Revista Mexicana de Ciencias Forestales Vol. 10 (55)
Septiembre –Octubre (2019)

DOI: https://doi.org/10.29298/rmcf.v10i55.604

Nota de Investigación

Potencial de reforestación de seis especies de pino para la restauración de zonas degradadas

Reforestation potential of six pine species for restoring of degraded zones

Andrés Flores*[1], Tomás Pineda Ojeda[2] y Eulogio Flores Ayala[2]

Resumen

En México, los bosques templados se han reducido debido al cambio de uso de la tierra para la agricultura, la tala ilegal, los incendios forestales, las plagas y las enfermedades. No obstante, el programa de reforestación (PR) es una estrategia para aumentar las áreas forestales y reducir la degradación de sus suelos. Los objetivos de este trabajo consistieron en evaluar el potencial de producción de planta para reforestación de *Pinus pseudostrobus*, *P. engelmannii*, *P. montezumae*, *P. greggii, P. arizonica* y *P. durangensis* para la restauración de zonas degradadas; y en determinar los esfuerzos del PR para la producción de las especies. Se estimaron las áreas potenciales para reforestación y las de degradación de tierras forestales; también se analizaron las capacidades del PR para la producción de planta de coníferas, basadas en el número de viveros establecidos (V), unidades de producción de germoplasma (UPG) y bancos de germoplasma (BG) instalados. Los resultados mostraron que las especies estudiadas pueden reducir 57.52 % del área total degradada. Las superficies anuales estimadas para restaurar fueron: 15 458.97 ha (*P. pseudostrobus*), 8 685.33 ha (*P. engelmannii*), 8 413.30 ha (*P. montezumae*), 7 618.73 ha (*P. greggii*), 3 081.18 ha (*P. arizonica*) y 1 400.10 ha (*P. durangensis*). Los esfuerzos del PR fueron buenos y regulares: cinco estados tienen 50 % del total de los V (113), y alrededor de 30 % de las UPG (22) y los BG (4). Esta información es esencial para planificar acciones de restauración con los taxa considerados en esta investigación.

Palabras clave: Bosque de coníferas, Conafor, plantación forestal, producción de planta en vivero, Programa apoyos para el desarrollo forestal sustentable, suelo forestal.

Abstract

Temperate forests in Mexico have been reduced due to land use change for agriculture, illegal logging, forest fires, and pests and disease. However, the reforestation program (RP) is a strategy to increase forest areas and decrease forest land degradation. The aims for this work were: to assess the reforestation potential for restoring degraded areas with *Pinus pseudostrobus*, *P. engelmannii*, *P. montezumae*, *P. greggii, P. arizonica* y *P. durangensis*; and to define the efforts of reforestation program for species production. The potential areas for reforestation and the degradation for forest lands were estimated. Also, the abilities of RP for seedlings production of conifers based on the number of nurseries established (N), germplasm production units defined (GPU) and germplasm banks (GB) installed were analyzed. The results showed that target species could reduce 57.52 % total area degraded. The annual areas estimated for restoration were: 15 458.97 ha (*P. pseudostrobus*), 8 685.33 ha (*P. engelmannii*), 8 413.30 ha (*P. montezumae*), 7 618.73 ha (*P. greggii*), 3 081.18 ha (*P. arizonica*) and 1 400.10 ha (*P. durangensis*). For RP, the efforts had a significantly impact, *i.e.*, five states had 50 % out all N (113), and around 30 % GPU (22) and GB (4). This information is essential to plan restoration actions for target species.

Key words: Temperate forest, *Conafor*, forest plantation, seedling production, support program for sustainable forest development, forest soil.

Fecha de recepción/Reception date: 19 de junio de 2019
Fecha de aceptación/Acceptance date: 26 de agosto de 2019

[1]Centro Nacional de Investigación Disciplinaria en Conservación y Mejoramiento de Ecosistemas Forestales, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. México.
[2]Campo Experimental Valle de México, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. México.
*Autor por correspondencia; correo-e: flores.andres@inifap.gob.mx

The temperate forests in Mexico cover an area near to 323 305 km^2 (Galicia *et al.,* 2015), and it hosts important species that provide multiple environmental goods and services (Aguirre, 2015). However, these ecosystems are degraded through land use change, illegal logging and the presence of fires and diseases (Goldstein *et al.,* 2011). With the purpose of counteracting the negative effects of deforestation, it is estimated that more than 250 000 ha have been reforested in the last decade in Mexico (Burney *et al.,* 2015).

The production of quality plant in nursery has improved considerably in the country, from a traditional model (use of polyethylene bag) to a technified (use of container). This change in technology has increased the quality of seedlings, which is essential for the success of reforestation (Velázquez *et al*., 2011).

The Supports Program for the Sustainable Forest Development (*Programa Apoyos para el Desarrollo Forestal Sustentable)* (Forest Restauration and Productive Reconversion component, *(componente Restauración Forestal y Reconversión Productiva)*, is a key player for the restoration of degraded forest land (Secretaría de Economía, 2019). However, its efficient operation requires knowing the areas to be recovered and the appropriate species. Therefore, the present work had as objectives: i) to evaluate the potential of plant production for reforestation of six conifers (*Pinus pseudostrobus* Lindl., *P. engelmannii* Carrière, *P. montezumae* Lamb., *P. greggii* Engelm. ex Parl., *P. arizonica* Engelm. and *P. durangensis* Martínez) for the restoration of degraded areas that are among the most used in the country, and ii) determine the efforts of the reforestation program for the production of the species.

The average of plant produced in nurseries by species was estimated based on the 2016-2018 records of the National Forestry Commission (Conafor, 2018), which is a good indicator of the number of seedlings that are bound to reforestation programs and of soil conservation by state. Likewise, the areas of forest land with medium (III.C) and low (III.D) degradation were determined based on the forest restoration zoning map of Conafor (Conafor, 2017); high degradation zones (III.A and III.B) were not considered because they require more time and soil conservation works to be restored. The processing and representation of the information was carried out through the QGIS program (http://qgis.osgeo.org) (QGIS Development Team, 2015).

When comparing the areas that can be reforested (1 100 plants ha^{-1}) with the amount of plant produced and the areas of medium and low degradation, the species together showed that they have a potential to restore 42.18 % of areas III.C and III.D (Table 1). In particular, *P. pseudostrobus* has the capacity to restore 15 458.97 ha; *P. engelmannii,* 8 685.33 ha; *P. montezumae,* 8 413.30 ha; *P. greggii,* 7 618.73 ha; *P. arizonica,* 3 081.18; and *P. durangensis,* 1 400.10 ha.

Table 1. Number of plants produced from six species of pine, potential of restoration areas (ha) and degraded areas (ha) and by state.

Species	State	Produced seedlings[¶]	Potencial of the restoration areas (ha)[†]	Degraded lands (ha)[‡]
P. pseudostrobus	*Chiapas*	1 093 250	993.86	553.98
	Edo México	3 038 250	2 762.05	37.96
	Guanajuato	133 333	121.21	219.45
	Guerrero	1 567 500	1 425.00	1 039.77
	Hidalgo	258 987	235.44	689.18
	Michoacán	6 078 333	5 525.76	185.77
	Morelos	150 000	136.36	1.85
	Nuevo León	680 000	618.18	6 820.35
	Oaxaca	1 357 891	1 234.45	481.03
	Puebla	1 154 272	1 049.34	437.08
	Querétaro	102 705	93.37	27.51
	Tamaulipas	16 667	15.15	4 012.53
	Tlaxcala	529 767	481.61	1.13
	Veracruz	843 914	767.19	860.53
	Subtotal	17 004 869	15 458.97	15 368.12
P. engelmannii	*Chihuahua*	3 735 855	3 396.23	32 035.24
	Durango	4 721 966	4 292.70	13 194.50
	Sinaloa	1 096 037	996.40	236.31
	Subtotal	9 553 858	8 685.33	45 466.05
P. montezumae	*Ciudad de México*	93 108	84.64	0.00
	Edo. México	2 284 872	2 077.16	37.96
	Guerrero	100 000	90.91	1 039.77
	Hidalgo	1 383 333	1 257.58	689.18
	Michoacán	2 656 000	2 414.55	185.77
	Moelosr	439 147	399.22	1.85

Species	State	Produced seedlings[¶]	Potencial of the restoration areas (ha)[†]	Degraded lands (ha)[‡]
	Puebla	1 280 233	1 163.85	437.08
	Tlaxcala	529 311	481.19	1.13
	Veracruz	488 627	444.21	860.53
	Subtotal	9 254 632	8 413.30	3 253.27
P. greggii	*Coahuila*	50 833	46.21	10 837.18
	Edo. México	2 522 955	2 293.60	37.96
	Guerrero	83 333	75.76	1 039.77
	Hidalgo	1 648 053	1 498.23	689.18
	Jaiscol	583 123	530.11	2 273.54
	Michoacán	1 138 333	1 034.85	185.77
	Morelos	16 667	15.15	1.85
	Nayarit	209 213	190.19	228.90
	Oaxaca	891 848	810.77	481.03
	Puebla	295 000	268.18	437.08
	Querétaro	230 827	209.84	27.51
	Tamaulipas	94 642	86.04	4 012.53
	Tlaxcala	422 778	384.34	1.13
	Veracruz	126 333	114.85	860.53
	Zacatecas	66 667	60.61	3 332.89
	Subtotal	8 380 605	7 618.73	24 446.85
P. arizonica	*Chihuahua*	1 567 791	1 425.26	32 035.24
	Coahuila	4 167	3.79	10 837.18
	Durango	1 817 335	1 652.12	13 194.50
	Subtotal	3 389 293	3 081.18	56 066.92
P. durangensis	*Aguascalientes*	26 667	24.24	138.01
	Chihuahua	1 362 247	1 238.41	32 035.24
	Durango	151 200	137.45	13 194.50
	Subtotal	1 540 114	1 400.10	45 367.75
	Total	49 123 371	44 657.61	77 644.69

[¶]Source: Conafor (2018).

[†]With a planting density of 1 100 ha^{-1} plants; ‡Total degradation area (III.C + III.D).

For each species, the efforts of the reforestation program (RP) for plant production were estimated based on the number of established nurseries (N), germplasm production units (GPU) and germplasm banks (GB). These efforts were rated based on the scale of assessment proposed in Table 2. The information used came from the records of Conafor, which are a real database on the work of management and production of seedlings of the species. The evaluation showed that the efforts of the RP were good and regular, i. e., five States had 50 % of the total of the N (113), and about 30 % of the GPU (22) and the GB (4) (Table 3).

Table 2. Scale for assessing efforts of the reforestation program.

Relative importance of the effort (%)*	**Valoration**
81 a 100	Excelente
61 a 80	Muy bueno
41 a 60	Bueno
21 a 40	Regular

*Relative importance of effort = (Number of nurseries or germplasm producing units or germplasm banks in the *i*-ésimo state/Total number of nurseries or germplasm producing units or germplasm banks) × 100.

Table 3. Nurseries (N), germplasm producing units (GPU), germplasm banks (GB) and species produced by State.

State	Num. N	Num. GPU	Num. GB	Produced species[1]	
				Nurseries	GPU
Chiapas	29	6	0	Pps	Pps, Pps
Michoacán	26	8	1	Pgr, Pmo, Pps	Pps, Pps
Edo. México	21	2	1	Pgr, Pmo, Pps	Pps
Veracruz	20	4	1	Pgr, Pmo, Pps	Pps, Pmo, Pps
Puebla	17	2	1	Pgr, Pmo, Pps	Pmo
Chihuahua	14	10	1	Par, Pdu, Pen	Par, Par, Pen, Pen, Pdu, Pdu, Pdu, Par, Pdu
Durango	14	4	1	Par, Pdu, Pen	Pdu, Par, Pen
Hidalgo	13	3	0	Pgr, Pmo, Pps	Pmo
Oaxaca	12	4	1	Pgr, Pps	Pps, Pps
Guerrero	7	5	0	Pgr, Pmo, Pps	-
Nayarit	7	1	1	Pgr	-
Jalisco	6	3	1	Pgr	-
Zacatecas	6	0	0	Pgr	-
Morelos	5	2	0	Pgr, Pmo, Pps	Pps, Pmo
Aguascalientes	4	1	1	Pdu	-
Querétaro	4	1	1	Pgr, Pps	-
Tlaxcala	4	1	1	Pgr, Pmo, Pps	-
Coahuila	3	1	0	Par, Pgr	-
Sinaloa	3	1	0	Pen	-
Tamaulipas	3	1	1	Pgr, Pps	-
Guanajuato	2	2	0	Pps	Pte
Ciudad de México	1	0	0	Pmo	-
Nuevo León	1	2	1	Pps	Pps
Total	*222*	*64*	*14*		

[1]Par = *P. arizonica;* Pdu = *P. durangensis;* Pen = *P. engelmannii;* Pgr = *P. greggi;* Pmo = *P. montezumae;* Pps = *P. pseudostrobus*.

The above information shows the ability of each species to reforest areas for restoration purposes, which can help recover areas of moderate to low degradation. This action allows to reverse part of the 45 % of the area that is degraded in the country (Semarnat-CP, 2002).

The species analyzed present significant efforts in the reforestation program for plant production, which give the possibility of improving the success of reforestation as long as the establishment site meets the particular ecological requirements of the plants. In this regard, this work must be carried out with quality seedlings to ensure a higher survival rate, for example. *P. pseudostrobus* has achieved 65 to 60 % while *P. montezumae* has recorded 70 to 60 % (Barrera *et al.,* 2018).

The knowledge exposed in this work is essential to plan restoration actions for the species under study.

Acknowledgements

The authors thank the *Comisión Nacional Forestal* for providing information on plant nursery production, and the distribution of nurseries, germplasm producing units and germplasm banks.

Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Andrés Flores: work planning, structuring, data analysis and writing of the manuscript; Tomás Pineda Ojeda: data analysis and writing of the manuscript; Eulogio Flores Ayala: writing and discussion of the document.

References

Aguirre C., O. A. 2015. Manejo forestal en el siglo XXI. Madera y Bosques 21:17-28. Doi: 10.21829/myb.2015.210423.

Barrera R., R., R. López A. and H. J. Muñoz F. 2018. Survival and growth of *Pinus pseudostrobus* Lindl. and *Pinus montezumae* Lamb. on different planting dates. Revista Mexicana de Ciencias Forestales 9(50):1-19. Doi: 10.29298/rmcf.v9i50.245.

Burney, O., A. Aldrete, R. Alvarez R., J. A. Prieto R., J. R. Sánchez V. and J. G. Mexal. 2015. Mexico-addressing challenges to reforestation. Journal of Forestry 113(4):404–413. Doi: 10.5849/jof.14-007.

Comisión Nacional Forestal (Conafor). 2017. Zonificación forestal. https://www.cnf.gob.mx:8443/snif/portal/zonificacion (19 de junio de 2019).

Comisión Nacional Forestal (Conafor). 2018. Sistema Nacional de Información y Gestión Forestal. https://snigf.cnf.gob.mx/ (19 de junio de 2019).

Galicia, L., L. Gómez M. and V. Magaña. 2015. Climate change impacts and adaptation strategies in temperate forests in central Mexico: a participatory approach. Mitigation and Adaptation Strategies for Global Change 20(1):21–42. Doi: 10.1007/s11027-013-9477-8.

Goldstein, A., H. Erickson, N. Gephart and S. Stevenson. 2011. Evaluation of land use policy and financial mechanism that affect deforestation in Mexico. http://www.monitoreoforestal.gob.mx/repositoriodigital/files/original/388205ed5a67d798d8ce85b6dc4a0cb8.pdf (19 de junio de 2019).

QGIS Development Team. 2015. QGIS Geographic Information System (v 2.8.7). Open source geospatial foundation project. Beaverton, OR, USA. http://qgis.osgeo.org (1 de mayo de 2018).

Secretaría de Economía. 2019. Programa apoyos para el desarrollo forestal sustentable 2019. https://www.dof.gob.mx/nota_detalle.php?codigo=5551178&fecha=26/02/2019 (19 de junio de 2019).

Secretaría de Medio Ambiente y Recursos Naturales-Colegio de Posgraduados (Semarnat-CP). 2002. Evaluación de la degradación del suelo causada por el hombre en la República Mexicana, escala 1:250 000. México, D. F., México. 58 p.

Velázquez M., A., A. Aldrete, A. Gómez G. y T. Landeral O. 2011. Evaluación de costos de producción de planta en viveros forestales que abastecen proyectos de plantaciones forestales comerciales. http://www.conafor.gob.mx:8080/documentos/docs/5/41361.%20Evaluaci%C3%B3n%20de%20costos%20de%20producci%C3%B3n%20de%20planta%20en%20viveros.pdf (8 de agosto de 2019).