). The Law considers three conservation categories (Law N° 26,331, Art. 9): Category I (red), representing areas of high conservation value; Category II (yellow), representing areas of medium conservation value; Category III (green), representing areas of low conservation value. Deforestation is not allowed in Category I and II, while in Category III it is allowed after the approval of a Land Use Change plan by the provincial authorities. The National Fund for the Enrichment and Conservation of Native Forests created by the Law should be distributed annually among the provinces that have their OTBN approved by Provincial Law. Part of the funding is destined for the generation of institutional capacities in the provincial bodies in charge of implementing and regulating the Law, and part is adjudicated to landholders who have approved a Management Plan or a Conservation Plan.

The OTBNs of each province must be updated every five years from the approval of the provincial acts (Art. 6 of the regulatory decree N° 91/09 of the Law N° 26,331). This allows a comprehensive review of the corresponding regulations and adjusts the native forests zoning plans on a provincial scale according to the criteria established by Law. The Provincial Laws of OTBN approved in the Dry Chaco ecoregion by the National Application Authority, in chronological order of approval, are: Salta (2008), Santiago del Estero (2009; updated in 2015), Chaco (2009), San Luis (2009), Formosa (2010), Tucumán (2010), Córdoba (2010), Catamarca (2010), San Juan (2010; updated in 2016), Jujuy (2011), Santa Fe (2013) and La Rioja (2010) (Fig. 1, Table 1). [See deforestation before and after the enactment of Law N° 26.331 in the Supplemental Files, Figure S1; See total and relative area classified in each category of the OTBN zoning maps for all the provinces in the Supplemental Files, Figure S2].

Two previous studies assessed the effectiveness of the Forest Law for reducing deforestation rates based on the same database of forest conversion (Nolte et al., 2017a; Volante and Seghezzo, 2018). However, they arrive at different conclusions: while Nolte et al. (2017a) suggest that the Forest Law was effective for reducing deforestation rates, Volante and Seghezzo (2018) consider that these reductions were not widespread and that there is little evidence for attributing this reduction to the enforcement of the Law. The main differences between these two studies lie on their spatial scales, methodological approaches, and impact assessment. While Nolte et al. (2017a) employed a counterfactual analysis to assess the impact of the forest law at the farm level, Volante and Seghezzo (2018) analysed the compliance of the Law by describing the temporal changes in deforestation rates between strict vs. less strict zones, before and after its enforcement at the province level (Nolte et al., 2018). In accordance with Volante and Seghezzo (2018) results, Camba Sans et al. (2018) concluded that in Santiago del Estero the zoning policy was not effective enough, since deforestation surpassed the level of deforestation allowed. Ceddia and Zepharovich (2017) also concluded that regulations were not effective in Salta for slowing down deforestation trends.

This study aimed to analyse the deforestation under the Forest Law in the Argentine Dry Chaco ecoregion a decade after its enactment and to assess compliance with forest protection standards in this region. Estimating discrepancies between the legal objectives and the observed results is useful to think about solutions to improve the environmental governance of the region (Nolte et al., 2018). Despite the importance of assessing the Forest Law for the definition of future land use planning policies, an evaluation of the level of compliance of the Forest Law and other normative related to the native forest conservation for the entire Argentine Dry Chaco ecoregion was not been performed yet. There have been complaints from numerous NGOs about non-compliance with the forest law, but the magnitude of this non-compliance has yet to be rigorously quantified.

4. Methods

4.1. Assumptions of the analysis

According to the National Forest Law of Argentina and the interpretation that each province made of the categories (Table 2), deforestation was considered as illegal, when:

- i) It occurred in areas of high conservation value (Category I, red), where forest use and deforestation are prohibited. According to the National Law, these areas should not be transformed, regardless of their status or level of degradation, due to their

Table 1

Normative regulations (and respective updates) for the Territorial Planning of Native Forests (OTBN, its acronym in Spanish) of each provincial jurisdiction belonging to the Dry Chaco ecoregion and date of enactment, with their respective updates.

Province	Normative (First OTBN)	Enactment	Normative (OTBN Update)	Enactment
Salta	Provincial Law N° 7543	December 16, 2008	–	–
Santiago del Estero	Provincial Law N° 6942	March 17, 2009	Provincial Act N° 3133	December 23, 2015
Chaco	Provincial Law N° 6409	September 24, 2009	–	–
San Luis	Provincial Law N° IX-697	December 16, 2009	–	–
Formosa	Provincial Law N° 1552	June 09, 2010	–	–
Tucumán	Provincial Law N° 8304	June 24, 2010	–	–
Córdoba	Provincial Law N° 9814	August 05, 2010	–	–
Catamarca	Provincial Law N° 5311	September 09, 2010	–	–
San Juan	Provincial Law N° 8174	November 11, 2010	Provincial Law N° 1438-L	July 18, 2016
Jujuy	Provincial Law N° 5676	April 14, 2011	–	–
Santa Fe	Provincial Law N° 13,372	December 11, 2013	–	–
La Rioja	Provincial Law N° 9771	September 01, 2015	–	–

Table 2

Restrictions imposed for each category of conservation according to the Provincial Laws of OTBN in the jurisdictions included in the Argentine Dry Chaco.

Province	Category I (red)	Category II (yellow)	Category III (green)
Santiago del Estero		The level of transformation allowed in category IIb is between 10 and 20%, depending on the size of the property and a previous zoning of Santiago del Estero (details in Sans et al., 2018, Table 1). In category IIa sustainable use is allowed but deforestation is prohibited.	May be partially or entirely transformed, prior approval of the Land Use Plan.
Formosa	Forest use and deforestation are prohibited.	Sustainable use (Art. 4, Law N° 26,331) is allowed, but deforestation is prohibited.	The level of transformation allowed depends on the size of the property, the subcategory and the physiognomic group involved. Allows the transformation of 60% of the area in Sub-category IIIa (Central and Eastern) and 20% in Sub-category IIIb (Corridors).
Salta, Chaco, Córdoba, Jujuy, San Juan, Santa Fe, Tucumán, La Rioja			May be partially or entirely transformed, prior approval of the Land Use Plan.

connectivity and their location concerning reserves, their outstanding biological values, watershed protection and/or the presence of indigenous communities.

- ii) It occurred in areas of medium conservation value (Category II, yellow), where forest use is allowed but not deforestation. According to the National Law, these areas should not be transformed, and can only be subjected to sustainable use, tourism, collection and scientific research. This category also included deforestation in Santiago del Estero that occurred in Category IIb, where deforestation was partially allowed based on the provincial zoning (Provincial Law N° 6942 and Provincial Decree N° 3133-L). In this case, deforestation was considered illegal when it occurred in yellow areas that included green dots and above the permitted values according to the size of the property (methodology used by [Sans et al., 2018](#)).
- iii) It occurred in areas of low conservation value (Category III, green) in the province of Formosa, where deforestation was partially allowed based on the provincial zoning (Provincial Law N° 1552). According to this Law (Art. 17 and 19; Provincial Law N° 1552), Category III (which represents 70% of the area zoned in the province) comprises two classes: Category IIIa, where transformations of up to 20% of the surface of each property are admitted; and Category IIIb, where transformations of up to 60% of the surface of each property are admitted ([Torrella et al., 2018](#)). In this case, the deforested area above the admitted values according to the size of the property was considered illegal.
- iv) It occurred during the precautionary measure ordered by the National Supreme Court of Justice that ordered the provisional cessation of logging and deforestation in the departments of San Martín, Orán and Rivadavia, in the province of Salta. This measure took place in December 2008. The lawsuit was filed by indigenous communities and “criollos” (i.e. descendants of European immigrants, today impoverished) against the province of Salta and the National State, holding the province of Salta responsible for granting authorizations of approximately one million hectares of clearing in the last quarter of 2007 prior to the sanction of the Law and the National State for the lack of control (Cause entitled “Salas, Dino and others vs. Province of Salta and National State”). The measure was revoked in December 2011, in which the Court ruled that clearances authorizations should be adapted to the provincial zoning (Law N° 7543), already in force. Although the measure also included the department of Santa Victoria, it was not considered, because it is outside the study area.

Deforestation was NOT considered as illegal when:

- i) It occurred in areas of low conservation values (Category III, except in the case of Formosa), where deforestation is partially or totally allowed once the plan for the sustainable management of native forests has been approved within the criteria of the National Law. According to the National Law, these areas are likely to be transformed after the approval of a land use change plan, which must contemplate minimum conditions of sustained production in the short, medium and long term and the use of available technologies that allow the efficient performance of the proposed activity. All land use change plans submitted to the competent provincial bodies should be evaluated in the framework of a public audience where interested actors participate, and potentially affected groups are consulted. In this sense, this approach underestimates illegal deforestation, since it does not consider deforested plots of more than 10 ha that were performed without the approval by the provincial government after a public audience and consultation of potentially affected groups.
- ii) It occurred in Uncategorized areas or areas that have been categorized as “non-forest” by the OTBN zoning maps. In this sense, the database used to quantify deforestation includes areas whose natural coverage has been transformed by the anthropic action. Since some controversy about the definition of forest exists ([FAO, 2014](#)) and each province used different base information of available forests ([Gautreau et al., 2014](#)), it is possible that there have been forest areas with different conservation

status that are included in one of these categories. In this sense, this approach underestimates the calculation of illegal deforestation, since it does not consider the transformation of forest ecosystems that were not classified as forest in the OTBN zoning maps.

- iii) It occurred during the “moratorium on deforestation permits”. During the time between the enactment of the National Law and the approval of the Provincial Territorial Planning of Native Forests (OTBN), deforestation could not be authorized (Art 8, Law N° 26,331). This approach underestimates illegal deforestation since it does not consider the occurrence of deforested areas that were cleared without deforestation permits, even in areas that were later categorized as high or medium conservation value.

4.2. Data analysis

To estimate the deforested area that was not allowed by Law (hereafter, illegal deforestation) in each jurisdiction, we overlapped the OTBN zoning maps approved by each province with an annual plot level deforestation database using QGIS 3.8.1. software (QGIS Development Team, 2018) [See methodological overview in the Supplemental Files, Figure S3]. The shapefiles of the provincial OTBN zoning maps (Fig. 1) were provided by the Ministry of Environment and Sustainable Development of Argentina (MAyDS, 2018). The deforestation database was obtained from the project “Monitoreo de la Deforestación en el Chaco Seco” (LART, 2017). This database, with an overall classification accuracy of 97.8%, was built by manually digitalizing polygons of deforested plots from 1976 to the present, using Landsat imagery (see methodological procedure in Vallejos et al., 2015). The time window selected to perform the analysis was from 2008 to 2017. We estimated the illegal deforestation according to the criteria listed above (see “Assumptions of the Analysis” section) by conservation category and by year of occurrence. We also calculated the area transformed in areas categorized as “non-forest” and uncategorized areas.

Santiago del Estero and Formosa provinces had restrictions based the size of the properties (Table 2), for which it was necessary to use the rural cadastral cartography. The rural cadastral cartography of Santiago del Estero (Angueira et al., 2007) and Formosa (IDEF, 2017) were used to perform calculations. In the case of Formosa, the cadastre was manually digitalized, as the information was not downloadable. Thus, we calculated the maximum allowed value that could be deforested by law in each cadastral unit belonging to Category IIB (yellow) in Santiago del Estero and Category IIIa and IIIb (green) in Formosa.

5. Results

Ten years after the enactment of the Forest Law (from 2008 to 2017) 2,599,721 ha of the native ecosystem had been transformed. Provinces with the largest total transformed area was Santiago del Estero (908,617 ha), followed by Salta (532,890 ha), Formosa (395,411 ha), Chaco (306,832 ha) and Córdoba (170,384 ha) (Fig. 2). 40% of the total transformed area occurred in Category III (green), 32% in Category II (yellow) and 4% in Category I (red), corresponding to areas of low, medium, and high conservation value, respectively. Moreover, 15% occurred in non-forest area, and 9% in unclassified areas.

The total area illegally deforested in the Dry Chaco ecoregion from 2008 to 2017 was 722,782 ha (28% of the total transformed area in this period), of which 59,732 ha were deforested in high conservation value areas, 644,396 ha in medium conservation value areas and 18,654 ha in low conservation value areas of Formosa. The province with the largest area of illegal deforestation was Santiago del Estero (399,834 ha), followed by Salta (146,366 ha), Chaco (80,478 ha), San Luis (31,291 ha), Formosa (26,470 ha), Córdoba (25,183 ha), Catamarca (5200 ha), Santa Fe (3574 ha), Tucumán (2117 ha), Jujuy (1092 ha), La Rioja (943 ha), Jujuy (535 ha) and San Juan (243 ha). The province with the highest deforestation in areas of high conservation value (Category I) was Córdoba (21,116 ha), followed by Salta (16,832 ha), while the province with the largest deforested area in areas of medium conservation value (Category II) was Santiago del Estero (382,749 ha) (Fig. 3).

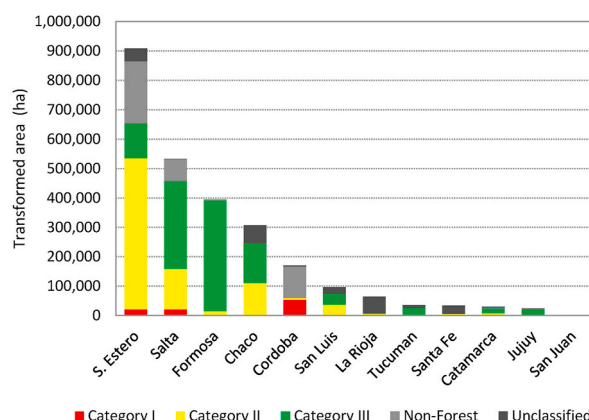


Fig. 2. Deforested area by province in the categories established by the provincial OTBNs in the Dry Chaco ecoregion from 2008 to 2017. Light grey represents transformation in areas that were categorized as non-forest, while dark grey represents transformation in areas that were not classified in the provincial zonings.

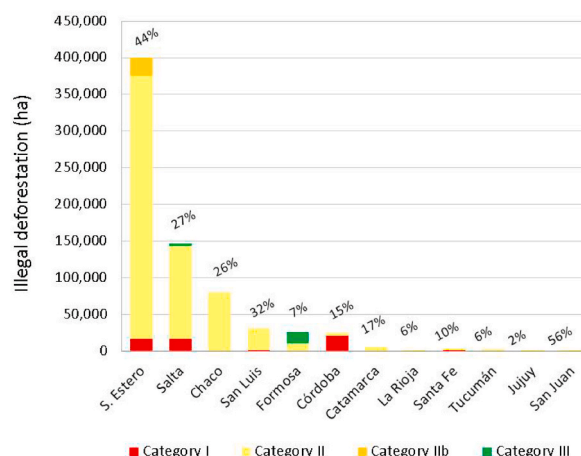


Fig. 3. Total deforestation not allowed by the Forest Law and provincial OTBNs by province and category of conservation. Labels show the percentage of not allowed deforestation over the total transformed area in each province from 2008 to 2017.

The total deforested area during the moratorium on deforestation permits was 235,286 ha. This value considers the period between the enactment of the National Law and the approval of OTBNs in each province. La Rioja, Córdoba, and Santa Fe were the provinces with the highest proportion of deforested area during the moratorium of deforestation permits in areas that were later considered restricted by the OTBNs (87%, 58% and 42%, respectively, in relation with the total deforested in restricted areas) (Fig. 4). The largest area illegally deforested (110,575 ha) was detected in 2011, but the largest deforested area in categories that were later considered as high and medium conservation value was detected in 2008, during the moratorium (157,283 ha) (Fig. 5).

During the precautionary measure of the National Supreme Court of Justice in the province of Salta (2009–2011) 50,905 ha were deforested in the portion of the Dry Chaco corresponding to the departments of San Martín (53%), Orán (36%) and Rivadavia (10%) (Fig. 6). This area corresponds to 84% of the total deforestation in the province of Salta during this period (2009–2011) and represents about 30% of the total deforestation in areas of high and medium conservation value (Categories I and II) between 2008 and 2017 in the province of Salta.

6. Discussion

Our analysis provides an estimate of the deforested area in the Argentine Dry Chaco and assesses compliance with the Forest Law a decade after its enactment. We found that at least 772,782 ha were deforested exceeding the values allowed by the National Law and the provincial OTBNs between 2008 and 2017. This area represents 28% of the total deforested area in this period. This analysis is extremely conservative and probably underestimate illegal deforestation since it does not consider transformed areas within Category III (green) corresponding to areas of low conservation value that did not have a deforestation permit issued by the provincial authorities (a requirement imposed by the National Law). This estimate also does not consider forest areas transformed in any category during the moratorium on deforestation permits that did not have prior authorization to the enactment of the National Law, nor native forest conversion in areas that were categorized as non-forest by provincial zonings or were uncategorized. Additionally, since we used an annual database of deforestation, clearings that occurred since the date of enactment of the OTBN within a province (end of moratorium) and the beginning of the following year were neither quantified in the estimate. For some provinces in which the sanction occurred at the beginning or middle of the year, this sub estimation may have been meaningful.

Additionally, our results show that 401,714 ha were transformed in areas classified as “non-forest” and 228,855 ha in unclassified areas by the OTBN provincial zoning maps, which represents 24% of the total transformed area between 2008 and 2017. It is important to keep in mind that the total area of native forests declared by the provinces in their OTBN does not coincide with the area surveyed in the First National Forest Inventory (SAyDS, 2005). For example, in Santiago del Estero, 7,108,203 ha of native forests were declared (MAyDS, 2017), representing 85% of the area inventoried by the SAyDS (2005). In contrast, 1,208,942 ha of native forests were declared in Jujuy (MAyDS, 2017), representing 115% of the inventoried by the SAyDS (2005). This could explain part of the deforested area in areas not classified or classified as non-forest. Another part could be explained by the database of deforestation we used in this analysis, which considers transformed areas with anthropic evidence of changes in land use by visual interpretation of satellite imagery, so some of the detected clearings might not strictly be forests according to the definition of forest made by the Forest Law and the provincial OTBNs but could be another cover of native vegetation (e.g. shrublands).

According to the Forest Law, the provinces had to make their OTBNs within a maximum period of one year after the enactment of the Forest Law (Art. 6, Law N° 26,331), but many provinces significantly delayed this process. One of the reasons why the OTBN proposals were delayed was that the regulatory norm of the Forest Law that was supposed to be performed within ninety days after the Law enactment, finally took place fourteen months later, in February 2009. Despite the claim of many environmental groups regarding the increase in deforestation occurring in that period, the Forest Law defined that during the moratorium of deforestation permits,

Cumulative deforestation (ha) in areas not allowed by the Forest Law

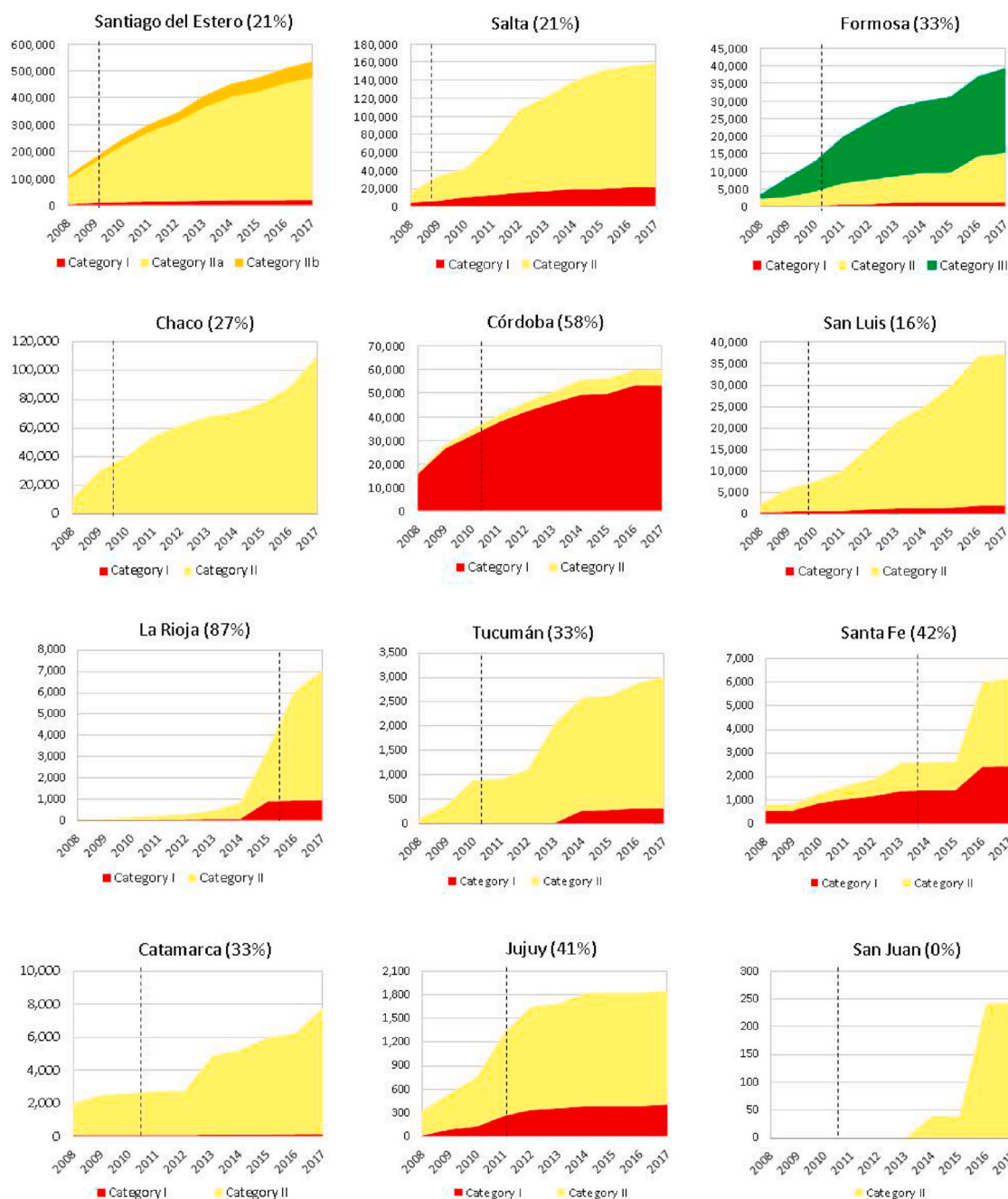


Fig. 4. Cumulative deforestation in areas not allowed by the Forest Law and the provincial OTBNs from 2008 to 2017 within the twelve provinces included in the Argentine Dry Chaco ecoregion. Areas of high (Category I), medium (Category II) and low (Category III) conservation value are represented in red, yellow, and green colours, respectively. Dotted lines represent the date of enactment of each OTBN. Values in brackets represent the proportion of deforested area during the moratorium of deforestation permits in areas that were later considered restricted by the OTBNs.

provinces were not allowed to authorize deforestation (Art. 7, Law N° 26,331), which means that deforestation authorized before November 2007 met the sufficient legal requirements to be carried out during the moratorium. As there is no official information available about which deforestation was authorized prior to the enactment of the Forest Law and which was not, it is difficult to separate deforestation that was executed respecting the moratorium. Our study shows that in some cases (e.g. Córdoba and Jujuy) the rate of deforestation decreased in areas that were later categorized as medium and high conservation value after the approval of the OTBN (end of moratorium). This could indicate a lack of consideration of the environmental sustainability criteria in the approval of the permits by the provincial authorities or the lack of permission to carry out a land use change by the landowners.

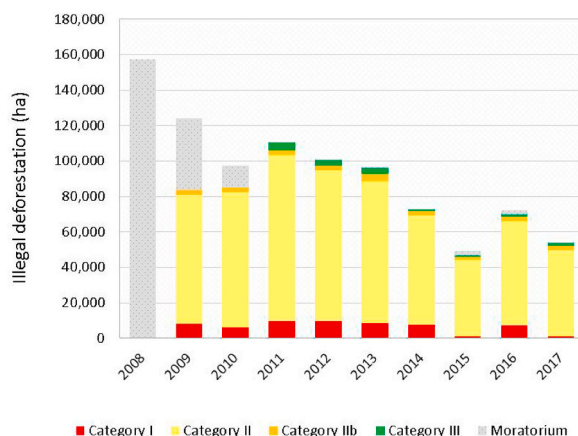


Fig. 5. Total deforestation not allowed by the Forest Law and provincial OTBNs by year (from 2008 to 2017) in Dry Chaco ecoregion by category of conservation. Deforested area during the moratorium on deforestation permits that were later categorized as medium and high conservation values are shown in grey.

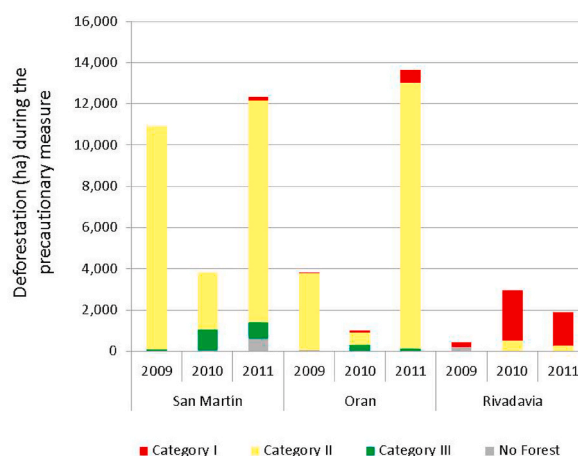


Fig. 6. Deforestation occurred during the precautionary measure of the National Supreme Court of Justice (2009–2011) that ordered the provisional cessation deforestation in the departments of San Martín, Orán and Rivadavia in the province of Salta. In total, 50,905 ha were deforested in the Dry Chaco portion corresponding to those departments.

The province of Salta deserves a special analysis since, in December 2008, the National Supreme Court of Justice acceded to the request of indigenous communities and “criollos”, giving rise to a precautionary measure, and ordered the Government of the province the cessation of deforestation and logging of native forests in the departments of Orán, San Martín, Rivadavia, and Santa Victoria (Buliubasich, 2013). In this decision, the Supreme Court evaluated the absence of information related to cumulative environmental impacts and the lack of precise determination of the areas that could be categorized as sectors of high or medium conservation value (Paruelo et al., 2011). Despite the disposition of the Supreme Court, 50,905 ha were illegally deforested during the period in which the precautionary measure was extended (2009–2011) in the Dry Chaco portion of the departments of San Martín, Orán, and Rivadavia. Our results show that 30% of the total deforestation in areas of high and medium conservation value (Categories I and II) in the province of Salta between 2008 and 2017 was performed in contravention with the precautionary measure provided by the Supreme Court of Justice.

The property recategorizations represent a special consideration to assess compliance with the Law, given that the conservation category defined in the OTBNs can be redefined at the property scale through an administrative process (FARN, 2019a). The Ministry of Environment and Sustainable Development of the Nation (MAYDS) and the Federal Environment Council (COFEMA) provided methodological guidelines for updates of the territorial planning of native forests. According to these guidelines, zoning changes should be granted only for exceptional cases according to the principle of non-regression in environmental matters, but never systematically applied, so that changes in zoning to a conservation category below the established value constitute a violation of the Law (Di Pangraccio et al., 2014). However, many provinces did not take those guidelines. In the province of Salta, more than 150,000 ha of native forests initially zoned in categories I (red) and II (yellow) were re-categorized to category III (green), through decrees 221/10

and 3136/11, in 2010 and 2011. Thus, a rejection public campaign was performed across the country. In September 2014, the Office of the Ombudsman of the Nation urged the provincial government to revoke those decrees that allowed recategorizations, to deepen the control mechanisms and to apply the maximum sanctions provided for in the provincial law of OTBN N° 7543. As a result of this procedure, in December 2014 the government of Salta revoked the decrees that allowed recategorization and owners who have carried out illegal deforestation were urged to recompose the damaged environment (FARN, 2019a). In the province of Chaco, the Undersecretariat of Natural Resources of the province carried out – in a systematic way – re-categorizations that modify the zoning established in the OTBN, at the simple request of the owner, through decrees 1103/12, 742/15 and 598/16. In this way, 67 farms, covering 51,768 ha of native forests initially zoned in Category II to Category III, were recategorized (Greenpeace, 2018).

In the provinces of Formosa and Santiago del Estero, according to the OTBN zoning policies, the maximum area to be transformed according to the Law depends on the size of the property and the zone where the property is located (Law N° 1552 in Formosa and Law N° 6942 in Santiago del Estero). This type of zoning represents a major obstacle to ensuring compliance with the minimum criteria established by the Forest Law as legal insecurity over land tenure in these provinces is very high (Rivas and Natera Rivas, 2009) and there are no reliable updated available cadastres. In this sense, it is essential to carry out a survey and measurement of rural lands to generate information that contributes to improve the accuracy of the data and facilitates the processes of territorial planning. The digitalization and creation of an information management system will improve the Forest Law assessment in these provinces and will also contribute to a critical review of current legislation on land administration and adjudication.

7. Conclusion

Illegal deforestation results from the equilibrium between economic demands of the agricultural sector and strength of the State to ensure compliance with the law (Alcañiz and Gutierrez, 2020). On one hand, deforestation is determined by increases in economic activity of the agricultural sector (Gasparri et al., 2013). On the other hand, the laws that regulate land use in forest areas generally depend on the willingness and power of local governments to implement and enforce the law (Burgess et al., 2011). Understanding how these two forces operate is necessary to establish viable policies with local governance systems.

Forest management processes are characterized by being highly politicized, driven by interest groups and electoral strategies, and often shaped by corruption (Nikolakis and Innes, 2020). Decentralized governance processes that involve a diverse network of actors in decision-making are increasingly shaping forest policy (Libert-Amico and Larson, 2020; Lund et al., 2018). In turn, non-state rules can influence and shape forest laws and regulations, helping to improve forest standards in some jurisdictions (Cashore et al., 2007). Forest use policies are no longer composed solely of rules, laws and regulations at the local level, but global agencies are involved to develop forest standards that go beyond those required by the state (Gulbrandsen, 2004; McDermott et al., 2015). For the Mercosur countries (Argentina, Uruguay, Brazil, Paraguay, Venezuela and Bolivia) the fulfilment of environmental standards represents a vital issue for the access to international markets. The Mercosur-EU agreement is strongly questioned precisely because of aspects linked to illegal deforestation (Kehoe et al., 2020).

The enactment of the Forest Law in Argentina was an unprecedented advance towards environmental regulation and territorial planning. Nevertheless, its effective implementation faces severe difficulties that must be solved. Our study showed that illegal deforestation represents a significant portion of total deforestation. We hypothesize that illegal deforestation within the framework of the Forest Law occurs for two fundamental reasons: (a) The payments for environmental services contemplated by the Law fail to offset the gains generated from deforestation; (b) Penalties and fines for illegal deforestation are not severe enough to offset the gains generated from deforestation.

The effectiveness of the payments for environmental services is based on the design, the conditions of implementation and the ability to create real incentives for stakeholders to abstain from generating environmental impacts (Börner et al., 2017). The Forest Law stipulates that the National Fund for the Enrichment and Conservation of Native Forests may not be less than 0.3% of the national budget (Art. 31, Law N° 26,331), but the annual budget assigned for its implementation has been progressively reduced in relation to what is stipulated by law. In 2010, the allocation to the Fund represented 36% of what was established by Law, while in 2017 this percentage decreased to 8% (FARN, 2019b). In a context of high land prices driven by high prices of agricultural products, the payment obtained for the conservation or sustainable management of forests is insufficient compared to the profits generated from agricultural production or real estate business. The value of cleared land is currently three times that of forest land, and the profit margin is still very positive, even discounting clearing costs. For example, in Santiago del Estero, 1 ha occupied by forest can cost approximately USD 800, while its price without forest reaches USD 3,200, being the cost of clearing USD 1200 (Mónaco et al., 2019).

The Forest Law includes a system of sanctions for those people who do not comply with the regulations (Art. 29, Law N° 26,331), which are governed by the corresponding administrative procedure rules in each jurisdiction, according to the nature of the infringement. The local enforcement authorities are responsible for forwarding information on infringements that have occurred in their area to the national authority, which must compile and publish data, however, currently only three provinces of the Chaco region report data in this system: Catamarca, Córdoba and Salta (Mónaco et al., 2019). Regarding the application of sanctions to offenders, they have been scarce, and in addition fines have been established whose value has not been dissuasive in relation to the increase in the real estate value of the land (Di Pangrazio and Cáceres, 2019).

Although the violation of the norm is considered as a contravention from the point of view of civil law, the Forest Law also allowed environmental damages to be considered legal damages, allowing judicial action in cases of environmental disturbances. An example of the application of this legal procedure was in the northeast of the province of Salta, where the provincial Justice sentenced the owner of an establishment to one year in prison for the crime of judicial disobedience aggravated by illegal practice in areas explicitly protected by law, in October 2015. The lawsuit also includes a fine that would be used to finance environmental restoration activities.

This case established jurisprudence to condemn illegal deforestation in the framework of criminal law (Aguiar et al., 2018).

Environmental policymaking is a result of a political struggle in which multiple stakeholders attempt to influence decisions towards their preferred outcomes (Nepstad et al., 2014). In this sense, land use changes in areas not permitted by law are a sign of deficiencies in the control by provincial authorities and reflect the asymmetry of power among the multiple actors operating in the region. Provincial zoning maps in the Argentine Dry Chaco were shaped by intense struggles between the interests of the agricultural industry, peasants, indigenous groups, environmental activists, academics and the national government (Cabrol and Cáceres, 2017; Silveti et al., 2013). In the same way, different movements also arose at the provincial and national level denouncing breach of law and demanding rigorous control in relation to native forest loss by the provincial and national state. This highlights the convergence of expectations in the legal framework, as a strategic regulatory space for the defence of different interests concerning territorial planning and environmental protection.

Deforestation is a wicked problem that cannot be solved, but simply one that we must co-exist with (Nikolakis and Innes, 2020). As legal mechanisms to regulate deforestation does not solve the problem of illegal deforestation, it becomes necessary to consider other instruments such as collaborative forest governance, through incentives to participate and mechanisms to reconcile power among actors (Nikolakis and Hotte, 2019). The effective control of deforestation in Argentina still faces great challenges. The optimal functioning of the Forest Law depends, ultimately, on the degree of involvement, commitment and dedication that each of the interested parties contributes. In short, the fulfilment and scope of the objectives of the law depends on the speed, mobilization, updating of each of these instruments and the degree of social, institutional and political participation that is achieved.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://10.1016/j.envdev.2021.100611>

“La ley es tela de araña, / y en mi ignorancia lo explico, / no la tema el hombre rico, / no la tema el que mande, / pues la rompe el bicho grande, / y sólo enrieda a los chicos”.

“The law is spider’s web, / and in my ignorance I explain it, / the rich man does not fear it, / the boss does not fear it, / since it is broken by the big animal, / and only entangle the little bugs”.

“Martín Fierro”. José Hernández

Credit author statement

María Vallejos: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. Gonzalo H. Camba-Sans: Conceptualization, Methodology, Writing – review & editing. Sebastian Aguiar: Conceptualization, Writing – review & editing. Matías E. Mastrángelo: Conceptualization, Writing – review & editing. José; M. Paruelo: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

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