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Original Article

Changes in vegetation diversity of temperate forests in central Mexico under different levels of reforestation

Farklı ağaçlandırma tiplerinde orta Meksika ılıman ormanları bitki örtüsü çeşitliliğindeki değişiklikler

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ABSTRACT

Mexican temperate forests are plant communities with high biodiversity. However, they are susceptible to human activity changes such as deforestation. This study aimed to evaluate and compare changes in vegetation diversity in three temperate forest communities with different tree composition: 1) natural tree composition dominated by *Quercus* spp. (CF), 2) mixed composition, mainly Quercus spp.-*Cupressus lindleyi* (MF), and 3) completely reforested habitat, exclusively by *C. lindleyi* (RF). 90 quadrats were sampled in the dry season and 135 in the rainy season. To compare the reforestation effect on plant communities, multivariate and diversity analyses were undertaken. RF had the greatest species richness (S=31) and diversity (H'=1.3). In contrast, CF had lowest values (S=13, H'=0.9). The Discriminant Analysis (DA) showed a significant difference in plant community composition. RF had more species associated with disturbed habitats, while species typical of conserved forest were abundant in CF and MF. Although RF had the greatest diversity, the results suggest an ecological impoverishment due to the occurrence of synanthropic species – mainly weeds and grasses. The lowest diversity in CF was associated with the native species. The recognition of native species and species related to conserved habitats is important to reforestation planning, especially where there is no other effective strategy of forest management left. The knowledge of local species associated with conserved habitats and related to specific canopy tree species is important for designing reforestation plans adjusted to the local scale.

Keywords: Floristic diversity, forest management, mountain forest, oaks, synanthropic vegetation

ÖZ

Meksika ılıman ormanları biyolojik çeşitliliği yüksek bitki topluluklarıdır. Bununla birlikte, insan aktivite değişikliklerinin yol açtığı orman alanı kayıplarına karşı hassastırlar. Bu çalışma, farklı ağaç türü kompozisyonuna sahip üç ılıman orman topluluğunda bitki örtüsü çeşitliliğindeki değişiklikleri değerlendirmeyi ve karşılaştırmayı amaçlamıştır: 1) *Quercus* spp. (CF) meşçeresi türü, 2) karışık meşçere karışık tür olarak, esas olarak *Quercus* spp. -*Cupressus lindleyi* (MF) ve 3) tamamen *Cupressus lindleyi* (RF) türü ile tamamen yeniden ağaçlandırılmıştır. Kuru mevsimde 90 adet örnek alandan, yağışlı mevsimde ise 135 örnek alandan veriler elde edilmiştir. Ağaçlandırma çalışmalarının bitki toplulukları üzerindeki etkisini karşılaştırmak için çok değişkenli ve çeşitlilik analizleri yapılmıştır. RF ağaçlandırma alanlarının en büyük tür zenginliğine (S=31) ve çeşitliliğe (H'=1,3) sahip olduğu tespit edilmiştir. Buna karşılık, CF ağaçlandırma alanlarının ise en düşük değerlere sahip (S=13, H'=0,9) olduğu görülmüştür. Gerçekleştirilen Diskriminant Analizi (DA) bitki topluluğu bileşiminde önemli bir farklılık olduğunu göstermiştir. RF alanları rahatsız edilmiş habitatlarla ilişkili daha fazla türe sahipken, korunan ormana özgü türler CF ve MF alanlarında daha fazla bulunmaktadır. RF alanları en fazla tür çeşitliliğe sahip olmasına rağmen, sonuçlar sinantropik türlerin (özellikle yabani otlar ve otlar) ortaya çıkması nedeniyle ekolojik bir fakirleşmeyi göstermektedir. CF alanlarındaki en düşük tür çeşitliliğinin yerli türlerle ilişkili olduğu görülmüştür. Yerli türlerin ve korunan habitatlarla ilgili türlerin tanınmasının, özellikle orman yönetiminin başka etkili bir stratejisinin kalmaması durumunda ağaçlandırma planlaması açısından önemli olduğu ortaya çıkmaktadır. Korunan habitatlarla ve belirli bir kapalılık oluşturan ağaç türleriyle ilişkili yerel türlerin bilgisi, yerel ölçeğe göre uyarlanmış ağaçlandırma planlarının tasarlanması için önemlidir.

Anahtar Kelimeler: Floristik çeşitlilik, orman yönetimi, dağ ormanı, meşeler, sinantropik bitki örtüsü

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INTRODUCTION

Temperate forests in Mexico face serious environmental threats (Galicia and García-Romero, 2007) because they are ecosystems highly susceptible to human activities. The latter cause deleterious effects at a different level: ecosystem, community, species, and population (Bocco et al., 2001; Galicia et al., 2018). Yet, data about transformation rates of forest cover are imprecise (Velázquez et al., 2002). This is due to recent reports that mention either a decrease or even an increase of forest cover (Gómez-Tagle Ch et al., 2015). Others point out that the increase of forest cover has been calculated mainly for forests undergoing degradation processes rather than for forests under restoration management (Rosete-Vergés et al., 2014). It means that deforestation continues to be considered a severe environmental problem having not only ecological effects but also financial, social, and cultural repercussions (Galicia et al., 2018).

Vegetation composition and species richness are determined by the type, frequency, and intensity of disturbance factors, such as deforestation, and they can even increase the diversity (Cárdenas et al., 2002; Luna-Cavazos et al., 2008; Quinteros et al., 2010). However, it is necessary to gather more information on plant diversity changes due to deforestation. This data might be important for planning conservation with a sustainable perspective (Lindenmayer et al., 2000) since it would be possible to take into account the restoration of ecological interactions based on adequate reforestation. These ecological interactions are very relevant in areas where vegetation provides several ecosystem services, which are essential to sustain highly populated cities (Gómez-Tagle Ch et al., 2015). Studied forests in this research are closely located to conservation areas, such as the Sanctuary of Protection of Flora and Water Brokman-Villa Victoria dams (List et al., 2009) and the Monarch Butterfly Biosphere Reserve (MBBR). Both sites have been subjected to a few botanical and ecological studies and face a critical loss of forest cover. Furthermore, these areas are in a highly marginalized rural region where people living in poverty have disturbed nature. For example, by practicing unplanned timber harvesting (Calzontzi-Marín et al., 2016). González-Espinosa et al. (2007) have reported that improper use of natural resources generates biological impoverishment and pushes people to live under insecure conditions. Thus, there is a necessity of basic information for building forest recovery strategies. To establish the degree of forest cover conservation, these strategies should use the knowledge about resident species and other useful data. Therefore, it is essential to gather floristic and ecological data. In that sense, it should be evaluated how reforestation changes plant diversity and abundance since both are indicators of reforestation strategy success. Some authors have even pointed out that those are attributes related to consumers (Ebeling et al., 2018).

There is contrasting information in the literature regarding the discussion so far. On the one hand, more diversity is expected in a conserved forest (Gotosa et al., 2013), however, there is opposing evidence (Bhatt and Bhatt, 2016) that turns it into an unsolved question. Are richness and species diversity higher in a conserved forest or an unconserved one? This study suggests that the knowledge of species richness and diversity is not enough to answer that question. Also, the species migratory status, either native or exotic, and ecological characteristics, such as synanthropic or wild, are necessary. This work aims to evaluate and compare the changes in vegetation diversity of temperate forests under three conservation regimes: 1) reforested, 2) mixed, and 3) natural. It was hypothesized that taxonomic diversity in the disturbed forest will be higher than in the conserved one. Moreover, their vegetation composition will differ regarding ecological traits like migratory status and environmental affinities. Finally, the endemic species typical for conserved habitats will be common in less disturbed forests too.

MATERIALS AND METHODS

Study Area

Three localities were selected in the northern State of Mexico: El Oro, San Jose del Rincon, and San Felipe del Progreso municipalities. They are all close to each other (at 6 km approximately) and neighboring two protected natural areas - MBBR and the Sanctuary of Protection of Flora and Water Brokman-Villa Victoria dams. The reforested habitat (RF) is a 20 years old monospecific stand of *Cupressus lindleyi* Klotzsch ex Endl. According to the local people, it was subjected to frequent seasonal fires. The natural vegetation was dominated by oaks. The mixed forest (MF) is an area with primary forest, part of which is reforested with *C. lindleyi*. Among the most important native trees are *Pinus* sp., *Quercus crassipes* Humb. & Bonpl, *Quercus rugosa* Née, and *Arbutus* sp. There is no reforestation plan for this forest. The conserved forest (CF) is dominated by tree species such as *Pinus* sp., *Q. rugosa*, *Quercus laurina* Bonpl, and *Alnus* sp. All three forest types grow on hillsides with the same soil type (Andosol) (Table 1).

Table 1. Physical traits of the three forests studied

Forest	Localization	Weather	Disturbing factor
RF	19° 40′ 30″N, 100° 05′ 51″W, 2679 m a.s.l	Cb'w2; 5 to 12°C, 200 to 1800 mm	Reforestation, cattle crossing, grazing, fires
MF	19° 43′ 06″N, 100° 05′ 38″W, 2738 m a.s.l	Cw2; 18 to 20°C, 200 to 1800 mm	Reforestation, cattle crossing, firewood extraction
CF	19° 45′ 48″N, 99° 59′ 20″W, 2908 m a.s.l	Cb'w2; 5 to 12°C, 200 to 1800 mm	Firewood extraction

RF: reforested forest; MF: mixed forest; CF: conserved forest

Table 2. Checklist of families and species from shrub and herbaceous layers of the temperate forests

		Forests		
Families	Species	CF	MF	RF
Acanthaceae	*Dyschoriste microphylla* Kuntze	-	-	x
	Ruellia sp.	x	-	x
Aspleniaceae	*Asplenium hallbergii* Mickel & Beitel	x	-	-
Asteraceae	*Aldama dentata* La Llave	-	x	x
	Bidens ferulifolia (Jacq.) Sweet	-	-	x
	Dahlia merckii Lehm.	x	-	-
	Erigeron scaberrimus Gardner	-	x	-
	Gnaphalium oxyphyllum DC.	-	-	x
	Melampodium sp.	-	x	-
	Pinaropappus roseus Less.	-	-	x
	Pseudognaphalium viscosum (Kunth) Anderb.	-	x	-
	Zinnia haageana Regel	-	x	-
Anthericaceae	*Echeandia nana* (Baker) Cruden	-	x	x
Amaranthaceae	*Gomphrena serrata* L.	x	-	-
Begoniaceae	*Begonia gracilis* Kunth	-	x	-
Brassicaceae	*Lepidium virginicum* var. *pubescens* (Greene) Thell.	-	x	-
Buddlejaceae	*Buddleja sessiliflora* Kunth	-	-	x
Caryophyllaceae	*Cerastium nutans* Raf.	-	-	x
	Scleranthus annuus L.	x	-	-
	Silene laciniata Cav.	-	x	-
Commelinaceae	*Tripogandra angustifolia* (B.L.Rob.) Woodson	x	-	-
Convolvulaceae	*Ipomoea purpurea* (L.) Roth	-	x	x
Crassulaceae	*Echeveria secunda* Booth ex Lindl.	x	-	-
	Sedum sp.	-	x	-
Cyperaceae	*Bulbostylis juncoides* (Vahl) Kük. ex Osten	-	-	x
	Rhynchospora colorata (Hitchc.) H.Pfeiff.	-	-	x
Ericaceae	*Arctostaphylos pungens* Kunth	x	-	-
Fabaceae	*Medicago polymorpha* L.	-	x	-
	Trifolium goniocarpum Lojac	-	-	x
Geraniaceae	*Geranium lilacinum* R. Knuth	x	-	-
Hydrophyllaceae	*Nama dichotoma var. dichotoma* (Ruiz & Pav.) Choisy	-	-	x
Hypoxidaceae	*Hypoxis mexicana* Schult. & Schult.f.	x	x	-
Iridaceae	*Sisyrinchium tolucense* Peyr.	-	-	x
Lamiaceae	*Salvia laevis* Benth.	-	-	x
	S. reptans Jacq.	-	x	-
	Stachys coccinea Ortega	x	-	-
Lentibulariaceae	*Pinguicula moranensis* Kunth	x	x	-
Lythraceae	*Cuphea aequipetala* Cav.	-	x	x

Table 2. Checklist of families and species from shrub and herbaceous layers of the temperate forests (Continued)

		Forests		
Families	Species	CF	MF	RF
	C. wrightii var. wrightii Gray	-	-	x
Orchidaceae	*Schiedeella llaveana* Schltr.	-	x	-
Orobanchaceae	*Conopholis alpina* Liebm.	-	x	-
Oxalidaceae	*Oxalis jacquiniana* Kunth	x	x	x
Plantaginaceae	*Plantago linearis Kunth* var. *mexicana* Pilg	-	-	x
Poaceae	*Aristida ternipes* Cav.	-	-	x
	Bouteloua barbata Lag.	-	-	x
	B. curtipendula (Michx.) Torr.	-	-	x
	Chascolytrum subaristatum Desv.	-	-	x
	Eragrostis intermedia Hitchc.	-	-	x
	Piptochaetium fimbriatum (Kunth) Hitchc.	-	-	x
	Urochloa plantaginea (Link) R.D.Webster	-	-	x
Rubiaceae	*Bouvardia ternifolia* (Cav.) Schltdl.	-	x	x
	Crusea longiflora (Willd. ex Roem. & Schult.) W.R. Anderson	-	x	-
Scrophulariaceae	*Bacopa procumbens* (Mill.) Greenm.	-	-	x
	Castilleja tenuiflora Benth.	x	-	-
	Penstemon atropurpureus G.Don	x	-	-
Solanaceae	*Petunia parviflora* Juss.	-	-	x
Verbenaceae	*Verbena ciliata* Benth.	-	-	x

(x): presence (-): absence. CF: conserved forest; MF: mixed forest; RF: reforested forest

Table 3. Species richness and diversity data of three temperate forests

Forest	H'	1/D	1-D	J
CF	0.90	4.84	0.20	0.72
MF	1.03	5.70	0.17	0.73
RF	1.30	15.49	0.06	0.85

H': Shannon-Wiener index diversity; 1/D: Simpson index diversity; 1-D: Dominance; J': evenness

Field Sampling

The data were collected during the two climatic seasons – dry and rainy. During the dry season, each forest type was sampled along three 500 meter transects divided into ten 10×10 m quadrats. That produced a total of 90 samples or 30 samples from each forest type. Three transects were set during the rainy season. Each contained fifteen 10×10 m quadrats or a total of 135 quadrats – 45 samples from each forest type. All collected plants had enough phenological characteristics for their identification to species level. Plant specimens were transferred to the herbaria of the Iztapalapa-Metropolitan Autonomous University and the Life Sciences Division of Guanajuato University. In each quadrant, all species abundance, richness, and diversity were determined as recommended by Flores and Álvarez-Sánchez (2004).

Identified species were grouped by their geographic occurrence following the example of previous studies (López-Pérez et al., 2011, Salas-Araiza et al., 2015). This led us to group all species according to their distribution as native, northern, southern, or cosmopolitan. We followed the Megamexico concept of Rzedowski (1991) that has been applied to infer the species biogeographic affinity. This allowed prioritizing areas for conservation since it is grounded in natural history, evolutionary lineages, and endemism (Alcántara and Luna, 1997; Sosa and De-Nova, 2012). Thus, the species can be grouped into: megamexico 1 – Northamerican distribution, megamexico 2 – Southamerican distribution, and megamexico 3 – both North- and Southamerican distribution. Also, according to their environmental adaptive responses, the species were grouped into: 1) plants occupying disturbed habitats (synanthropic species), 2) plants commonly found in temperate forests, and 3) conservation bioindicator plants. Finally, using databases of "NaturaLista" and "Malezas de México", all described species were grouped by their life form into annuals, biannuals, or perennials.

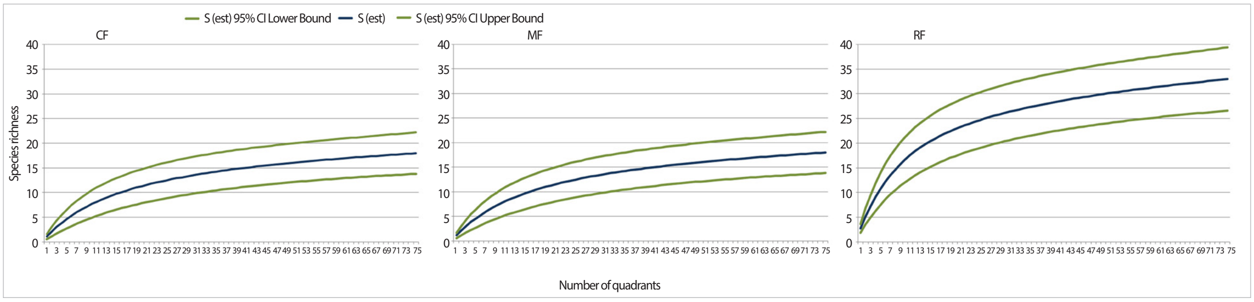

Figure 1. Species accumulation richness curves from temperate forests
CF: conserved forest; MF: mixed forest; RF: reforested forest

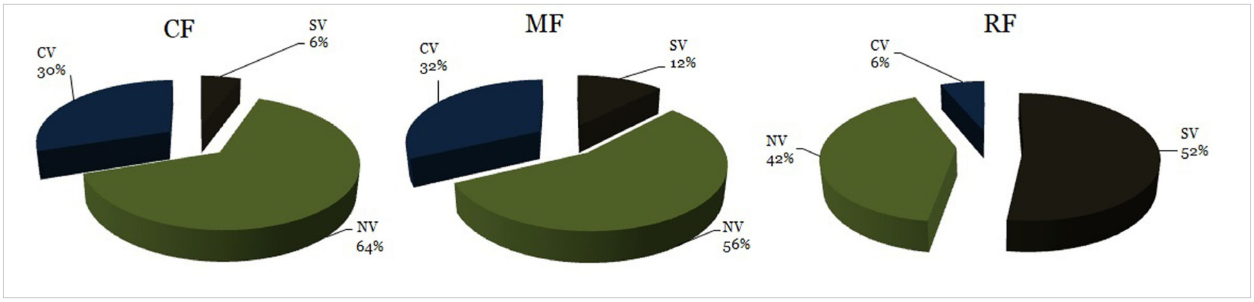

Figure 2. Species proportions grouped by habitat affinities and reported in the literature
SV: synanthropic species; NV: typical species of temperate forests; CV: bioindicator species of conserving forests; CF: conserved temperate forest; MF: mixed forest; RF: reforested forest

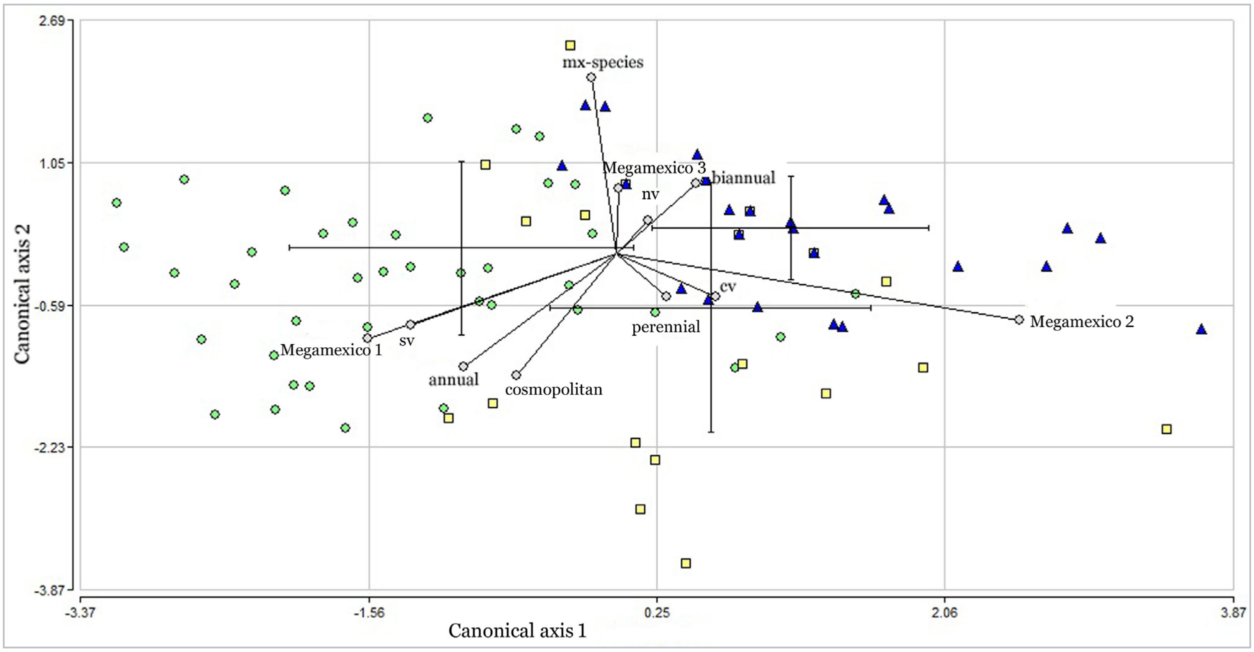

Figure 3. DA Bi-plot, the first canonical axis explained 89.5% of the variance and the second canonical axis explained 10.4%
RF: green circles; MF: yellow squares and CF: blue triangles; mx-species: native species, Megamexico 1, Megamexico 2, Megamexico 3; CV, NV, sv in Figure 2

Statistical Analyses

The Shannon-Wiener and Simpson indices were used to 1) evaluate community evenness using Simpson inverse index divided by species number in the sample, which ranges from 0 (minimal) to 1 (maximal) evenness (Martínez-Cruz et al., 2009), 2) estimate community diversity and its dominance, and 3) make a statistical comparison between habitat diversity indices using Hutcheson t-test. Species accumulation curves were made with the rarefaction method. This proved to be a good species richness estimator for plant communities (Selgrath and Gergel, 2019). All analyses were done with Estimates 9.1 software (Colwell, 2013). Diversity indices comparison was made with PAST software (Hammer et al., 2001). Discriminant Analysis (DA) was used to compare plant community composition in terms of species ecological traits. Infostat, ver 2011 software (Di Rienzo et al., 2008) was employed.

RESULTS AND DISCUSSION

Plant Species Richness and Diversity

We described 2,990 plant specimens (mean=522, S.E.=0.23) belonging to 57 species and 31 families. Asteraceae (S=9) and Poaceae (S=7) had the greatest species richness. Species richness was higher in disturbed than in conserved habitats. CF was the forest type with fewer species (S=13), MF had intermediate species richness (S=23), and RF showed the highest species number (S=31) (Table 2). The rarefaction species curves did not reach an asymptote in any forest type suggesting that it was necessary to increase the sampling effort (Figure 1).

Diversity indices showed significant differences between forest types. CF had the lowest diversity (CF-MF, $t_{1058.6\ (2)0.05}=3.8$, $p<0.0001$; CF-RF $t_{595.05\ (2)0.05}=15.67$, $p<0.0001$), whereas MF had a significantly lower diversity than RF ($t_{724.08\ (2)0.05}=10.43$, $p<0.0001$). This confirmed the higher diversity expectation for reforested habitats (RF). Also, they had the lowest dominance and highest evenness compared to other forest types (Table 3).

Plant Community Structure

Most RF species were associated with disturbed habitats. A very few species typical to the conserved temperate forest were found. In contrast, the species associated with conserved forests were most abundant in CF and MF. Due to reforestation, the scarcity of species typical to secondary vegetation was remarkable (Figure 2).

With 89.5% explained variation, the DA showed a division between CF and RF, while MF was the only forest that shared species with CF and RF (Centroids=1.09, 0.59, −0.98, respectively). According to the canonical standardized functions, the most important variables that split CF and RF along the first axis were the species with southern distribution (1.19) and species related to conserved vegetation (0.23). In contrast, cosmopolitan species (−0.21), species with northern distribution (−0.86), and species of secondary vegetation (−0.25) occupied RF. However, some of them were also found in MF. The mean ordination error rate was 20.5 % in CF, 62.5 % in MF, and 15.5 % in RF. This shows spatial data dispersion and allows us to designate MF as the most variable forest (Figure 3).

The reforestation has affected each forest in a particular manner. The high diversity found in RF was associated with low dominance and a large number of secondary vegetation species. Mainly annual plants have been reported from abandoned habitats (Gotosa et al., 2013). This study has found annuals such as *Eragrostis intermedia* Hitchc., *Urochloa plantaginea* (Link) R.D. Webster, and *Sisyrinchium tolucense* Peyr. Also, many species found in RF have a cosmopolitan distribution. For example, *Chascolytrum Subaristatum* Desv., *U. plantaginea,* and *Cerastium nutans* Raf. By contrast, species typically found in temperate forests were most common in CF, such as *Asplenium hallbergii* Mickel & Beitel, *Geranium lilacinum* R. Knuth, *Pinguicula moranensis* Kunth, and *Echeveria secunda* Booth ex Lindl. This requires explanation since there is evidence that forests with a high degree of disturbance, such as RF, have low species diversity and abundance (Bhatt and Bhatt, 2016). However, other studies suggest the opposite – a diversity increase (Gotosa et al., 2013). This discrepancy has been a central problem in ecology that was partially solved by the Intermediate Disturbance Hypothesis (Yeboah and Chen, 2016). This study shows that both species richness and taxonomic diversity are not important at all, but more important is species identity.

Although CF forest had low diversity, most resident species were typical for conserved habitats. For example, *A. hallbergii*, *Castilleja tenuiflora* Benth., and *Oxalis jacquiniana* Kunth were found in MBBR central parts (Cornejo-Tenorio et al., 2003). According to personal communication with local people, the reforestation of RF was done twenty years ago. Since fires occur frequently in this forest, it seems enough time for the continuous arrival of pioneer species. Both might be causes for the high RF diversity.

Environmental conditions were different in MF. For example, both plant species associated with secondary vegetation and species with cosmopolitan distribution were not as abundant as in RF. Here were found species from MBBR's central zone, such as *Pseudognaphalium viscosum* (Kunth) Anderb. and *P. moranensis* (Cornejo-Tenorio et al., 2003), as well as other species commonly found in the conserved temperate forest like *Echeandia nana* (Baker) Cruden and *Schiedeella llaveana* Schltr. Another feature of MF was its intermediate diversity, showing values between those of CF and RF. Also, it was lower than those obtained in other studies of MFs (Wills et al., 2017), which may be a reforestation consequence. The MF reforestation was carried out without a clear strategy since plantation distances between trees (mainly *C. lindleyi*) barely reach two meters. This leads to increased overshadowing and restriction of pioneer species arrival (Mallik, 2003). It has been observed that canopy cover strongly influences plant community structure (Wainwright et al., 2017).

Species richness and diversity were lowest in CF and its dominance was highest among all studied forests. This suggests a low heterogeneity of CF community structure, despite that plant species associated with CFs were more common than plants occupying secondary vegetation. Haeussler et al. (2002) reported a similar trend. They have found lower species richness in conserved forests compared to deforested habitats where pioneer plant species were highly abundant. Also, species found in CF had Mexican distribution and southern and northern biogeographic affinities, which confirms the appropriate conservation conditions. Santibañez-Andrade et al. (2015) pointed out that the presence of native or exotic species is an indicator of the degree of habitat modification since the secondary vegetation can alter the ecosystem's functional properties and, as a consequence, modify the ecological interactions. Also, our results indicate that forest communities differ regarding their species richness, diversity, and plant ecological traits, although there are shared species between them. The DA showed a remarkable disturbance gradient – CF being most conserved appeared at the end and RF being highly disturbed was found at the other end. MF being the forest under intermediate disturbance was occupied by species associated with conserved habitats, species with a cosmopolitan distribution, short life cycle, etc. Tree cover change due to monospecific reforestation has led to an increase in exotic and synanthropic species (Rembold et al., 2017).

Some authors have emphasized the high diversity of Mexican temperate forests assigning it to their geographic location, endemism, and biogeographic history (Gopar-Merino and Velázquez, 2016). In this regard, CF, MF, and RF contained plant species with northern and southern biogeographical affinities and endemic species such as *Bouvardia ternifolia* (Cav.) Schltdl, *Cuphea aequipetala* Cav., and *G. lilacinum,* respectively. However, the remarkable presence of synanthropic species in RF can be an evidence of a forest undergoing ecological homogenization since most of its species are ecologically similar in terms of their life cycle and life form. However, the scarcity of herbs and mushrooms in MF, which were not observed during fieldwork, suggests the absence of other functional ecosystem groups, mainly insects saprophages, fungivores, and predators.

Reforestation has affected differently the three forests located very close to each other. In this regard, reforestation form can influence ecological processes by modification of canopy cover which affects the species that grow under the established conditions. Therefore, reforestation should be designed to take into account tree species with economic and cultural values. The studied forests have more than one *Quercus* species. These species must be a priority in a reforestation plan owing to their ecological traits, economic importance, and cultural values (Mölder et al., 2019). These traits make *Quercus* a key genus for forest conservation and management (Marañón et al., 2014). Residents of the study zone use the forests for firewood extraction and collection of other seasonal resources, such as edible mushrooms. The mushrooms are found in places with vegetation cover dominated by different *Quercus* species such as *Q. laurina*, *Q. rugosa,* and *Q. crassipes*. The selection of species with such traits could be a bridge to ecological attributes and social preferences leading to ecological restoration of disturbed ecosystems with a perspective to sustainable reforestation (Chechina and Hamann, 2015). This is significant for the local and indigenous people inhabiting regions such as the study zone. Forests in these areas help to recharge aquifers that supply water to more than 42 million of megalopolis inhabitants (Gómez-Tagle Ch et al., 2015) including the cities of Mexico and Toluca.

The high diversity found in RF was influenced by synanthropic species. Often, they are exotic species that are associated with secondary vegetation, most of them ecologically similar. On the contrary, CF was less diverse, but it had more native species and plants related to conserved habitats. MF was the intermediate forest, occupied by both species groups: synanthropic and related to conserved habitats. The results of this study are important for designing a reforestation plan by using plant ecological traits rather than simple taxonomic richness. At a local scale, this focus is relevant to designing reforestation plans adjusted to a small geographic extent.

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