Agrociencia

PRESSURE-STATE-RESPONSE MODEL FOR THE DIAGNOSIS OF ENVIRONMENTAL IMPACTS ON A PROTECTED FOREST ECOSYSTEM

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ABSTRACT

The Molino de Flores Nezahualcóyotl National Park has a high ecological and cultural relevance in the periurban area of Texcoco, Mexico. The aim of this study was to evaluate the environmental pressures, the state of the ecosystem, and the effects of management activities through the use of the Pressure-State-Response (PSR) model. The proposed hypothesis suggests that anthropogenic pressures negatively affect the health of the forest, while restoration efforts are designed to alleviate these impacts. The information was obtained by interviewing authorities, making field observations, and conducting perception surveys on visitors. The results identified intensive tourism, invasive exotic species, and forest fires as the main sources of pressure. The state of the ecosystem reflects a high resilience and a biological wealth of 540 registered species, with evidence of the recovery of native fauna and flora after management interventions. Institutional responses emphasize the implementation of mycorrhizal reforestation, fire management strategies, and environmental education initiatives. In conclusion, the PSR model is an effective tool for an integrated diagnosis. Although the system is resilient, it is imperative to strengthen funding and public awareness to ensure the sustainability of the area against urban pressure.

Keywords: environmental management, intensive tourism, biological wealth, protected natural areas.

INTRODUCTION

Forest ecosystems face diverse, increasing environmental pressures derived from human activities, climate change, and degradation processes that jeopardize their balance, ecological functionality, and the provision of vital ecosystem services (Albanbaeva *et al*., 2025). In Mexico, nearly 70 % of the territory is covered by forest ecosystems, indicating the need for solid methodological tools to evaluate the impacts on the environment in an integral manner and thus provide elements that guide decision-making processes towards sustainable management (CONAFOR, 2021).

Citation: Juárez-Zavala DF, Hernández-Acosta E. 2026. Pressure-State-Response model for the diagnosis of environmental impact on a protected forest ecosystem. **Agrociencia.** https://doi.org/ 10.47163/agrociencia.v60i3.3596

Editor in Chief:
Dr. Fernando C. Gómez Merino

Received: November 24, 2025.
Approved: April 07, 2026.
Published in Agrociencia:
April 16, 2026.

The Pressure-State-Response (PSR) model developed by the Organization for Economic Cooperation and Development (OECD) helps diagnose the causality between human activities and the health of ecosystems. It is arranged into three components: Pressure, associated with human and natural factors that affect the resilience of ecosystems; State, which describes the current conditions of the forests; and Response, which refers to the sustainable management actions and policies (Solís-Mendoza *et al.*, 2025). This model is relevant in forest ecosystems in Mexico. The National Forestry Commission (CONAFOR) incorporates it as a conceptual framework for forest assessment and management, integrating it into the National Forest Information System (SNIF) to promote systematic monitoring and decision-making based on scientific evidence (CONAFOR, 2021). The PSR model has been successfully applied in national forest contexts to identify weaknesses in waste management and environmental policies (Vázquez-Valencia and García-Almada *et al.*, 2018).

The Molino de Flores Nezahualcóyotl National Park (PNMFN), located in a peri-urban transition area between natural and urban areas, is a site of interest for the use of the PSR model, as it undergoes diverse environmental pressures due to tourism, urbanization, and the invasion of exotic species, among others, which jeopardize its ecological functionality and its biological wealth. The Protected Natural Area (PNA) is maintained with environmental education programs and the permanent effort of authorities to maintain the balance between its ecological and cultural conservation.

Due to the above, the aim of this study was to evaluate the environmental pressures, the state of the ecosystem, and the effects of the management activities implemented in the PNMFN, with the help of the PSR model. The hypothesis proposed is that the anthropogenic pressures found in the park exert a negative influence on the state of the forest, whereas the management and restoration actions implemented are responses aimed at mitigating these impacts and to promote their recovery.

MATERIALS AND METHODS

Area of study

The investigation was carried out in the PNMFN, located in the municipality of Texcoco, State of Mexico, which was designated as a PNA in 1937 and stands out for its ecological, socioeconomic, and cultural relevance for the region. It covers a surface of 50.22 ha, with approximate geographic coordinates of 19° 31′ N and 98° 53′ W and an altitude between 2250 and 2450 m. It is located in a transition area between the Mexican Central Highlands and the mountain systems of San Miguel Tlaixpan, La Purificación, the San Nicolás Tlaminca range, and Nativitas, within the Valley of Mexico basin (SEMARNAT, 2016).

Its soils are predominantly of volcanic origin (Regosols and Andosols), with textures varying from clay loam to sandy, which show low water retention, as well as signs of compaction and erosion in degraded areas (INEGI, 2020a). The climate is classified as subhumid temperate (C(w0)(w)) with rains in the summer. Its mean annual temperature fluctuates between 14 and 18 °C, and annual rainfall varies between 600 and 800 mm. It has a notable seasonal stability, which has a direct influence on the dynamics of the vegetation (INEGI, 2020b).

The PNMFN provides ecosystem regulation, provision, and recreation services supported by tree species such as pines (*Pinus* spp.), the ahuehuete or Montezuma cypress (*Taxodium mucronatum* Ten.), and ash (*Fraxinus udhei* (Wenz.) Lingelsh.). These plant communities harbor fauna such as the hummingbird (*Archilochus colubris* Linnaeus, 1758), vireo (*Vireo* spp.), thrush, oriole, snakes (*Thamnophis* spp.), lizards (*Sceloporus* spp.), and frogs (Ranidae) (CONANP, 2023; iNaturalist, 2025).

The map of the polygon corresponding to the PNMFN, provided by the Park Directorate, with modifications made by the author for this study, shows the internal zoning of the PNA, which comprises the areas of El Jardín, the CONAFOR nursery, Cuchilla, Upper Nursery, Casco, Ahuehuetes-Eucaliptos, Capilla, Aguacatera, La Loma, Loma Alta, and Loma Baja (Figure 1).

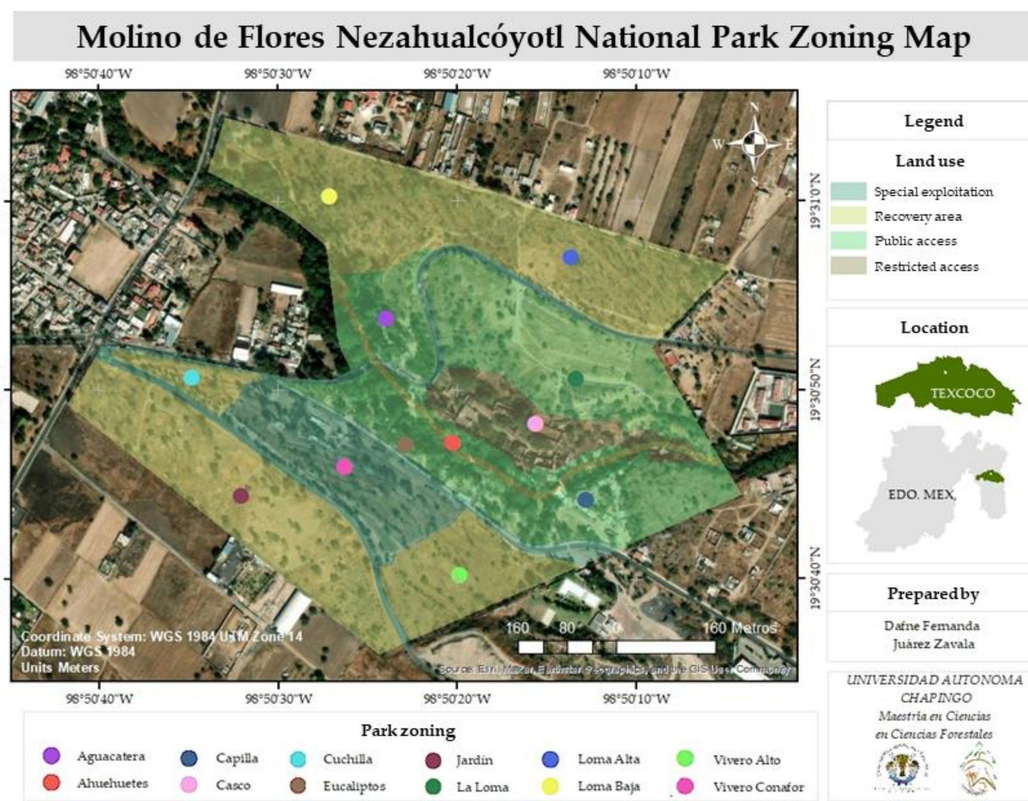

Figure 1. Location and zoning of the Molino de Flores Nezahualcóyotl National Park (PNMFN).

Evaluation of the environmental impacts

To evaluate the environmental impacts on the PNMFN, a mixed quantitative-qualitative approach was adopted based on the PSR model developed by the OECD and adapted by the Secretariat of Environment and Natural Resources for its use in forest ecosystems (Figure 2) (SEMARNAT, 2014). This model enabled the analysis of the causal relationships between human activities, the state of the environment, and the institutional responses through the identification of pressure (P), state (S), and response (R) indicators.

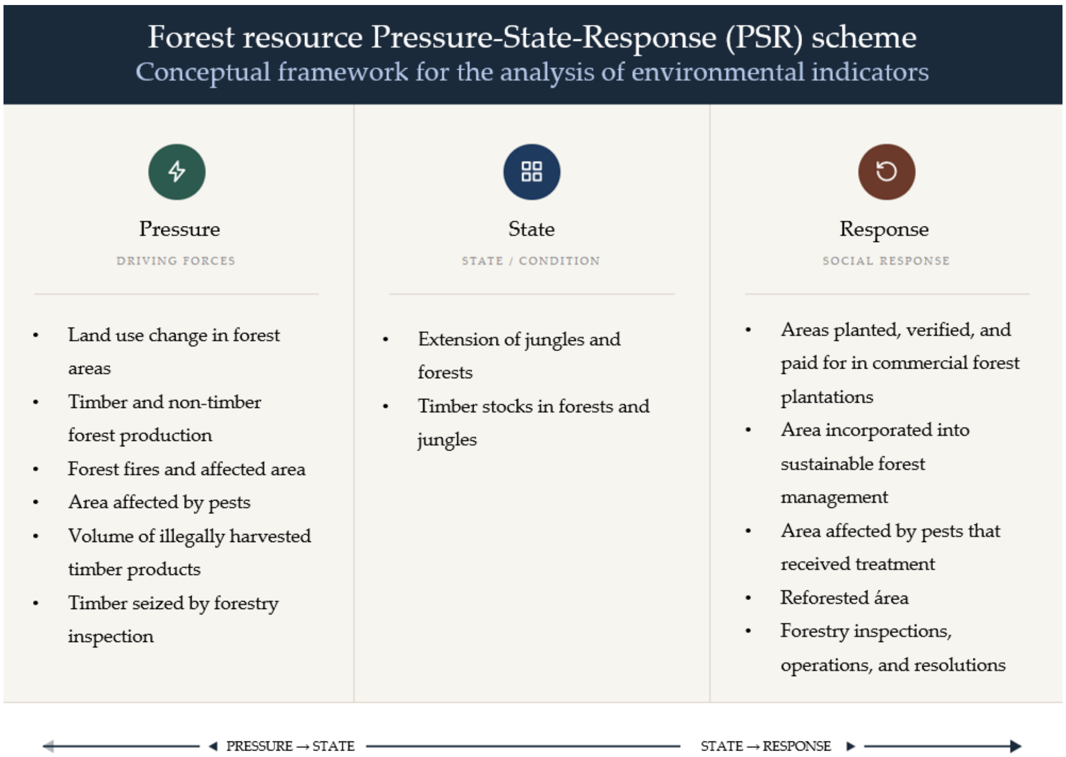

Figure 2. Pressure-State-Response (PSR) conceptual framework applied to the forestry sector. Solid arrows indicate the causal sequence between the dimensions of the model. Model adapted from SEMARNAT (2014).

The administrative structure of the PNMFN is officially composed of one director and two technicians (N = 3). In addition, the area supports an environmentalist brigade composed, on average, by eight elements (N = 8). To obtain operative and management information, a target population of 11 individuals (official staff plus brigade members) was defined. Due to the specialization of the functions and the reduced population sizes, a non-probabilistic purposive (judgmental) sampling method was used. The sample (n = 2) consisted of the park director and an engineer in renewable natural resources, who was a member of the ecological brigade.

Interviews were used to document the environmental pressure-generating actions, the current state of the ecosystem, and the management activities implemented as a response to the pressures. They were carried out using a structured script, which was based on methodological recommendations for environmental perception studies (Díaz-Pérez *et al.*, 2025).

In addition, surveys were conducted on 120 park visitors, chosen by simple randomized sampling during days of tourist visits. An annual population of 120 000 visitors has been estimated, according to the data provided by the PNMFN Directorate. This figure helps gauge the anthropic pressure to which the area is exposed and underscores the importance of the management strategies implemented. This sample size provides an approximate accuracy of ±9 % (margin of error, *ME*) for proportion estimations at a confidence level of 95 %. This calculation is based on a conservative proportion (p = 0.5, z = 1.96). The margin of error was estimated using:

$$ME = z \times \sqrt{\frac{p(1-p)}{n}} \approx 1.96 \times \sqrt{\frac{0.25}{120}} \approx 0.09$$

The instrument helped explore the perception of visitors on the state of the ecosystem, the recreational activities carried out in the park, and their knowledge on conservation measures (Díaz-Pérez *et al.*, 2025).

Visits were made to different areas of the park to document anthropic pressure indicators (solid waste, traces of fires, and soil compaction) and validate the information from interviews and surveys, as well as identify indicators of the state of the ecosystem. Fieldwork took place from January 2024 to August 2025, during which the necessary information was collected.

Model application

To apply the PSR model of the PNMFN, a systematization matrix was developed based on the methodological structure proposed by SEMARNAT (2014) on forest resources. In this matrix, the main pressure factors, the current state of the ecosystem, and the institutional responses implemented were categorized. The selection and classification of indicators were carried out using information obtained with interviews, surveys, and field observations. This process prioritized the most recurring or relevant factors in the environmental dynamics of the park. Subsequently, every indicator was classified depending on its function within the socioenvironmental system: pressure, when it represented activities or actions that lead to alterations in the ecosystem; state, when it described the current conditions of the environment; and response, when it corresponded to institutional measures or management strategies aimed at mitigating or controlling the identified impacts.

The combination of interviews, surveys, and observations helped integrate and contrast the different sources of information, which strengthened the validity in the identification of indicators and the interpretation of the causal relations between activities. From this process onwards, the information was structured systematically, helping identify the main environmental pressures, the state of the ecosystem and the management responses in the PNMFN.

RESULTS AND DISCUSSION

Social perception of the site

The social characterization of the study area (n = 120) shows that the park is a well-established recreation area for middle-aged adults (53.3 %). Visitors express a mostly stable perception of the ecosystem and consider its quality to be "moderate" (Table 1). Although anthropic pressures derived from tourist and commercial influx are identified, users acknowledge conservation efforts, though they suggest strengthening the visibility of the reforestation actions and interpretative infrastructure to improve the experience of connecting with nature.

Visitors indicated reforestation, the establishment of local nurseries, and the restoration of degraded areas as their main proposals. They also mentioned the need to strengthen cleaning efforts, improve waste management, prevent forest fires, and broaden environmental education activities through interpretative signage and workshops for the public.

The Pressure-State-Response Model in the forest ecosystem

The indicators of the PSR model summarize the causal relations between pressures, states, and responses in the forest ecosystem of the PNMFN (Figure 3). Implementing the model in the PNMFN helped evaluate the socioecological dynamics that influence the integrity of the ecosystem, following the methodological structure proposed by the SEMARNAT (2014) for PNAs. The results indicate a complex interaction between human and natural pressures, the current state of biodiversity, and institutional responses.

In Mexico, the application of the PSR model in the forestry sector was documented in the years 2006 and 2013. The most recent study was made by Vázquez-Valencia and García-Almada *et al.* (2018), in Cihuatlán, Jalisco. The authors report pressure indicators related to inadequate waste management, vulnerability to climate change, atmospheric pollution, and deterioration of biodiversity. Regarding the state indicators, the authors specify that the ecosystem is deteriorating, with evident loss of biodiversity that negatively affects the quality of life in the municipality. In addition, they underscore that the institutional responses are insufficient, which highlights the inefficiency in the application of the existing legislation.

Table 1. Descriptive analysis of the social perception and environmental management of the Molino de Flores Netzahualcoyotl National Park (PNMFN).

	Variable/category	%	*n* = 120
	1. Reasons for visiting		
Main reason	Tourism/recreation	71.7	86
	Connecting with nature	20.0	24
	Other (research, conservation, gathering, etc.)	8.3	10
	2. Quality of the forest ecosystems		
Perceived quality of the forest	Regular	45.0	54
	Good	30.0	36
	Bad	20.0	24
	Very bad	3.3	4
	Very good	1.7	2
	3. Perception of reforestation		
Reforestations observed	Found reforestation	56.7	68
	Did not find reforestation	43.3	52
	4. Perception of biodiversity (fauna and flora)		
Diversity perceived	Little diversity	45.0	54
	Broad diversity	43.3	52
	Very diverse	8.3	10
	No perceptible diversity	3.3	4
	5. Human impact (visibility)		
Visibility of the negative impact	Very visible	58.3	70
	Moderately visible	25.0	30
	Slightly visible	15.0	18
	Not visible	1.7	2
	6. Evaluation of conservation actions		
Grading actions	Regular	55.0	66
	Bad	20.0	24
	Good	15.0	18
	Very bad	5.0	6
	Very good	5.0	6

Solís-Mendoza *et al.* (2025) indicate that this model facilitates the understanding of the cause-effect processes and the identification of adaptive strategies, such as polycentric governance, the maintenance of biodiversity, and diversified forest management, in order to face pressures such as climate change, market globalization, and outdated forest policies that interfere with the biological wealth, resilience, and local livelihoods.

Pressure indicators

The analysis of anthropic and natural pressures identified in the PNMFN helped acknowledge the main factors that influence the integrity of the ecosystem. Intensive tourism represents a significant pressure, with an annual influx of 100 000 to 120 000

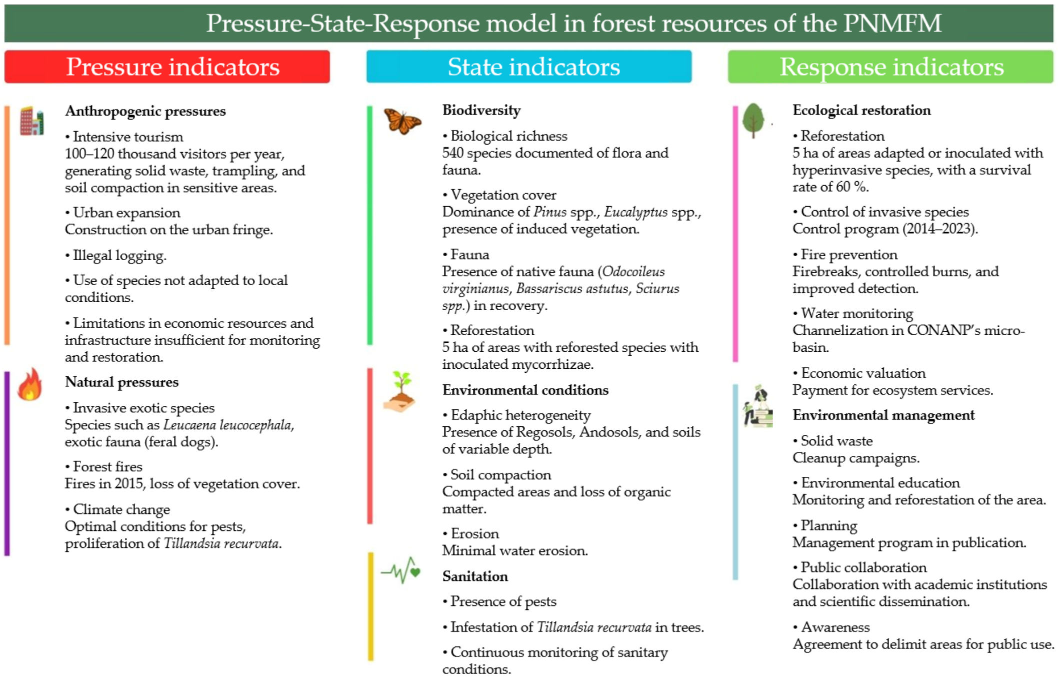

Figure 3. Pressure-State-Response Model applied to the Molino de Flores Netzahualcóyotl National Park (PNMFN) focused on its forest ecosystem. Based on the modified scheme by SEMARNAT (2014).

visitors, concentrated mainly in the commercial and ahuehuetes areas, according to the information provided by the park director during the interviews conducted for this study.

The descriptive analysis of the surveys conducted indicates that 71.7 % of visitors indicated recreation as the main reason for their visit (Table 1). This concentration of tourists in the PNA generates a visible accumulation of urban solid wastes, both organic and inorganic. This problem was pointed out by the park director and the engineer of the environmental brigade, and 58.3 % of the people surveyed identified it as the most highly visible environmental impact. Thus, the recreational and commercial activities appear to be one of the main triggers of environmental deterioration. Out of all the users, 31.7 % claim to visit the park on a regular basis, which implies a recurring anthropogenic burden on the ecosystem.

Although intensive tourism is an important economic activity, it can also become a direct source of environmental impact, mainly due to the accumulation of solid waste, soil compaction and erosion, the loss of native vegetation, and the alteration of habitats. These results coincide with reports from diverse studies. For example, Pereira *et al*. (2022) documented that trampling on tourist paths increased soil compaction, with apparent densities near 1.6 g cm^{-3} and reduced porosity, which promotes surface runoff and losses of up to 10 Mg ha^{-1} of silt and 6 Mg ha^{-1} of clay. In the PNMFN, the perception of the quality of the ecosystem in the most visited areas was graded by 45 % of tourists as moderate (Table 1).

The findings coincide with studies that document the impacts of unregulated tourism in natural ecosystems. Mendoza-González *et al*. (2012) point out that this activity leads to contamination by solid waste and to soil compaction. Pérez-Ramírez and Flores-Montes (2019) reported, in Piedra Herrada, State of Mexico, that visitor overload exceeds the carrying capacity, leading to soil compaction and a reduction in biodiversity. Lara-Pulido *et al*. (2021) documented that unplanned tourism in Baja California Sur reduced the natural geomorphology by more than 40 %, and in the Iztaccíhuatl-Popocatepetl National Park, the accumulation of waste, soil compaction, and land use changes affecting the ecological balance have been recorded (Baloch *et al*., 2022). In field tours and interviews in the PNMFN, areas with limited access to tourism, designed to preserve the ecosystem, were observed to have healthier vegetation and a lower soil compaction.

Another important pressure factor is the presence of exotic invasive species, such as *Ricinus communis* L. (castor bean) and *Leonotis nepetifolia* (L.) R. Br. (lion's ear), which were identified in field tours within the area. According to the perceptions of visitors, there is no difference in the percentage (45 and 43 %) when evaluating the biodiversity (Table 1). The invasion of exotic species affects the natural regeneration processes, particularly in herbaceous and shrub communities, reducing biodiversity (CONABIO, 2023). The local fauna, such as cats and dogs, constitutes a direct pressure on the native fauna in the PNMFN. The control of invasive species in the PNAs helps native communities to regenerate. However, its success depends on adequate management of the ecological factors, removal of invasive species, active restoration, and constant monitoring (Petri and Ibáñez, 2025).

Forest fires are a recurring pressure that originates from the combustion of light materials such as grasses and bushes, which spread across the soil cover. The documented evidence proves that forest fires are a relevant threat since they not only degrade vegetation but also release large amounts of greenhouse gases, feeding into climate change (Gajendiran *et al.*, 2024). In the case of the PNMFN, according to information provided by the director during the interviews, in 2024 alone, eight fires were recorded in different points of the PNA, mainly in the area of "El jardín" during the dry season, which displays the recurrence of this type of disturbance in the area.

In the PNMFN, climate change is also manifested with the proliferation of *Tillandsia recurvata* L. (ball moss). This phenomenon compromises forest health by modifying the structure of the tree canopy and promoting the presence of pathogens. Under water stress conditions, the incidence of pests increases, which can cause massive tree mortality, particularly with water stress in the soil and altitudinal shifts of species, thereby altering the energy dynamics of forest communities. For example, in *Bursera copallifera* (Sessé and Moc. ex DC.) Bullock, branches with *T. recurvata* present a lower rate of survival and sprout production, as well as a reduction of up to 43 % in the aptitude of the host tree. When the epiphyte is removed, the vigor of the tree increases (Vergara-Torres *et al*., 2024).

Urban expansion is one of the greatest threats, associated with the municipal demographic growth in the periphery of the park. A concrete example is the recent construction of a housing development adjacent to the area "El Jardín," which increases the pressure on the natural resources and fragmentation of the ecosystem. Real estate development reduces ecological connectivity, which affects biodiversity and limits the ability of the PNAs to fulfill their conservation function, especially in the outskirts and metropolitan areas (Aguilar *et al*., 2022).

This impact is also evident in other PNAs. In the Nevado de Toluca National Park, urbanization has generated acid rains and soil degradation (García-Solorio *et al*., 2022), whereas Aguilar *et al*. (2022) documented rates of plant coverage loss of up to 30 % in accelerated expansion periods. Caro-Borrero *et al*. (2021) indicate that this process can reduce ecological connectivity by over 40 %, limiting the mobility of fauna and natural regeneration.

The director in charge of the PNA mentioned that the location of the park in an altitude transition causes imbalances in the soil and climate conditions, which influences the selection of species for reforestation programs. The quality of the ecosystem is perceived mostly as regular (45 %), which reflects the technical challenges mentioned by the administration. This situation, along with the historical agricultural use of the land, explains the problems resulting from the reforestations with improperly adapted species, as shown in earlier restoration attempts due to nutrient and water restrictions, which represents a potential risk in the context of the PNMFN, particularly during the dry seasons (Juan-Ovejero *et al*., 2022).

The lack of economic resources is an identified pressure that limits the implementation of restoration, monitoring, and conservation projects, including the lack of specialized laboratories for the detailed characterization of the park (Baker and Gittman, 2024). This institutional deficiency translates into a negative perception among users, who rate the current conservation measures as deficient.

State indicators

The evaluation of the state of the forest ecosystem of the PNMFN revealed a considerable biological wealth. There is a record of 540 fauna and flora species, a figure that comes from the technical inventories performed for the creation of the park management program. This document is in the integration phase before its publication, which sustains the validity and relevance of the biological information presented. The area stands out for its relevance as a conservation core, since it maintains an important species diversity. Despite its lower extension in comparison with other Mexican PNAs such as the Lago de Texcoco National Park, which houses 370 fauna species and 250 flora species in its 14 000 ha, the PNMFN displays a considerable density of species per surface unit (CONAGUA, 2025).

The plant structure presented a dominance of species introduced in reforestations, mainly *Pinus* sp., *Eucalyptus* sp., and *Quercus* sp. These species present a noticeable dominance of the higher canopy in all areas of the park, which displaces the natural succession of native species. This situation is reflected as a documented pattern, where this dominance generates a structural and functional homogenization, which compromises long-term ecological resilience (Arnesi *et al.,* 2024). This degradation coincides with the perceptions of the visitors: 45 % graded the ecosystem quality as "regular" and 20 % as "bad," mainly due to concerns over the integrity of the vegetation and cleanliness (Table 1).

The actions to remove exotic invasive species carried out in 2024 and 2025 consisted of the manual and selective elimination of infestation hotspots in priority regeneration areas. Although these preventive actions do not involve a measurable volumetric extraction, the release of space favors an increase in the density of native species, particularly in shrub and herbaceous communities. This improvement was pointed out by the park director and the brigade technician, who recorded the increase in population density during field surveys and flower inventories. These measures enable the recovery of native flora.

According to Maynard-Bean and Kaye (2019), these interventions are efficient for the stability and restructuring of native communities, which coincides with the observations in the area under study. Jiménez-Hernández *et al.* (2023) evaluated the removal of *Hedera helix* L. (English ivy) in temperate forests in Mexico City, which resulted in the recovery of native species and a floral composition similar to that of non-invaded sites within a year, highlighting the quick response of native vegetation after the elimination of invasive species and the resilience of altered ecosystems.

The wild fauna presented a positive response after the park access restrictions implemented during the COVID-19 pandemic in 2020. According to reports by the park director and the brigade technician, an increase was recorded in the abundance and distribution of species such as opossums (*Didelphis virginiana* Kerr, 1792), ringtails (*Bassariscus astutus* Lichtenstein, 1830), and squirrels (*Sciurus* sp.), which currently cover areas from which they are absent or restricted to specific areas such as the CONAFOR nursery. These results coincide with those reported by Ewart *et al*. (2024), who pointed out that the abundance of native fauna is lower in non-protected areas or in those with a greater presence of humans or domestic fauna. This situation is evident in the park, with the increase in the population density of species due to the restriction of access to specific parts of the PNA. The perception of the biodiversity among the visitors is split: 45 % consider its diversity to be scarce, whereas 43.3 % consider it to be broad, suggesting the need to strengthen interpretative resources to make the recovery of the biota of the ecosystem visible (Table 1).

The qualitative observations in the soils displayed degradation in frequently transited areas, with visible compaction and a loss of organic matter as a result of forest fires. Agbeshie *et al*. (2022) indicate that severe fires consume surface organic matter, reduce organic carbon, and affect the stability of soil aggregates; they also note that frequent transit increases compaction, which limits water infiltration and promotes erosion. However, the erosive processes in the PNMFN remain at minimum levels due to the presence of a natural accumulation zone in the river and the stability provided by the remaining vegetation. The director in charge mentioned that in the 1990s, the area of "El Jardín" received the addition of exogenous soils originating from activities related to the construction of a nearby shopping mall. The origin and quality of these soils are unknown, which causes variability in their characteristics and in the terrain of the area.

Response indicators

The implemented institutional responses integrate ecological restoration and environmental management components. The forest rehabilitation programs have covered 5 ha since 2020, and they incorporate native species adapted to the local climate conditions, such as *Vachellia farnesiana* (L.) Wight and Arn., *Quercus* sp., *Acacia farnesiana* (L.) Willd., and *Pinus* sp. inoculated with edible ectomycorrhizal fungi (*Suillus kaibabensis* (Thiers) Kretzer and Bruns, *Hebeloma mesophaeum* (Pers.) Quél., and *Laccaria laccata* (Scop.) Cooke). This strategy enables a survival rate of over 60 %. A nursery was established for the production of plants inoculated with these mycorrhizae, and 56.7 % of the visitors identified the results of the reforestations carried out in the park (Table 1).

Inoculation with edible ectomycorrhizal fungi is an adequate strategy, since this symbiosis promotes the absorption of nutrients and water, with an increase in the survival of trees under adverse conditions (Rodríguez-Gómez Tagle *et al*., 2024). Its effectiveness depends on the compatibility between the fungus and the host species, as well as on its adaptation to local conditions (Policelli *et al*., 2020). These actions, along with the removal of harmful species, lead to favorable results, particularly in areas near the gallery forest and parking lots.

Indicators were established in the PNMFN to evaluate the state of conservation, which includes the follow-up of plant survival, the evaluation of forest health, and systematic inventories to identify and characterize the species of the different ecosystems of the park. This integral approach has been applied in diverse regions. Ortiz-Fernández *et al*. (2024) used indicators such as species inventories, the monitoring of coverage, vegetative composition, and the proportion of native vs. introduced species. Pío-León *et al*. (2024) include counts of species richness and endemism, inventories of flora and fauna, and georeferenced records to identify priority areas and information gaps.

Cleanup and environmental education programs in 2023 had up to 200 participants, according to the brigade technician. These programs display advances in the sensibilization of visitors, although their impact is limited in relation to the high number of visitors. Mahbubi *et al*. (2025) indicate that the integration of digital media and participatory workshops can improve their effectiveness.

Forest fire prevention management includes the implementation of firebreaks in critical urban-forest interface zones, controlled burns, and preventive cleaning, complemented by training for technical staff and coordination with firefighters and municipal civil protection. The design of the firebreaks, adjusted annually based on fuel load and priority areas, effectively prevents the spread of fire. Gómez-Mendoza and Rodríguez-

Trejo (2021) point out that prescribed burns and mechanical treatments are efficient in pine forests in Mexico, whereas Gao *et al*. (2024) document reductions of over 50 % in fires with preventive measures. Nevertheless, the recurrence of these events in the park underscores the need to enhance monitoring with advanced technologies and continuous training in the face of budgetary limitations.

In the last decade, a collaboration system was established with academic institutions to implement conservation actions, which strengthens the identification of priority areas and the creation of projects aimed at ecological restoration. González *et al*. (2023) point out that this collaboration provides methodological rigor, technological access, and adaptive management. Another program was implemented to monitor the composition and structure of the natural resources in forests and scrublands, following protocols by the National Protected Natural Areas Commission (CONANP), enabling the follow-up of changes in biodiversity. The strategy integrates local connectivity with training programs aimed at young people and the local population, with activities such as beekeeping and environmental awareness (Vallejo-Chávez, 2022).

Agreements were made with shopkeepers to regulate public use and restrict access to protected or special use areas, ensuring the continuity of economic activities under criteria compatible with the conservation of the PNA. The exclusion of visitors from critical areas favored the integrity of the ecosystems, the recovery of the wild fauna, and the reestablishment of functional habitats, which intensified after the restrictions due to the COVID-19 pandemic. As a part of this management, an unregulated tourism-monitoring system and control measures were implemented to mitigate environmental impacts derived from anthropogenic activity, given that human pressure reduces ecosystem resilience and increases the risk of loss of biodiversity (Keith *et al*., 2023).

Likewise, a management program was developed nearing its publication, which includes the zoning of priority sites and a list of species with their relative abundance. This instrument represents an integral response to the understanding of biodiversity and optimizing ecosystem management. Zoning enables the application of specific measures according to the needs of each area, maximizing results and reducing conflicts between development and conservation (Xie *et al*., 2024). The use of standardized protocols ensures comparability with other PNAs and strengthens integral management based on social, ecological, technical, and economic knowledge (CONANP, 2020). Most visitors perceive conservation actions as regular (55 %), which reflects an intermediate valuation of the park management efforts (Table 1).

CONCLUSIONS

The Pressure-State-Response model in the Molino de Flores Nezahualcóyotl National Park helped evaluate environmental pressures, the state of the ecosystem, and the effects of the implemented management actions in an integrated manner. Additionally, it helped organize and analyze the environmental information of the park, which displays its use as a support tool for management and to make decisions in protected natural areas.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the Secretariat of Science, Technology, and Innovation (SECIHTI) for the financial support provided for this investigation. We would particularly like to thank the geographer Agustín Tagle, director of the Molino de Flores National Park, for the institutional assistance provided and for his valuable support during the development of the study. We extend our gratitude to brigade member Eng. Magdalena García for her collaboration and specialized knowledge in the area of study that strengthened our results. Finally, we acknowledge the Molino de Flores National Park for allowing our research to be conducted on its premises and for the conservation actions that inspire this work.

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