Research Note

Producción maderable de *Abies religiosa* (Kunth) Schltdl. & Cham. en zonas de movimiento de germoplasma

Timber production of *Abies religiosa* (Kunth) Schltdl. & Cham. in germplasm movement zones

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Resumen

En México no existe una producción forestal autosuficiente. Esta situación requiere la mejora de los procesos que intervienen de manera integral en ella. *Abies religiosa* es el oyamel que más se aprovecha en los bosques de coníferas, y aporta valiosos dividendos económicos al sector industrial; por lo que es necesario implementar esquemas que lleven a su sostenibilidad. En el presente trabajo se determinó la cantidad de madera que se produce en las Zonas de Movimiento de Germoplasma (ZMG). El análisis determinó que la zona X.3 presentó la mayor cantidad, con 67.94 %; mientras que a X.1, X.2, XII.1 y XII.3 les correspondieron 32.06 %. Las zonas III.1, III.2, XII.4 y XII.5 no registraron producción maderable. Los resultados denotan que el máximo volumen se obtiene de la región localizada en la parte central del país; por lo tanto, es importante mantener e incrementar las actividades de fomento en la zona X.3, para perpetuar la especie y aprovecharla a través de otros servicios. La toma de decisiones en la gestión silvícola de esta pinácea puede estar circunscrita a las ZMG, en donde es factible administrar sus poblaciones de forma más efectiva para su conservación y manejo, además de favorecer su aprovechamiento a nivel regional, en cuyos rodales se mantengan características uniformes.

Palabras clave: Conservación forestal, gestión forestal, oyamel, producción forestal, sostenibilidad, zonas semilleras.

Abstract

In Mexico, timber production is insufficient to meet the market demand. In the face of this situation, it is necessary to improve the processes that participate integrally in it. *Abies religiosa* is the most harvested fir species in coniferous forests, and provides important profits to the industry sector; therefore, new models must be developed for its sustainability. In this work, the timber production for germplasm movement zones (GMZ) was estimated. The analysis showed that the X.3 zone had more timber production than other zones, i.e. 67.94 %, while X.1, X.2, XII.1 y XII.3 had 32.06 %, and III.1, III.2, XII.4 and XII.5 had none. Results showed that most of the timber production takes place in the central part of the country, and that X.3 zone needs to increase its forests development in order to maintain the species and exploit it by means of other services. Decisions on the forest management of this species of the family Pinaceae may be circumscribed to the GMZs, where its populations can be managed in a more effective way for their conservation and forest management; such decisions can also favor the exploitation of the species at a regional level, in stands that will keep their uniform characteristics.

Key words: Forest conservation, forest management, fir, forest production, sustainability, seed zones.

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The forest production in Mexico is not self-sufficient, given the demand for forest products, although approximately 6.2 million hectares of temperate and tropical forests are allocated to silvicultural activities (Torres-Rojo *et al.*, 2016); in these forests, conifers have the most intense management (Semarnat, 2016). This situation demands the implementation of both technical and administrative alternatives aiming toward the achievement of an efficient industrial transformation (Flores *et al.*, 2007) and an increase in the productivity of forests and plantations; toward the improvement of the commercialization channels, of an integral and sustainable management of resources, and toward compliance with the legislation currently in force (Flores *et al*., 2018). As for the administrative part, the regionalization of wooded areas based on particular (*e.g.* ecological) characteristics could be a key element that supports the management of tree masses without limiting the technical and economic efforts of the operational areas at a local or state level or within the forest management units (Umafor).

The genus *Abies* is the second timber pine species in the country (Semarnat, 2016), and *Abies religiosa* (Kunth) Schltdl. & Cham. is the species with the greatest economic importance, since it is the most exploited in conifer forests, contributing 2.8 % of the annual timber production (Semarnat, 2016). It reports valuable dividends to the industrial sector, because it is used to produce paper pulp, packing crates, poles, beams, andirons, piles, firewood and charcoal (Arriola *et al.*, 2015). In terms of silviculture, efforts have been made to determine the productivity of this species in forest masses (Vásquez-Bautista *et al*., 2016); however, sustainable production and conservation schemes still need to be implemented.

Within this context, the purpose of the present study was to determine the timber production of *A. religiosa* in the germplasm movement zones (GMZ) of Mexico; these are sufficiently homogeneous ecological areas where the species dwells, and whose operational management extends beyond the conventional scopes: local, state or forest management units (Umafor).

The GMZs were described as having an adequate regionalization level for use in the nationwide management of the species.

The data of the timber (m^3) harvested in 2017, compiled by the *Secretaría de Medio Ambiente y Recursos Naturales* (Department of the Environment and Natural Resources, (Semarnat) (Table 1) —which are used in the preparation of the Statistical Yearbook of Forest Production, and therefore constitute a good indicator of its contribution to the national Gross Domestic Product (GDP)— were utilized to estimate the output of each GMZ.

Table 1. Forest timber production (m^3) of *Abies religiosa* (Kunth) Schltdl. & Cham. harvested in 2017, by state.

State	Timber volume¶
Guerrero	1 138.26
Hidalgo	5 472.5
Jalisco	2 030.05
Michoacán	35 290.34
Morelos	52.58
Puebla	72.18
Tlaxcala	15 674.04
Veracruz	597.62
Total	60 327.57

¶According to information provided by Semarnat (2018).

The GMZs proposed by the *Comisión Nacional Forestal* (National Forest Commission) (Conafor, 2016) were utilized as forest management regions because they are forest resources management areas (Flores, 2018). Activities related to the establishment of germplasm producing units and to the management of forest germplasm are carried out in them (Secretaría de Economía, 2016). Within these areas, the distribution of the species

was determined based on the geographic data of the plots of the National Inventory of Forests and Soil (NIFS, 2004-2007), and was represented using the QGIS software (http://qgis.osgeo.org) (QGIS Development Team, 2015). This software has been developed for the analysis and projection of geographic data. The output of timber in each GMZ was estimated based on the relative importance of the sacred fir per GMZ and on the state outputs, according to the following proposed formula:

$$Vol.\,GMZ = \sum_{i=1}^{n}\sum_{j=i}^{n} IR_i * PE_j$$

Where:

Vol. GMZ = Volume of timber (m^3) of the germplasm movement zone

IR$_i$ (Relative Importance) = Number of plots of the NFIS with the presence of *Abies religiosa* within the ith GMZ / Total number of plots with the presence of *Abies religiosa* of the NIFS

PE$_j$ = Timber output (m^3) of the jth state

The analysis determined that GMZ X.3 had the largest timber production, amounting to 67.94 %, while X.1, X.2, XII.1 and XII.3 contributed 32.06 % (Table 2, Figure 1). Nevertheless, zones III.1, III.2, XII.4 and XII.5 did not contribute to the timber production (0.00 %), due to the low density of *A. religiosa* individuals (the NIFS records 5 to 91 individuals in the zones) of natural forests (Ruelas and Dávalos, 1999). The results indicate that the largest volume comes from forests located in the central part of the country: zone X.3 (*Hidalgo, Michoacán, Morelos, Puebla, Tlaxcala, Veracruz*). Therefore, sustainable management activities must be maintained and increased, and the sustainable management activities must be augmented in order to perpetuate the species in question and exploit it for other purposes*; i.e.* ecosystemic services (Cepeda *et al.*, 2016).

Table 2. Forest timber production of *Abies religiosa* (Kunth) Schltdl. & Cham. by GMZ.

GMZ	Num. of individuals of the NFIS	States	Timber production (m³)	(%)
X.1	5	*Jalisco*	845.85	1.40
X.2	10	*Michoacán*	14 704.31	24.37
X.3	91	*Hidalgo, Michoacán, Morelos, Puebla, Tlaxcala, Veracruz*	40 984.52	67.94
XII.1	7	*Jalisco*	1 184.20	1.96
XII.3	8	*Guerrero, Michoacán*	2 608.69	4.32
Total			60 327.57	100.00
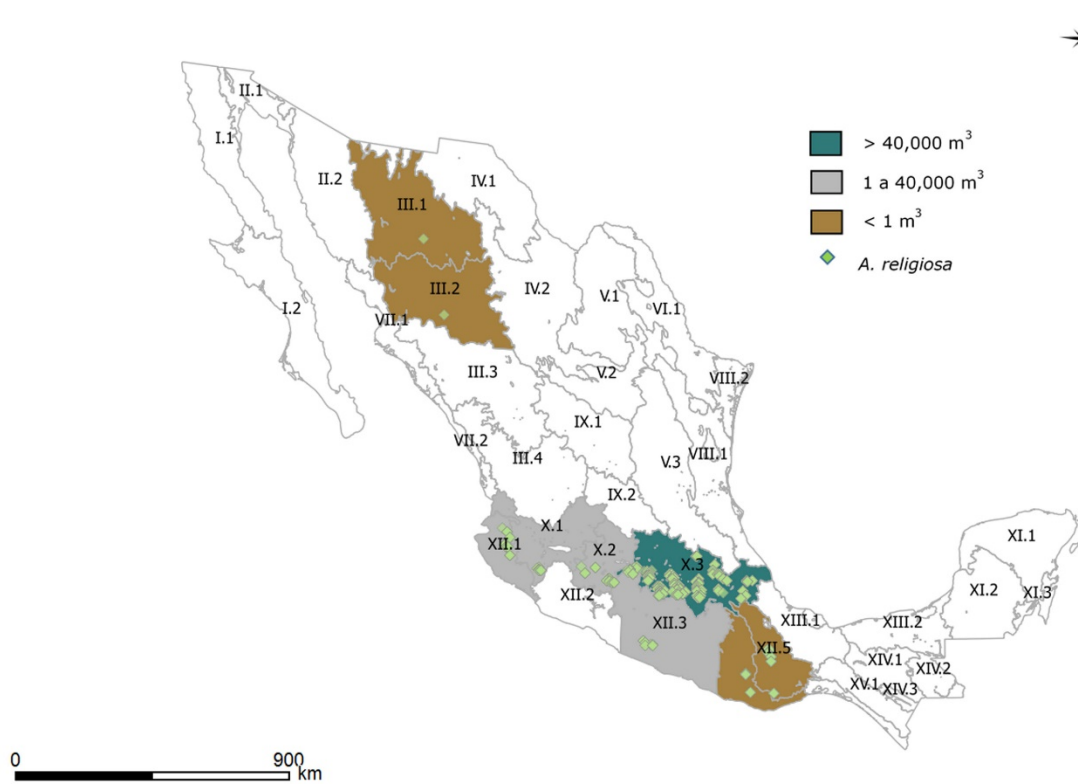
Figure 1. Timber production of *Abies religiosa* (Kunth) Schltdl. & Cham. in the GMZs.

On the other hand, although many efforts have been made to characterize some of the forest states in the country, for example, based on forest products and their production system (Carrillo *et al.*, 2017), this has not been done at a regional level, which would allow planning an optimal integral exploitation of the species of interest. The decision-making process in the management of *A. religiosa* forests may be circumscribed to the GMZs, as these areas are subjected to sufficiently homogeneous ecological conditions, with stands that have uniform genetic or phenotypic characteristics (Flores *et al*., 2014); also, the timber supply and transformation activities can be optimized within them without being limited to local or state operational areas or to forest management units (Umafor). This condition facilitates a more effective management of tree populations through the implementation of sustainable conservation and management policies intended to bring greater economic, social and industrial benefits.

Sustainable management of *A. religiosa* in the GMZs requires taking into account the environmental changes that will affect the populations of this species, in order to establish actions that may ensure their permanence and recovery, such as assisted migration into zones with a higher altitude and environmental suitability (Sáenz-Romero *et al*., 2012).

A. religiosa is a conifer that contributes significantly to the production chain of the forestry sector; the management of *A. religiosa* forests based on the sustainable conservation of homogeneous ecological zones (GMZs) must be therefore considered. This will favor the exploitation of the species at the level of regions where the stands can maintain uniform characteristics.

The analyzed areas differ as to their timber output: GMZ X.3 provides 67.94 % of the national production, while zones X.1, X.2, XII.1 and XII.3 contribute 32.06 %.

Forest management efforts —such as the establishment of germplasm producing units, protection of areas for the preservation of genetic resources, and forest germplasm management— must be increased in zone X.3, in order to ensure the continuity and sustainability of the species.

It is also necessary to delve into the results presented herein, in order to estimate the timber volumes (m^3 ha^{-1}) that can be produced in each GMZ, by developing statistical models for forest management.

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Conflict of interests

The author declares no conflict of interests.

Contribution by author

Andrés Flores: planning and structuring of the study, analysis of the information, and drafting of the manuscript.

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