Article

Characteristics of particular forest producers in Mexico

Juan Manuel Torres-Rojo[1§]
Fernando Carrillo Anzures[2]
Miguel Acosta Mireles[2]
Eulogio Flores Ayala[2]
Dora Ma. Sangerman-Jarquín[2]

[1]University Transdisciplinary Center for Sustainability-Iberoamerican University Santa Fe. Prolongation of Paseo de la Reforma 880, Lomas de Santa Fe, Álvaro Obregón, Mexico City. ZC. 01219. [2]Mexico Valley Experimental Field-INIFAP. Highway Los Reyes-Texcoco km 13.5, Coatlinchán, Texcoco, State of Mexico. ZC. 56250. (carrillo.fernando@inifap.gob.mx; acosta.miguel@inifap.gob.mx; flores.eulogio@inifap.gob.mx; sangerman.dora@inifap.gob.mx).

[§]Corresponding author: juan.torres@ibero.mx.

Abstract

Globally, 74% of forest area is owned by governments. In Mexico, private property can be collective (colony, ejidos and communities) or individual (natural or juridical persons). Individual forest property is related to the concept of small property, defined by the Agrarian Law as an area of land owned by a single owner. The objective was to characterize privately owned forest properties (POFPs) in terms of their abundance, composition and uses, as well as the general characteristics of the type of forest management applied, based on the fusion of available data and some assumptions. The cover of series VI of INEGI was used to characterize the vegetation cover of individual properties. Land use change estimates were made by difference between the cover of series VI and series III. Timber and non-timber harvest volumes and areas are derived from the relational database developed in Microsoft Access®. The results show that there are about 769 000 ha in POFPs under timber exploitation of a potential of 9.4 Mha of primary and secondary vegetation forests located on private properties; forests that could be added to sustainable forest management. It was observed that only 8% of temperate forests on private properties are legally exploited, so there is a large area of temperate forests that could be incorporated into sustainable forest management. POFPs have an important participation in timber production, representing an important component in forest management at the national level.

Keywords: family properties, forest property, small property, timber exploitation.

Reception date: March 2022
Acceptance date: May 2022

Introduction

Historically, most of the world's forests have been under government control and the most common use has been timber exploitation through concessions (Molnar *et al*., 2011). Sunderlin *et al*. (2008) estimate that, globally, 74% of forest area is owned by governments; about 2.3% is government owned but inhabited by forest communities; 9.1% is communally owned and managed by communities, while the remaining 14.2% is owned by individuals (individuals or companies).

In developing countries, the percentage of forests owned by communities is higher and reaches an average of 27% (Larson *et al*., 2010), with extreme cases such as China with 60% (Zinda and Zhang, 2018), Mexico with 62% (Torres and Callejas, 2015) and Papua New Guinea with more than 90% (White and Martin, 2002). However, at the global level, timber exploitation continues to be carried out mainly in forests owned by individuals and in state forests through the system of timber exploitation concessions (Molnar *et al*., 2011). In Mexico, private property can be collective (colony, ejidos and communities) or individual (natural or juridical persons).

Individual forest property is related to the concept of small property, which, according to the Agrarian Law, is defined as an area of land owned by a single owner. The maximum extent of the small property is defined in terms of the irrigated agricultural land or its equivalence for land of other uses. The legislation states that a natural person can own a maximum of 100 contiguous irrigated hectares and be considered a small owner. The equivalence of 8 for the case of land for forest use limits the 'small' forest property to a maximum of 800 ha (Article 119, Ley Agraria).

This maximum area of private forest property is large enough to carry out productive activities on an efficient scale. However, larger scales of production can be achieved if it is considered that the same law allows partnerships between small owners whose area is equivalent to a maximum area equal to twenty-five times the small property, that is 20 000 ha. In the forestry sector, these partnerships between individual properties are common in the management of forest resources in what is known as 'property sets' for timber management (Carrillo *et al*., 2017) or for forest management with various purposes (Pérez-Verdin *et al*., 2015).

In Mexico, the latest land use map published by the National Institute of Statistics and Geography (INEGI, 2017) shows that the country's forest area is approximately 66.2 million hectares. Of this area, it is estimated that about 61% (39.8 million ha) corresponds to ejido and communal property (Torres and Callejas, 2015), while the rest of the forest area is distributed between private property, agricultural colony and public property.

INEGI (2016), in its 'update of the agricultural census framework' estimates that 53.1% of the national area is socially owned (ejidos and communities), 44.8% privately owned (natural or juridical persons), while the remaining 2.1% is either government (federal, state and municipal) property, or defined in agricultural colonies.

Based on this information and under the assumption of a random distribution of land uses, it can be estimated that between 38% and 40% of the forest (temperate and tropical) area is under private property. This area, close to 25 million ha (Mha), has been poorly documented even though it is of high importance not only for the timber production derived from it, but also for the ecosystem services it generates.

Much of the characterization of forest management in Mexico has been carried out in ejidos and communities, so there is little information about the characteristics of private forest producers. Undoubtedly, this lack of knowledge must be modified in the near future given that, under the new Law for Sustainable Forest Development of 2018 (DOF, 2018), forest management carried out by 'rightful owners and possessors, under the principles of sustainability, equity, inclusion and respect for traditions, uses and customs', is also considered community forest management, it refers to the fact that a number of privately owned properties are usually family properties, where decision-making is carried out within the family (Mendoza *et al*., 2015).

With this background, the present work aims to characterize privately owned forest properties (POFPs) in terms of their abundance, composition and uses, as well as the general characteristics of the type of forest management to which they are subjected.

Materials and methods

The characterization of producers is based on the fusion of different available databases and some assumptions. For the characterization of the vegetation cover of the private properties, the cover of series VI of INEGI (INEGI, 2017) was used, which has 2014 as its reference year. It was assumed that the cover of private properties corresponds to the complement of the cover of properties (RAN, 2012) with social property (ejidos/communities), this derived from the fact that only 2.1% of the total area of the country is owned by the government (federal, state or municipal) or has the legal figure of colony (INEGI, 2016). Under this assumption, the estimated cover of privately owned land use would have a maximum overestimation of 2.1%.

The estimates of land use change were made by difference between the cover of series VI and the cover of series III (INEGI, 2017), which has 2002 as its reference year, using general categories of land uses. This difference was transformed into the annual rate of change of land use based on the compound interest formula for the 12-year period (difference between the reference year of the series used in the comparison). The estimation of the proportion of the area in private property that is in protected natural areas (PNAs) was made with reference to the PNA cover of CONABIO (CONABIO, 2021), while the estimation of the levels of marginalization in the areas of private property was approximated with the marginalization cover of CONAPO (CONAPO, 2016).

Estimates of timber and non-timber harvest volumes and areas are derived from the relational database in Microsoft Access® developed by Carrillo *et al*. (2017), which is integrated by the information contained in authorization documents of timber forest exploitation, forest management programs (FMPs) for the exploitation of timber forest resources and notices of non-timber exploitation, as well as other socioeconomic variables in different entities of the federal and state governments. The states included in this database are: Chihuahua, Durango, Jalisco, Michoacán,

Guerrero, Oaxaca, Puebla, State of Mexico, Chiapas, Quintana Roo, Veracruz and Campeche. Finally, the reclassification of types of producers, management systems and other variables are detailed in Carrillo *et al*. (2017).

Results

Characteristics of privately owned forest areas

Based on series VI of INEGI and considering the estimate of area by type of property defined in the 'update of the agricultural census framework' (INEGI, 2016), it was estimated that the total area considered under the status of private, state and colonial property (hereinafter POA) is 94.1 Mha. Of this total, 27.5% corresponds to forests and rainforests (equivalent to 25.8 Mha), a proportion lower than the 39% of forest cover represented by areas under the status of social property.

The difference in this proportion is that POA areas concentrate a greater proportion of area in urban areas (1.7%), agricultural areas (16%), pastures (19.4%) and forest plantations. It is notable that POAs concentrate 55% of the 27.5 Mha with agricultural use in the country (Torres and Rojas, 2018) and more than 85% of the area in forest plantations.

The higher population density in POAs makes them more prone to changes in land use, as shown in Table 1, where annual rates (period 2002-2014) of increase (i.e., negative value between the difference in cover 2002-2014) of the area in forest plantations (9.8%), agricultural area (0.38%), urban settlements (3.58%), area without vegetation (0.68%) and temperate forest (0.15%) stand out. This latter land cover would seem to indicate a significant annual recovery of the temperate forest cover in POAs; however, the breakdown of this land use into relevant subcategories (Table 1) shows that there is a loss of primary vegetation (mainly pine-oak) and an even greater gain in secondary vegetation, both processes make it appear a gain of cover in the aggregate (negative net deforestation).

Table 1. Annual rate of land use change in selected land uses within POAs.

Land use	Annual variation rate (%) (2002-2014)	Land use	Annual variation rate (%) (2002-2014)
Plantation	-9.8	Agriculture	-0.38
Temperate forest	-0.15	Rainforest	0.275
Oak forest	0.33	High evergreen rainforest	0.795
Oak-pine forest	0.28	Low deciduous rainforest	0.571
Pine forest	0.12	Low deciduous thorny rainforest	1.663
Pine-oak forest	0.91	Low evergreen rainforest	4.129
Cloud forest	0.63	Low semideciduous rainforest	3.948

Land use	Annual variation rate (%) (2002-2014)	Land use	Annual variation rate (%) (2002-2014)
Secondary tree vegetation of oak forests	-2.97	Medium semievergreen forest	2.002
Secondary tree vegetation of oak-pine forests	-3.11	Pasture	0.235
Secondary tree vegetation of pine forests	-2.34	Without vegetation	-0.682
Secondary tree vegetation of pine-oak forests	-2.81	Urban settlement	-3.585
Secondary tree vegetation of cloud forests	-1.81	Arid and semi-arid areas	0.228

Estimate based on series III and VI of INEGI (2016) and RAN (2012).

However, these figures clearly show a loss of primary vegetation and a marked degradation of the main types of vegetation of the temperate forest, in which timber exploitation is carried out. The impact of land use change on POAs covered by primary vegetation of rainforests is very high, mainly in low and medium rainforests (Table 1). As in the case of temperate forests, the secondary vegetation of rainforests registers an increase; however, not so high as to balance the loss of this land use.

The total area of terrestrial PNAs amounts to 21 372 350 ha (CONANP, 2019), of which approximately 43% (9.4 Mha) is in POAs, distributed in a wide variety of vegetation types and with also variable restrictions of land use. The fact that most of the PNAs under the category of Natural Monument are in POAs and more than half of the Natural Resource Protection Areas are also under a private property status stands out (Table 2).

Table 2. Area and proportion of POAs within PNAs by category.

Management category	Area in POAs (Mha)	Proportion of area in POAs (%)
Flora and Fauna Protection Areas	2.302	34.55
Natural Resource Protection Areas	2.466	54.76
Natural Monument	0.015	92.96
National Park	0.404	60.09
Biosphere Reserve	4.17	43.83
Sanctuary	0.002	39.63
Total	9.359	

Estimate based on data from CONANP (2019); INEGI (2017).

POAs are closer to population centers and have greater accessibility in terms of communication routes than socially owned areas. Therefore, they have better accessibility to markets, health and education systems and, of course, technology and other resources.

Figure 1 shows the distribution of the proportion of the area in POAs by its category of marginalization in different classes of land use. It is notable that most of the forest areas in POAs are in areas of high and very high marginalization; areas in plantations (85%), temperate forest (59%) and arid zones (92%) stand out. In contrast, only 40% of the rainforest areas in POAs are of high and very high marginalization.

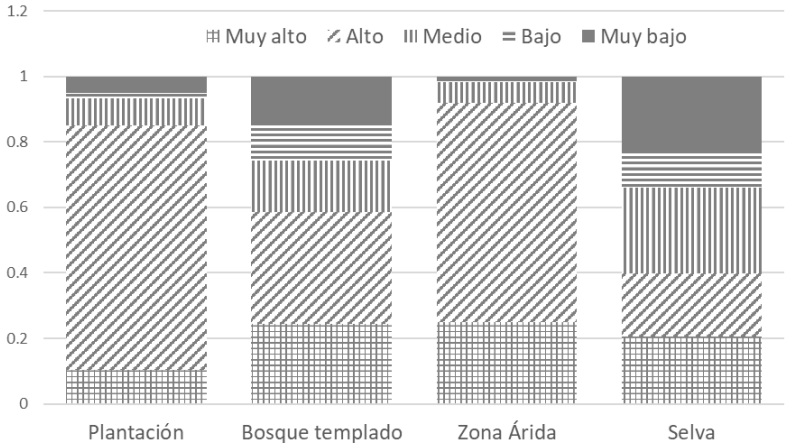

Figure 1. Distribution of the proportion of the area in POAs by its category of marginalization and by selected land uses. Elaboration with data from CONAPO (2016); INEGI (2017).

It should be noted that the rainforest areas in POAs with a low level of marginalization are concentrated in vegetation types such as low deciduous rainforests in the west of the country and medium rainforests in Campeche and Quintana Roo.

Characteristics of privately owned areas of timber exploitation

CONAFOR (2019) indicates that there are 11 390 privately owned forest properties (POFPs) that have reported some type of permit request. The sample analyzed in the database reported by Carrillo *et al*. (2017) consists of 7 556 POFPs (66% of the total) that have carried out some type of timber forest exploitation. This sample considers timber forest exploitation in variable periods for the 12 states included in the database. In some states, exploitations have been reported since 1990, such as the states of Durango and Veracruz, while in others there is only information until after 2004. With this sample, differences were identified between the exploitations carried out on socially owned land versus those that are carried out on privately owned land.

Timber production in POAs is quite atomized. The data reflect that privately owned properties under timber exploitation only concentrate 9.7% of the forest area in the 12 states analyzed; however, these properties represent 78% of the exploitation permits. The average exploitation area per privately owned property is 102 ha, an area that contrasts with the average exploitation area in socially owned properties, which amounts to 1 519 ha. This level of atomization forces privately owned properties to tend to exploit, on average, 81% of the forest area they own, a figure that contrasts with 37% of socially owned forest properties.

The size distribution of the forest area of POFPs is very asymmetrical; the high frequency of properties with a forest area of less than 30 ha stands out (Figure 2). The data show that 61.1% of POFPs have a wooded area of less than 30 ha and only 7.6% have a wooded area of more than 300 ha. Small properties are occasionally integrated into property sets (PSs) for their management; the average size of the properties is 98 ha, while the average size of the property sets amounts to 180 ha. Nevertheless, the frequency of property sets of less than 30 ha is high, the data show that 58% of property sets have an area of less than 60 ha.

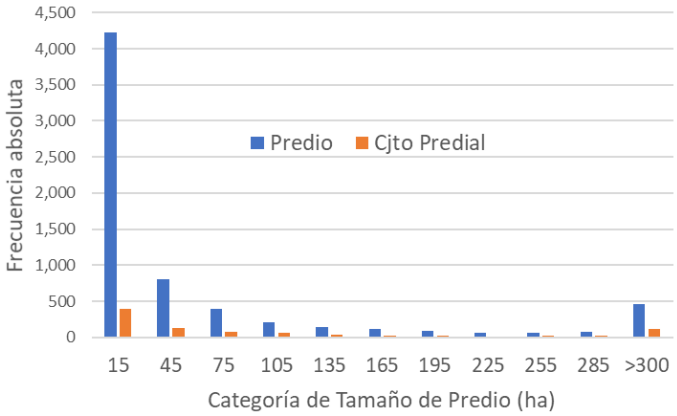

Figure 2. Size distribution of POFPs.

The average authorized annual yield is another contrasting variable. Privately owned forest properties (POFPs) show an average authorized annual yield of the order of 5.35 m^3 ha, while socially owned forest properties (SOFPs) have an authorized yield of less than half (2.89 m^3 ha). For its part, the average number of authorized annuities in POFPs is significantly lower (6.02 years) than the average authorization in SOFPs (9.05 years), which reflects more frequent exploitations in the former than in those of social property. Finally, a revealing fact is that if the average authorized area is divided by the average number of years of the authorizations, the quotient estimates the annual exploitation area. This area is 17 ha for POFPs, contrasting with the 168 ha in SOFPs (Table 3), which reflects an average annual exploitation per property of the order of 92 m^3.

Table 3. Comparison between the exploitation of socially owned land and POAs.

	Total	Private	Social sector
Forest area (ha)	9 792 811	950 277	8 781 771
No. of properties with authorization	9 690	7 556	2 134
Harvest area (ha)	4 035 479	769 010	3 242 169
Authorized annual volume (m^3)	13 480 816	4 115 529	9 365 287
Average authorized annual yield (m^3 ha^{-1})	3.34	5.35	2.89
Average harvest area per property (ha)	416	102	1 519
Average authorized volume per property (m^3)	1 391	545	4 389
Percentage of forest area	100	9.7%	89.7%
Percentage of exploited area	41.21%	80.92%	36.92%
Percentage of authorized volume	100	30.5%	65.5%

With data from Carrillo *et al*. (2017).

Taken together, these data show that POFPs have a more intensive, more frequent exploitation and is carried out in a greater proportion of the forest area of the property than SOFPs. This indicates that the conservation area in POFPs is more limited and that it is very difficult to achieve economies of scale for cultivation and harvest extraction.

Regarding the type of timber forest management, approximately 40.5% of the properties indicate a regular forest management (Silvicultural Development Method or SICODESI), 2.3% a mixed forest management (combination of regular and irregular) and 57% an irregular management (i.e., Mexican Method of Forest Management). The results show that 76% of the property sets have an irregular management, undoubtedly related to the fact that the selective system has fewer harvesting restrictions and allows cuts in the entire area under management.

It is noteworthy that a little more than 75% of the properties under the regular management system are in the states of Jalisco, Puebla and Veracruz. Within this system, the most used silvicultural method is parent trees (99%), followed by clearcutting (0.36%) and successive cuts (0.2%). Veracruz and Oaxaca are the only two states that report the use of a method of regeneration by clearcutting (not used in property sets) and Durango that of successive cuts. It should be noted that, under the name of regular system, it is common to observe in medium to large properties a combination of the silvicultural method of selection with the application of thinning, especially in the forests of the states of Durango and Chihuahua.

The annual current increase (ACI) reports show an average value of 4.34 m^3 ha^{-1} $year^{-1}$; however, the variation is very high. The states of Chiapas, Durango and Chihuahua show lower annual growth (ACI) with average values between 2.6-2.7 m^3 ha^{-1} $year^{-1}$, average values between 2.8-3.5 m^3 ha year in Jalisco and Michoacán and high values between 3.8-5.9 m^3 ha^{-1} $year^{-1}$ in Veracruz, Puebla, Oaxaca and Mexico. A relevant fact is that the average authorized yield (Table 3) is higher than the estimate of the reported average ACI, a difference that reflects a slightly higher exploitation than the growth rate, as has been reported in some studies (Cubbage *et al*., 2015).

The vertical integration of POFPs is very low. The data shows that 88% of producers sell their standing wood, 10% carry out exploitation and extraction and only 2% do some transformation of the logs. Vertical integration is closely related to scale; the properties that sell standing wood have an average size of 86 ha, while those that sell logs have an average area of 291 ha, and those that have transformation machinery have an average area of 560 ha. It should be noted that 98% of the property sets sell their standing wood.

Finally, the results show that, on average, there are about 769 000 ha in POFPs under timber exploitation of a potential of almost 9.4 Mha of forests of primary and secondary vegetation of pine, oak, pine-oak associations located in private property; forests that could be added to sustainable forest management.

Discussion

Traditionally, private property of the forest has been seen as a form of property in which a sustainable resource management is more likely to be achieved because the owners regularly have productive objectives (Conway *et al*., 2003), in contrast to the forms of common property that could be subject to overexploitation, derived from the lack of organization among the users of the resource, what is known as the tragedy of the commons (Hardin, 1968).

However, the collective action developed by many communities for the sustainable management of their forest resources allows the creation of socio-environmental systems that contradict this principle by being able to self-impose restrictions on access and management of the resource in order to achieve its sustainability, even at the expense of their personal benefits (Ostrom, 1990; Agrawal, 2007; Bray, 2020). Hence, if the restrictions of self-government or management imposed by the community are aligned and are of the same magnitude as those that ensure sustainable management, there should be no difference either in the efficiency with which the resource is managed, or in ensuring its sustainability, regardless of the form of property of the forest (Gibson *et al*., 2002).

So, the only differences should be attributed to the various preferences in the management objectives of owners or users that establish criteria for harvesting or forest structure (Tucker, 1999) under the assumption that there are institutions and rules to enforce the restrictions on the use of the forest (Gibson *et al*., 2002).

The results presented here show that POFPs are managed with an objective more linked to timber production than to the production of other satisfiers and ecosystem services, as is the case of SOFPs. The timber harvest in POFPs is higher per unit area and more frequent than in SOFPs; nevertheless, whether it is efficient and sustainable remains in doubt, given that there is no evidence of vertical integration accompanying these high production volumes, nor of a harvest volume less than or equal to the growth volume (ACI).

These characteristics of the production in POFPs suggest little investment in efficient and environmentally friendly harvesting systems that could ensure ecosystem conservation and a long-term timber yield. Similarly, they suggest the probable application of management systems that are eliminating the timber inventory, which puts at risk the permanence of optimal residual volumes that ensure not only the highest timber production, but also a high production of ecosystem services (Pukkala, 2016).

The problem of the rapid elimination of the adult forest inventory (degradation) is aggravated by the characteristics of production in smallholdings and property sets, since areas of high density of smallholdings with a permanent harvesting activity negatively impact the landscape by concentrating large areas of forest under production and leaving few areas without harvesting activities, increasing fragmentation and degradation (Ask and Carlsson, 2000). The immediate effect is a decrease in ecosystem services and a decrease in long-term timber productivity. Collective actions to identify corridors and conservation areas in these aggregates of smallholdings can certainly contribute to reducing the negative impact of the fragmentation and degradation generated by the forest management in smallholdings (Fischer *et al*., 2010) or reducing conservation and protection costs (Canadas *et al*., 2016).

A practice that could contribute to promoting this collective action would be the promotion of the exploitation through property sets with contiguous properties, which allows increasing the extent of conservation areas and balancing the exploitation in the entire property set, in addition to providing more economic advantages for the set of owners. A problem faced by a high percentage of POFPs is the lack of regularization of properties (Toledo Aceves *et al*., 2019), which hinders the procedures for exploitation requests, access to government support programs and the horizontal integration of companies that may have a larger scale of production.

A mechanism that could mitigate this problem would incorporate more POFPs into sustainable production, would reduce the serious problem of illegal logging, which is largely concentrated in these properties due to the relative absenteeism of their owners (Honey-Rosés 2009), and would improve the well-being of smallholder owners, who, as has been proven in the characterization presented, show a high level of marginalization.

The results show that only 8% of temperate forests in privately owned areas are legally exploited, so there is a large area of temperate forests that could be incorporated into sustainable forest management. The exploitation on a low scale makes forest management and its exploitation more expensive, so there is undoubtedly a pending issue in the development of public policies that: 1) encourage the partnership between POFPs or SOFPs to generate economies of scale and reduce fixed costs (fire control, plant production, road maintenance, among others), as well as reducing problems of fragmentation and degradation through collective actions in the definition of conservation areas or biological corridors; 2) that reduce transaction costs when processing timber management and exploitation programs, and strengthen investment in the forest; and 3) that encourage the creation of productive structures that provide goods and services for the sustainable exploitation of the forest (services of harvesting and sale of wood, supply of inputs for forest management and harvesting, integration of associations for the collection or processing of wood in different stages of transformation, among others) that give greater added value to production, that reduce the costs of exploitation and improve the income of smallholder producers. Some of these practices have proven their advantages in the management of large areas of private smallholdings in the Nordic countries.

Conclusions

The work showed that POFPs have an important participation in timber production and represent an important component in forest management at the national level. Nevertheless, there are indicators that show a very intensive exploitation of forest areas under private properties, which suggest a reduction in the volume of the inventory, landscape fragmentation and a likely degradation of forest areas. This suggests the convenience of generating and strengthening public policies and the collective action of producers and society in general to reduce the barriers that prevent the incorporation of more POFPs into sustainable forest management, improve the partnership between producers to generate economies of scale and mitigate the effects of forest management through smallholdings, directly or indirectly strengthening the social, technical and economic capacities of POFPs.

Cited literature

Agrawal, A. 2007. Forests, governance, and sustainability: common property theory and its contributions. Inter. J. Commons. 1(1):111-136.

Ask, P. and Carlsson, M. 2000. Nature conservation and timber production in areas with fragmented ownership patterns. Forest Pol. Econ. 1(3-4):209-223.

Bray, D. B. 2020. Mexico's community forest Enterprises: success on the commons and the seeds of a Good Anthropocene. University of Arizona Press. 292 p.

Canadas, M. J.; Novais, A. and Marques, M. 2016. Wildfires, forest management and landowner's collective action: A comparative approach at the local level. Land Use Policy. 56:179-188.

Carrillo-Anzures, F.; Acosta-Mireles, M.; Flores-Ayala, E.; Torres-Rojo, J. M.; Sangerman-Jarquín, D. M.; González-Molina, L. y Buendía-Rodríguez, E. 2017. Caracterización de productores forestales en 12 estados de la República Mexicana. Rev. Mex. Cienc. Agríc. 8(7):1561-1573.

CONANP. 2019. Comisión Nacional de Áreas Naturales Protegidas. Áreas naturales protegidas decretadas. http://sig.conanp.gob.mx/website/pagsig/datos_anp.htm#:~:text=%C3%81reas%20Naturales%20Protegidas%20decretadas,una%20superficie%20de%20596%2C867.34%20hect%C3%A1reas.

CONAFOR. 2019. Comisión Nacional Forestal. El sector forestal mexicano en cifras 2019. CONAFOR. Zapopan, México. http://www.conafor.gob.mx:8080/documentos/docs/1/7749El%20Sector%20Forestal%20Mexicano%20en%20Cifras%202019.pdf.

CONABIO. 2021. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. Geoportal de áreas las naturales protegidas. https://monitoreo.conabio.gob.mx/areas-protegidas.html.

CONAPO. Consejo Nacional de Población. 2016. Índices de marginación municipal 1990-2015. http://www.conapo.gob.mx/es/CONAPO/datos_abiertos_del_indice_de_marginacion.

Conway, M. C.; Amacher, G. S.; Sullivan, J. and Wear, D. 2003. Decisions nonindustrial forest landowners make: an empirical examination. J. Forest Econ. 9(3):181-203.

Cubbage, F. W.; Davis, R. R.; Rodríguez, P. D.; Mollenhauer, R.; Kraus-Elsin, Y.; Frey, G. E.; González-Hernández, I. A.; Albarrán-Hurtado, H.; Salazar-Cruz, A. and Chemor-Salas, D. N. 2015. Community forestry enterprises in Mexico: sustainability and competitiveness. J. Sustain. For. 34(6-7):623-650.

DOF. 2018. Diario Oficial de la Federación. Secretaría de Medio Ambiente y Recursos Naturales. (Ed.). Vespertina decreto por el que se abroga la Ley General de Desarrollo Forestal Sustentable, publicada en el Diario Oficial de la Federación. 2-48 pp.

Fischer, A. P.; Bliss, J.; Ingemarson, F.; Lidestav, G. and Lönnstedt, L. 2010. From the small woodland problem to ecosocial systems: the evolution of social research on small-scale forestry in Sweden and the USA. Scandinavian J. For. Res. 25(4):390-398.

Gibson, C. C.; Lehoucq, F. E. and Williams, J. T. 2002. Does privatization protect natural resources? Property rights and forests in Guatemala. Soc. Sci. Q. 83(1):206-225.

Hardin, G. 1968. The tragedy of the commons. Science. 162(3859):1243-1248.

Honey-Rosés, J. 2009. Illegal logging in common property forests. Soc. Nat. Resour. 22(10):916-930.

INEGI. 2016. Instituto Nacional de Estadística y Geografía. Actualización del marco censal agropecuario 2016. http://www.beta.inegi.org.mx/programas/amca/2016/.

INEGI. 2017. Instituto Nacional de Estadística y Geografía. Cobertura de uso del suelo y vegetación serie VI. https://www.inegi.org.mx/temas/usosuelo/#descargas.

Larson, A. M.; Barry, D.; Dahal, G. R. and Colfer, C. J. P. 2010. Forests for people: community rights and forest tenure reform. Earthscan, Londres. 263 p.

Mendoza, M. A.; Fajardo, J. J.; Curiel, G.; Domínguez, F.; Apodaca, M.; Rodríguez-Camarillo, M. G. and Zepeta, J. 2015. Harvest regulation for multi-resource management, old and new approaches (old and new). Forests. 6(3):670-691.

Molnar, A.; Barney, K.; DeVito, M.; Karsenty, A.; Elson, D.; Benavides, M.; Tipula, P.; Soria, C.; Shearman, P. and France, M. 2011. Land acquisition of rights on forest lands for tropical timber concessions and commercial wood plantations. Washington, DC. USA. The International Land Coalition. 6 p.

Ostrom, E. 1990. Governing the commons. The evolution of institutions for collective action. Cambridge University Press. 3-8 pp.

Pérez-Verdín, G.; Cassian-Santos, J. M.; Von Gadow, K. and Monarrez-Gonzalez, J. C. 2015. Molinillos private forest estate, Durango, Mexico. *In*: forest plans of North America Academic Press. 97-105 pp.

Pukkala, T. 2016. Which type of forest management provides most ecosystem services? For. Ecosyst. 3(1):1-16.

RAN. 2012. Registro Agrario Nacional. Padrón e historial de núcleos agrarios: PHINA, V3. <http://phina.ran.gob.mx:8080/phina2/>.

Sunderlin, W.D.; Hatcher, J. and Liddle, M. 2008. From exclusion to ownership? Challenges and opportunities in advancing forest tenure reform. Rights and Resource Initiative. Washington, DC. 54 p.

Toledo-Aceves, T.; Gerez-Fernández, P. y Porter-Bolland, L. 2019. ¿Qué se necesita para avanzar hacia el manejo de los bosques de niebla secundarios en México? CCMSS, México. 1 p. http://www.ccmss.org.mx/.

Torres, T. F. y Rojas, M. A. 2018. El suelo agrícola en México: retrospección y prospectiva para la seguridad alimentaria. Realidad, datos y espacio. Rev. Inter. Est. Geogr. 9(3):137-155.

Torres-Rojo, J. M. y Amador-Callejas, J. 2015. Características de los núcleos agrarios forestales en México. *In*: desarrollo forestal comunitario: la política pública. Torres-Rojo, J. M. (Ed.). CIDE. Coyontura y Ensayo. 15-38 pp.

Tucker, C. M. 1999. Private versus common property forests: forest conditions and tenure in a Honduran community. Human Ecol. 27(2):201-230.

White A. and Martin, A. 2002. Who owns the world's forests? Forest tenure and public forests in transition. Forest Trends. Wasington, DC. 30 p.

Zinda, J. A. and Zhang, Z. 2018. Stabilizing forests and communities: accommodative buffering within China's collective forest tenure reform. The China Quarterly. 235:828-848.